Japan International Cooperation Agency (JICA)

The City of Bogotá

THE STUDY ON
DISASTER PREVENTION
IN THE BOGOTÁ METROPOLITAN AREA
IN THE REPUBLIC OF COLOMBIA

Final Report

- Main -

March 2002

Pacific Consultants International
OYO Corporation

PREFACE

In response to a request from the Government of Colombia, the Government of Japan decided to conduct a development study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia and entrusted the Study to the Japan International Cooperation Agency (JICA).

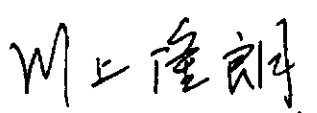
JICA sent to Colombia a study team headed by Mr. Hajime Tanaka of the joint venture of Pacific Consultants International Co. Ltd. and Oyo Corporation Ltd. to Colombia, between March 2001 and March 2002. In addition, JICA set up an Advisory Committee headed by Mr. Masayuki Watanabe of Institute of International Cooperation between March 2001 and March 2002, which examined the Study from specialist and technical point of view.

The Study Team held discussions with the officials concerned of the Government of Colombia, and conducted field surveys at the study area. Upon returning to Japan, the Study Team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and promotion in Colombia, and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Colombia for their close cooperation extended to the Study Team.

March 2002



Takao Kawakami
President
Japan International Cooperation Agency

March 2002

Mr. Takao Kawakami
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

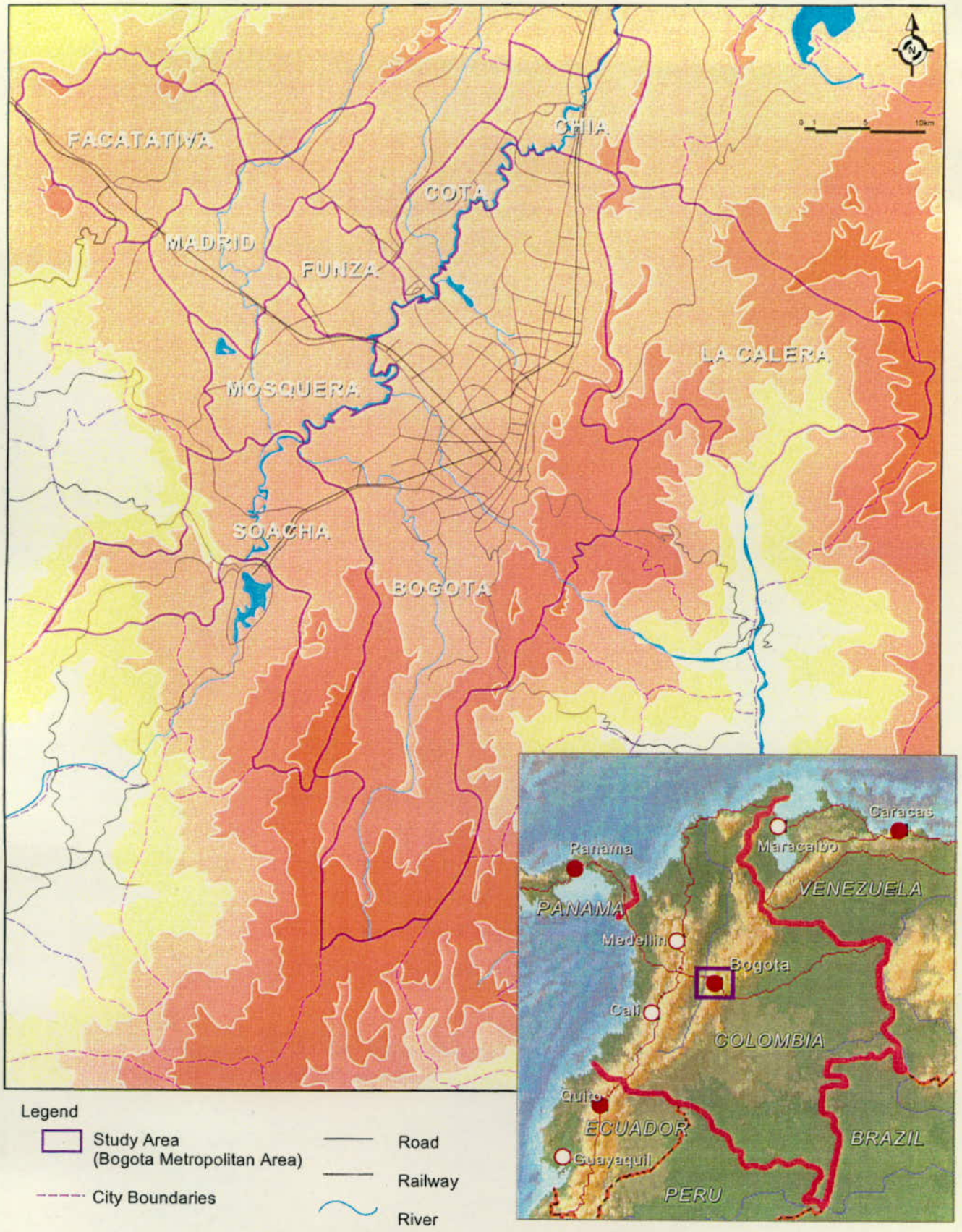
We are pleased to submit the final report entitled the" The Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia". This report compiles the results of the Study in accordance with the contracts signed on March 16 2001and April 12, 2001 between the Japan International Cooperation Agency and the joint venture of Pacific Consultants International and Oyo Corporation ltd.

In the Study, the Study Team presents the Master Plan Study based on the analysis of the existing conditions and problems. The report consists of the Summary, Main Report, GIS Maps and Data Book.

All members of the Study Team wish to express sincere appreciation to the personnel of your Agency, Advisory Committee, and the Embassy of Japan in Colombia, and also to the officials concerned of the Government of the Republic of Colombia, the Government of Bogotá City and the Government of Cundinamarca Prefecture for their cooperation extended to the Study Team. The Study Team sincerely hopes that the results of the Study will contribute to the disaster prevention for the Bogotá Metropolitan Area and also to the promotion of socio-economic development for the area.

Yours Faithfully

Hajime Tanaka
Team Leader
The Study on Disaster Prevention
in the Bogotá Metropolitan Area
in the Republic of Colombia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VENEZUELA
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Bogota
Cali
COLOMBIA
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ECUADOR
BRAZIL
Guayaquil
PERU
Legend
Study Area
(Bogota Metropolitan Area)
City Boundaries
Road
Railway
River

Study Area

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10) This basic plan for disaster prevention shows the direction of the prevention and attention of disasters. The following are recommended:

- It is necessary to arrange the disaster prevention organizations for the Bogotá Metropolitan Area through each committee for prevention and attention of disaster, the city of Bogotá, the prefecture of Cundinamarca and National levels. The responsible and supporting agencies assigned by the committee should implement the disaster prevention plans and prepare for the emergency response. Also, it is necessary to arrange coordination agreements with other cities and prefectures and international agencies.
- It is indispensable to decide a leading coordination agency for the Bogotá Metropolitan Area in order to coordinate the related agencies and the implementation of projects.
- It is important for the city of Bogotá to assign DPAE as an Administrative Department considering the required coordination among the administrative organizations for planning the disaster prevention measures before, in and after a disaster, especially seismic disaster.
- It is necessary for the agencies, which are responsible for infrastructure and lifeline facilities, to conduct diagnostic studies on the proposed projects and effect reinforcements as proposed by the study.
- It is necessary for the Localities of Bogotá and the 8 municipalities of Cundinamarca to prepare their disaster prevention plans and emergency response plans

the Locality office for inspection of construction works after getting the approval of the design from the CURADURIA.

4) It is recommended that the governments of Bogotá and Cundinamarca review the seismic design and construction standards for masonry buildings duly based on the actual conditions, building damages estimated and the assessment of the building damages in the 1999 Quindio earthquake.

5) It is recommended that the Bogotá Metropolitan Area review the existing information or communication systems and promote the development of a Disaster Management Information System as a basic management tool for disaster prevention and emergency response of the Bogotá Metropolitan Area.

6) It is recommended that public or service entities prepare their emergency response plans, which consist of preparedness for disaster prevention, strengthening the facilities like water supply tanks for emergency response in a disaster due to their seismic diagnosis studies based on the damages estimated, and for restoration of the damaged facilities after a disaster, including materials and equipment.

7) Public education for disaster prevention is necessary for the government staff to strengthen the government organizations and for communities to enhance the public awareness. The government organizations should be strengthened to cope with their responsibilities in preparedness for disaster prevention and also responsibilities in emergency response. Also, enhancement of disaster prevention awareness of the inhabitants, and communities in general, is recommended, to make it easier for the people to understand the need to follow the regulations related to disaster prevention. Seismic-resistant design for new buildings and strengthening of existing building structures are also recommended.

8) Early execution of a pilot study is necessary to promote the Basic Plan for Disaster Prevention of the Bogotá Metropolitan Area. It is recommended that the pilot study on disaster prevention include organization of local communities, emergency response facilities and restoration plan and that the pilot area be selected from the vulnerable localities and municipalities prioritized from disaster prevention aspects in Bogotá and Cundinamarca. They are localities of Santa Fe, San Cristobal, Usme, Bosa, Kennedy, Suba, Rafael Uribe and Ciudad Bolivar, and municipalities of Cota and Soacha.

9) For further study of the existing conditions of the Bogotá Metropolitan Area, studies required to be conducted are listed as follows:

- Development study on disaster prevention for pilot areas in the Bogotá Metropolitan Area,
- Geophysical study on Cundinamarca,
- Geotechnical study on Cundinamarca,
- Study on Water Resources and Environmental Management for Upper Rio Bogotá.

4. CONCLUSION AND RECOMMENDATION

For disaster prevention of the Bogotá Metropolitan Area, the related entities are the city government of Bogotá, the Prefecture government of Cundinamarca and the National government. The existing disaster prevention organizations have already been prepared for landslides and floods, but not for earthquakes. It is necessary for the related three governments to arrange the responsible organizations for preparedness of disaster prevention and emergency response in order to cope with seismic disaster.

The Basic Plan has proposed to reduce the number of weak buildings by strengthening by phased expansion until 2010. As for the vulnerable Localities and Municipalities identified in the Bogotá Metropolitan Area, the vulnerable areas are proposed to be improved through pilot studies. The government organizations for disaster prevention and emergency response for earthquake shall involve the whole government organizations, and it will be necessary to prepare themselves to handle their responsibilities and functions.

The proposed Basic Plan for disaster prevention of the Bogotá Metropolitan Area will be effective in technical, economic, financial, social and environmental terms. By implementation of the proposed projects, it is hoped that the vulnerability of the area to seismic disaster would be sufficiently addressed.

It is concluded and recommended that the related governments of the Bogotá Metropolitan Area to take immediate actions for implementation of the following:

1) It is recommended that the government of Bogotá D.C., the government of Cundinamarca and the National government take immediate actions to arrange the government organizations for the preparedness of disaster prevention and the emergency response before, in and after a seismic disaster.
2) It is recommended that the related agencies hold a common database and maintain it properly because the database developed in the Study is a basic tool for disaster management.
3) For alleviation of the seismic damage. it is most important for the Bogotá Metropolitan Area to reduce the number of weak buildings or those without seismic resistance by strengthening (seismic retrofitting); moreover, it is important to reduce the number of informal building constructions. Also, it is recommended that the CURADURIA, which is responsible for giving approval of construction of new buildings in Bogotá, expand its capacity to meet the demand of new building constructions and to extend the responsibility to the seismic retrofitting or strengthening projects. Further, it is recommended that the governments of Bogotá and Cundinamarca introduce an authorized inspection system of

Table 5 Evaluation of Programs

No	Program	Expected Impacts	Evaluation Items			
			Technology	Social	Environment	Economy
1-1	Seismic diagnosis study of important buildings	Reduction of weak building for the governments and emergency response organizations will reduce the seismic damage. The number of improved building is more than 700 in total.	A	C	C	C
1-2	Strengthen important building facilities		A	A	A	A
2-1	Seismic diagnosis study of vehicular and pedestrian bridges	Improvement of existing vehicular bridges and pedestrian bridges will secure the emergency transportation networks required. The number of improved bridges is 58 in total.	A	C	C	C
2.2	Seismic reinforcement of vehicular and pedestrian bridges		A	B	A	A
3-1-1	Seismic reinforcement of water supply facilities	The seismic reinforcement of the water supply facilities (13 stations) will secure the water supply capacity.	A	C	A	C
3-1-2	Provision of emergency water supply facilities	Emergency water supply system will secure the emergency water supply by strengthening the water supply facilities (110,800m3 in total).	A	C	A	A
3-2	Seismic reinforcement of gas supply facilities	Improvements of existing gas supply facilities will secure the gas supply service.	A	C	B	B
3-3	Seismic reinforcement of electronic supply facilities	Improvement of existing electronic supply facilities will secure the power supply service.	A	C	B	B
3-4-1	Seismic diagnosis study for telephone facilities	Improvement of existing telephone facilities will secure communication service.	A	C	C	C
3-4-2	Seismic reinforcement of telephone facilities		A	C	B	B
4-1	Urban redevelopment of priority area	Improvement of vulnerable urban area. Total area, more than 7,000 ha in the Study Area will reduce the damage.	B	A	A	B
4-2	Road development		B	A	B	B
4-3	Open space development		B	A	A	C
4-4	Education and enlightenment program	Technology improvement will reduce secondary damage	-	-	-	-
5-1	Geophysical study of subsurface structure	Provision of more accurate information for seismic reinforcement for infrastructure and buildings.	A	C	C	C
5-2	Geotechnical study for site response and liquefaction evaluation		A	C	C	C
6	Landslide protection works	Five locations identified for priority area will be improved.	B	A	C	C
7-1	Flooding (Structural Measures)	The development of five rivers will protect the people in the hazard area from the floods	A	B	C	A
7-2	Flooding (Non-structural Measures)	Warring system installation and preparation of flood map will protect and mitigate the flood hazard area from the floods	A	B	C	C
8	Handling of hazardous materials	Establishment of inspection system	A	B	A	C
9	Health sector improvement program	Improve health sector capacity and improvement of emergency response capacity.	C	A	C	C
10	Education program	Disaster management education for all level will reduce the damage	-	-	-	-
11	Establishment of disaster management information system	Establishment of information system in the Study Area	B	A	C	B
12	Establishment of monitoring program	Establishment of warning system	B	A	C	B

Note: A: High impact

B: Medium impact

C: Low impact

Table 4 Cost Distribution of the Projects (Unit: Million COP)

Items	Cost Distribution									Total
	Short			Medium			Long			
Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Seismic Diagnosis Study of Important Buildings	927	926	30	625	626	52	1,001	1,002	152	5,340
Strengthen Important Buildings	9,232	18,316	18,342	24,713	31,229	22,118	45,363	45,364	49,627	264,303
Seismic Reinforcement of Vehicle and Ped. Bridge	6,825	6,825	57,700	57,700	57,700	57,700	57,700	-	-	302,150
Water Supply	4,805	4,805	88,420	101,580	101,580	101,380	99,680	12,200	12,450	526,900
Gas Supply system	775	575	1,110	1,110	1,130	1,130	200	200	200	6,430
Electronic Supply Systems	780	780	1,320	3,320	3,370	3,820	3,820	3,300	1,250	21,760
Telecommunication Systems	410	410	1,250	1,750	1,750	1,750	700	800	800	9,620
Urban Development	8,658	8,658	8,660	66,391	66,391	66,397	-	-	-	225,155
Earthquake Engineering	-	-	-	-	-	-	-	-	-	-
Landslide Program	830	2,471	2,471	2,364	2,364	2,375	579	580	-	14,034
Flooding Program	27,028	27,028	27,030	19,078	19,078	19,079	38,150	38,150	38,150	252,771
Industrial facility	-	-	-	-	-	-	-	-	-	-
Health Program	4,216	4,226	4,246	4,136	4,136	4,196	2,716	2,716	2,848	33,436
Education Program	-	-	-	-	-	-	-	-	-	-
Information System	1,603	1,603	1,603	1,603	1,603	1,605	-	-	-	9,620
Monitoring Program	70	66	3	3	3	3	3	3	3	157
Total	66,158	76,689	212,185	284,373	290,960	281,605	249,912	104,315	105,480	1,671,676
Toal (Time span)			355,032			856,937			459,707	

Source: Study Team

3.4 Evaluation

The proposed programs in the basic plan for disaster prevention of the Bogotá Metropolitan Area are evaluated in technological, social, environmental and economic terms. The programs are evaluated from A to C based on the expected impacts by each program. The results are summarized and shown in Table 4.

Table 3 Summary of Project Implementation

Program		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule								
					Short			Medium			Long		
					2002	2003	2004	2005	2006	2007	2008	2009	2010
1	Improvement of Important Buildings	1-1 Seismic Diagonosis Study of Important Buildings	Each Governmental Organization	5,340									
		1-2 Strengthen Important Buildings	Each Governmental Organization	264,303									
2	Improvement of Bridges	2-1 Sesmic Doagonosis Study of Vehicular and Pedistrian Bridges	Bogota City	13,650									
		2-2 Seismic Reinforcement of Vehicular and Pedstrian Bridiges	Bogota City	288,500									
3.1	Seismic Reinforcement of Water supply Facilities	3-1 Seismic reinforcement of waster supply facilities	EAAB	447,140									
		3-1-2 Provision of Emergency Water Supply Tanks	EAAB	79,760									
3.2	Seismic reinforcement of gas supply facilities	3-2-1 Seismic diagonostic study of gas supply facilities	Gas Natural Company	770									
		3-2-2 Seismic reinforcement of gas supply facilities	Gas Natural Company	5,660									
3.3	Seismic reinforcement of electronic supply facilities	3-3 Seismic diagonostic study of electronic supply facilities	CODENSA/EMG ESA	1,160									
		3-4 Seismic reinforcement of electronic supply facilities	CODENSA/EMG ESA	20,600									
3.4	Improvement of telephone facilities	3-3-1 Seismic diagonosis study for telephone facilities	ETB/CAPITEL	420									
		3-3-2 Seismic reinforcement of telephone facilities	ETB/CAPITEL	9,200									
4	Urban Redevelopement of priority area	4-1 Urban redevelopment of priority area	Bogota City	87,913									
		4-2 Road development	Bogota City	109,862									
		4-3 Open space development	Bogota City	27,380									
5	Earthquake eingineering	5-1 Geophysical Study of subsurface structure	DPAE/ INGEOMINAS	-									
		5-2 Geotechinical study for site response and liquifaction evaluation	DPAE/ INGEOMINAS	-									
6	Landslide	6-1 Landslide protection works	DPAE	14,034									
7	Foolding	7-1 Structure Measures	EAAB/ Cundinamarca	251,790									
		7-2 Non structure Measures	EAAB/ Cundinamarca	982									
8	Industrial Facility	8-1 Handling of hazadous materials	DAMA/CAR	-									
9	Health secior	9-1 Health sector improveemnt	Bogota/ Cundinamarca	33,436									
10	Education sector	10-1 Education Program	Bogota/ Cundinamarca	-									
11	Disaster management information system	11-1 Establishment of disaster management information system	Bogota/ Cundinamarca	9,620									
12	Monitoring program	12-1 Establishment of monitoring program	DPAE	157									

Source: Study Team

3) Implementation Agencies

The responsible agencies are divided into the following government sectors of Bogotá City, Cundinamarca Prefecture and national, privatized or private lifeline sectors, specifically, they are EAAB, CODENSA, EMGESA, ETB, CAPITEL, and private individuals.

For implementation of the Basic Plan, it is necessary to have a strong leading agency and mutual cooperation among the related organizations.

4) Implementation Schedule and Project Cost

Implementation schedule and project cost is planned for short, mid and long terms. The total project cost is COP 1,671,676 million (US$ 730.3 million) and due to the disbursement schedule, it is expected to use 22% of the total cost in the short term, while in the medium term, it is expected to use 51.5% of the total cost. More than 70% of the cost will be used by the end of the second term.

Implementation schedule and disbursement schedule are shown in the following tables:

- Government programs of assistance, support, technical services that facilitate disaster victims' recovery, such as grants and low-interest loans for repair or replacement of homes, business, and technical assistance and education and information.

6) Other Support Measures planned are as follows:

- Emergency health and medical measures,
- Disaster information management system, and
- Public education.

3.3 Implementation Schedule

1) Implementation Period

The projects are planned to be implemented by 2010 considering the target year of the Territorial Ordering Plan (POT) and the implementation schedule is divided into three terms corresponding to the mayoral term of office in the city of Bogotá as follows:

1. Short term: 2002 - 2004
2. Mid-term: 2005 - 2007
3. Long-term: 2008 - 2010

2) Proposed Projects

1. Arrangement of government organizations for disaster prevention and emergency response;
2. Improvement of important buildings, including diagnostic studies;
3. Improvement of bridges;
4. Seismic reinforcement of lifeline facilities, including diagnostic study of:
   - Water supply facilities, provision of emergency water supply tanks,
   - Gas supply facilities,
   - Electric supply facilities,

- Telephone facilities

5. Urban redevelopment of vulnerable areas;
6. Earthquake engineering study;
7. Landslide protection works;
8. Flood protection works;
9. Management improvement of hazardous materials by industrial facilities;
10. Improvement and reinforcement of health and medical sector;
11. Educational program for enhancement of awareness of disaster prevention;
12. Strengthening disaster management information systems;
13. Strengthening of monitoring programs of earthquake, landslide and flood, and establishment of warning systems for landslide and flood.

- For strengthening of rescue and support systems, it is necessary for emergency response organizations to arrange evacuation places and evacuation roads, and to strengthen shelters, and to secure water and food;
- For arrangement of fire fighting and rescue activities, it is necessary for emergency response organizations to strengthen the fire fighting capacity, fire fighting apparatus and rescue equipment;
- For arrangement of first aid and medical care system, it is necessary for emergency response organizations to arrange a first aid system, communication system, initial medical care system, back-up medical facilities and medical care environment;
- For arrangement of transportation system, it is necessary for emergency response organizations to arrange emergency traffic control system, emergency transportation system, teams and equipment for opening of emergency transportation routes and airport facilities.

4) Emergency Response Headquarters

It is required for the Bogotá Metropolitan Area to arrange the emergency response command center and sub-centers at national and local levels. The incident commander is local mayor, while for the Bogotá City or Cundinamarca government, it should be the Mayor of Bogotá City or Governor of Cundinamarca, respectively. The incident commanders for the Bogotá Metropolitan Area should be clarified by law.

The location of the Emergency Response Headquarters are proposed as follows:

- National: Ministry of Interior/DGPAD (in the building of the Secretary of Health, Bogotá City),
- Bogotá City: The building of the Secretary of Health, Bogotá City,
- Cundinamarca Prefecture: The building of the government of Cundinamarca,
- Localities and Municipalities: The buildings of Locality and Municipality governments.

5) Recovery and Rebuilding

It is proposed that, for the most vulnerable areas, a redevelopment plan be prepared during the period leading to preparedness for disaster prevention. The recovery and rebuilding plan can be divided into two categories: restoration of normal life and restoration of urban area. It is necessary for the governments to prepare the necessary institutional arrangements for recovering normal activities as follows:

- Promoting actions by disaster victims that enable to begin the process of rebuilding their homes, replacing property, resuming employment, restoring their business;
- Government programs of repairing, rebuilding public buildings, infrastructure and mitigating future disaster losses;

1) Arrangement of Emergency Response Organization

It is necessary for the Bogotá Metropolitan Area to arrange the emergency response organizations due to the required functions in and after the disaster. The necessary functions for the emergency response are categorized as follows:

- Emergency support functions: Transportation, communication, public works and engineering, fire fighting, information and planning, mass care, resources support, health and medical care, urban search and response, hazardous materials, food and energy.

2) Preparation for Emergency Response

For the emergency response, each responsible organization is to prepare for emergency response. The functions and resources to be prepared are as follows:

- Organization of specialized teams for damage estimation, emergency communications, medical assistance and support, search and rescue, etc.;
- Preparation of required equipment and supplies like food, water, power generators, camping goods, etc. for affected areas;
- Preparation of required facilities for disaster field offices and disaster recovery centers, etc.;
- Preparation of emergency activities (opening critical transportation routes, establishment of shelters and feeding facilities);
- Preparation of financial support (loan and grants) to repair or replace damaged housing for reducing damages and recovery period after the disaster;
- Preparation of financial arrangement to repair roads and public buildings,
- Arrangement of technical assistance to identify and implement mitigation opportunities to reduce future loss, and other assistance, including crisis counseling, tax relief and legal services.

3) Arrangement of Initial Response

In order to minimize the damage in a disaster, it is important for emergency response entities to prepare the following:

- For arrangement of initial response, it is necessary for each emergency response organization to prepare a manual for initial activities;
- Arrangement of base offices for emergency response activities and preparation of equipment;
- For strengthening of communication systems, it is necessary for related organizations to reinforce the existing communication and monitoring systems, and equipment;

It is necessary for them to arrange the government organizations for preparedness of disaster prevention and emergency response through the committees because of the responsibilities required to coping with the disaster. The leading agencies and coordinating agencies required are as follows:

Responsible Entity	Bogotá Metropolitan Area		
	Bogotá	Cundinamarca	National
Leading Agency	District Planning of Administrative Department (DAPD)	Government Secretary	Ministry of Interior
Coordinating Agency	DPAE-FOPAE	Government Secretary/OPAD	DGPAD

2) Strengthening of Urban Areas by Structural Measures

For strengthening the urban areas to cope with the disaster, structural and non-structural measures are planned as follows:

(1) Strengthening of emergency and strategic public buildings;
(2) Reinforcement of private buildings and control of informal building construction;
(3) Identification of emergency transportation road networks and strengthening of bridges as strategic infrastructures;
(4) Strengthening of strategic lifeline facilities;
(5) Arrangement of open spaces and evacuation places;
(6) Improvement and strengthening of vulnerable areas;
(7) Execution of protection works for landslide hazard areas (La Carbonera, Montebello, El Espino, Jerusalen, Montebello San Luis, El Paraiso);
(8) Execution of flood protection works for the Rio Bogotá and its tributaries;
(9) Installation of seismometer and emergency shut down system for industries.

3) Strengthening by Non-structural Measures

(1) Arrangement of monitoring systems for earthquake, landslide and flood, and warning systems for landslide and flood;
(2) Land use control for landslide hazard areas, flood hazard areas and areas along the rivers.

3.2 Emergency Response

In and after a disaster, the local and national governments require immediately to undertake emergency response and recovery activities in order to track the disaster: saving lives, protecting property, and meeting basic human needs; restoring the disaster-affected area; and reducing vulnerability to future disasters. It is necessary for the organizations to prepare themselves to conduct their functions in a disaster.

Table 2 Estimated Damage

Items			Case 1	Case 2	Case 3
Heavily Damaged Buildings (numbers)			399,384	421,989	61,829
Casualties	Deaths (numbers)		39,249	40,438	3,265
	Injuries (numbers)		272,627	281,560	23,749
Lifeline Facilities	Water Supply Pipeline	Damaged Points	3,753	1,545	16
		Ratio (Points/Km)	0.6	0.2	0.0
	Gus Supply Pipeline	Damaged Points	428	139	1
		Ratio (Points/Km)	0.05	0.02	0.00
	Electric Power Supply Cable	Damaged Length	2,409	1,001	0
		Ratio (%)	0.04	0.02	0.00
	Telecommunication Cable	Damaged Length	5,583	2,189	0
		Ratio (%)	0.05	0.02	0.00
Bridges	Vehicular Bridges (numbers)		53	58	0
	Pedestrian Bridges (numbers)		27	28	0

The main secondary seismic damages triggered by earthquake are landslide and Industrial fire. The high-risk area for the landslide caused by earthquake is the southern part of the Study area, for the case of the earthquake scenario case 1. Highly seismic damage for industrial facilities is forecasted in Puenta Aranda and Martires localities in Bogotá, for the case of the earthquake scenario case 1 and 2.

3. BASIC DISASTER PREVENTION PLAN

The basic disaster prevention plan for the Bogotá Metropolitan Area consists of Preparedness for Disaster Prevention, Emergency Response and Other Support Measures and the related organizations are the government of Bogotá City, the government of Cundinamarca Prefecture and the National Government.

3.1 Preparedness for Disaster Prevention

1) Arrangement Disaster Prevention Organizations

The government organizations of the Bogotá Metropolitan Area consist of three administrative levels, i.e., the government of Bogotá City, the government of Cundinamarca Prefecture and the National Government. Each of them has a Committee for Prevention and Attention of Disaster as follows:

- District Committee for Disaster Prevention and Attention
- Regional Committee for Disaster prevention and Attention
- National Committee for Disaster Prevention and Attention

In response to the request of the Government of Colombia (hereinafter referred to as "GOC"), the Government of Japan (hereinafter referred to as "GOJ") decided to conduct "The Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia (hereinafter referred to as "the Study") through JICA, the official agency responsible for the technical cooperation program of GOJ, in accordance with relevant laws and regulations in force in Japan. In November 2000, JICA dispatched the Preparatory Study Team to Colombia for the preliminary survey for the Study and discussed the Scope of Work with DPAE, OPAD and ACCI. The Study was conducted from mid April to mid September 2001 to March 2002.

For the protection of life and property of the people in the Bogotá Metropolitan Area from disasters, it is indispensable for the Bogotá Metropolitan Area to prepare for disaster prevention and emergency response and to strengthen the urban areas against seismic disasters. The basic measures studied are as follows:

(1) Arrangement of disaster prevention entities;
(2) Strengthening of buildings, infrastructure and lifeline facilities in the urban areas;
(3) Arrangement of emergency response;
(4) Enhancement of public awareness for disaster.

2. DISASTER SCENARIO

1) Scenario Earthquakes

For the Study, as scenario earthquakes, two faults and subduction event are selected and they are as follows:

Table 1 Scenario Earthquakes for the Study

Case	Fault name	Type	Magnitude	Peak Ground Acceleration (g)	Seismic Intensity (MMI)	Distance (km)*
Case-1	La Cajita	Near	6.4	0.1- 1.0	VII- X	20
Case-2	Guayuriba	Regional	7.0	0.1- 0.5	V- IX	60
Case-3	Subduction	Subduction	8.3	0.1- 0.2	V- VII	400

Source: Microzonificacion sismica de Santa Fe de Bogotá, INGEOMINAS 1997

Note: MMI=(Log (PGA)-0.014)/0.3

* Closest distance from INGEOMINAS

Some liquefaction potential area is identified in the southern part of Bogotá's urban area.

2) Seismic Damage Estimation

The estimated largest seismic damages among the scenario earthquakes are listed as follows:

THE STUDY ON DISASTER PREVENTION IN THE BOGOTÁ METROPOLITAN AREA IN THE REPUBLIC OF COLOMBIA OUTLINE

1. INTRODUCTION

This is an outline of the Summary Report of the Final Report (March 2002) for the Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia, which has been carried out in accordance with the Scope of Work and the Minutes of Meetings agreed and signed between the Government of Colombia (Direction of Prevention and Attention of Emergencies of Bogotá D.C. (DPAE), Office For Prevention and Attention of Disaster Cundinamarca (OPAD) and Colombian International Cooperation Agency (ACCI) and the Japan International Cooperation Agency (JICA) on November 27, 2000.

The Study Area, the Bogotá Metropolitan Area, consists of the city of Bogotá and the eight municipalities of the prefecture of Cundinamarca and covers 1,949 km^2 with a population of 6.99 million (in 2000). The city of Bogotá is the capital district of Santa Fe de Bogotá, which is also the capital of the Republic and of Cundinamarca Prefecture. Currently, the population of the city of Bogotá was rapidly increased, from 0.67 million in 1951 to 6.4 million in 2000, consequently, the urban area of Bogotá has been expanding to the surrounding municipalities of Cundinamarca.

In the Study Area, various types of disasters such as landslides, floods and earthquakes, and also industrial hazards are actualized due to the rapid urban development. Since the beginning of the 1990s, the national and local governments have prepared their organizations to cope with landslides and floods, but not against earthquakes yet.

As for earthquakes, the events over MSK VII in the Bogotá Metropolitan Area were recorded in 1917, 1923 and 1967 since the beginning of 1900; therefore, it is necessary for the area to be ready to cope with this magnitude of disaster. As for earthquake proof design in Colombia, the government of Colombia issued the seismic design code in 1984 and has been promoting its application for building construction. However, the seismic design has not come into wide use yet. In the Study Area, there are a large number of masonry buildings, of which a large part is lacking seismic resistance capacities. In a major earthquake, a large number of buildings and bridges will be collapsed and severe damages will occur. However, the public awareness for the disaster is still very low among the government, non-government entities and local communities in the Bogotá Metropolitan Area. In order to cope with the disaster, the Bogotá Metropolitan Area has to arrange the disaster prevention entities of the government, non-government entities and local communities and to strengthen the urban areas by enhancing public awareness for the disaster.

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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ACCI	Colombian Agency of International Cooperation (Agencia Colombiana de Cooperación Internacional)
ACERCAR	Environmental Technical Attendance Unit for Micro, Small, and Medium Sized Companies (Unidad de Asistencia Técnica Ambiental para la Micro, Pequeña y Mediana Empresa)
ACGIH	American Assembly of Government Industrial Hygienists
ACOTOFA	Colombian Association of Toxicology and Pharmacology (Asociación Colombiana de Toxicología y Farmacología)
AIS	Colombian Earthquake Engineering Association (Asociación Colombiana de Ingeniería Sísmica)
AMBAS	Generating Company of Electricity in Facatativa (Compañía Generadora de Electricidad en Facatativa)
ANDI	National Association of Industrialists (Asociación Nacional de Industriales)
ANSI	American National Standard Institute
API	American Petroleum Institute
ARP	Professional Risks Administrator (Administradora de Riesgos Profesionales)
ASEMGAS	Association of Liquefied Petroleum Gas Companies (Asociación de Empresas de Gas Licuado de Petróleo)
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
ASTM	American Society for Testing and Materials
ATC	Applied Technology Council
BOR	Beds Occupation Rate
CADELs	Administrative Center of Local Education (Centro Administrativo de Educación Local)
CAM	Municipal Committee of mutual Attendance for Prevention and Attention of Disasters
CAMI	Center of Immediate Medical Attention (Centro de Atención Médica Inmediata)
CAPS	Primary Attention Center (Centro de Atención Primaria)
CAR	Regional Autonomous Corporation (Corporación Autónoma Regional)
C.C.A.E.	Center for Coordination and Attention of Emergency (Centro de Coordinación y Atención de Emergencias)
CCF	Family Compensation Fund (Fondo de Compensación Familiar)
CCP	Colombian Code of Bridges (Código Colombiano de Puentes)
CCS	The Colombian Safety Council (Consejo Colombiano de Seguridad)
CDP	Productive Development Center (Centro de Desarrollo Productivo)
CEDERI	Center of studies about Disasters and natural Risks (Centro de Estudios sobre Desastres y Riesgos Naturales)
CEPREVE	Study Center for the Prevention of Disasters (Centro de Estudios para la Prevención de Desastres)
CISPROQUIM®	Safety Information Center of Chemical Products (Centro de Información de Seguridad sobre Productos Químicos)
CLE	Emergency Local Committee (Comité Local de Emergencia)
CLOPAD	Local Committee for the Prevention and Attention of Disasters (Comité Local para la Prevención y Atención de Desastres)
COE	Operational Emergency Committee (Comité Operativo de Emergencia)
CON-PNC	National Operative Committee of the National Contingency Plan (Comité Operativo Nacional del Plan Nacional de Contingencia)
CPVM	Promoting Fund of Military Housing (Fondo de Promoción de Vivienda Militar)

CRA	Regulation Committee for Water (Comité de Regulación para el Agua)
CREG	Regulation Committee for Energy and Gas (Comité de Regulación para la Energía y Gas)
CREPAD	Regional Committee for the Prevention and Attention of Disasters (Comité Regional para la Prevención y Atención de Desastres)
CRT	Regulation Committee for Telecommunications (Comité Regulador para las Telecomunicaciones)
CRU	Emergencies Regulating Center (Centro Regulador de Urgencias)
CRUC	Regulating Center of Urgencies of Cundinamarca (Centro Regulador de Urgencias de Cundinamarca)
CTE	Energy Transport Center (Centro de Transporte de Energía)
CTS	Information, Collection and Transmission System (Sistema de Recolección y Transmisión de la Información)
DABS	Administrative Department of Social Welfare (Departamento Administrativo de Bienestar Social)
DAMA	Administrative Department of the Environment (Departamento Administrativo del Medio Ambiente)
DANE	National Administrative Department of Statistics (Departamento Administrativo Nacional de Estadísticas)
DAPD	Administrative Department for District Planning (Departamento Administrativo de Planeación Distrital)
DB	Database
DBMSs	Database Management Systems
DGPAD	General Directive Office for Prevention and Attention of Disasters (Dirección General para la Prevención y Atención de Desastres)
DMA	Disaster Management Agency
DMIS	Disaster Management Information System
DNP	National Department of Planning (Departamento Nacional de Planeación)
DNPAD	National Office for the Attention of Disasters (Dirección Nacional para la Atención de Desastres)
DOT	Department of Transportation
DPAE	Direction for the Prevention and Attention of Emergency (Dirección para la Prevención y Atención de Emergencias)
DSS	Decisions Support System
EAAB	Company of Water Supply and Sewage Service of Bogotá (Empresa de Acueducto y Alcantarillado de Bogotá)
EAAB-ESP	Company of Water Supply and Sewage Service of Bogotá (Empresa de Acueducto y Alcantarillado de Bogotá)
ECOGAS	Colombian Company of Gas (Compañía Colombiana de Gas)
ECOPETROL	Colombian Company of Petroleum (Empresa Colombiana de Petróleos)
EEB	Company of Energy of Bogotá (Empresa de Energía de Bogotá)
EMGESA	Generating Company of Electric Energy (Empresa Generadora de Energía Eléctrica)
EMI	Emergency Management Institute
EOT	Territory Ordering Scheme (Esquema de Ordenamiento Territorial)
EPA	Environmental Protection Agency
EPM	Public Companies of Medellín (Empresas Públicas de Medellín)
EQT	Technical Team of DPAE (Equipo Técnico de DPAE)
ERG	Emergency Response Guidebook (Guía de Respuesta a Emergencias)
ESP	Public Services Company (Compañía de Servicio Públicos)
ESRI	Environmental System Research Institute

ETB	Company of Telecommunications of Bogotá (Empresa de Telecomunicaciones de Bogotá)
E.U.	Uni-personal Company (Empresa unipersonal)
FAVIDI	Fund of Saving and Housing of the District (Fondo de Ahorro y Vivienda del Distrito)
FCS	Flood Control Structures
FEMA	Federal Emergency Management Agency
FERROVIAS	Colombian Company of Railroad (Empresa Colombiana de Ferrocarriles)
FFMM	Military Forces (Fuerzas Militares)
FINDETER	Financial Society for Territorial Development (Sociedad Financiera para el Desarrollo Territorial)
FNA	National Fund of Saving (Fondo Nacional de Ahorro)
FNC	National Railway of Colombia (Ferrocarril Nacional de Colombia)
FOPAE	Fund for Prevention and Attention of Emergencies (Fondo para la Prevención y Atención de Emergencias)
FOREC	Fund for Reconstruction of Coffee Axis Region (Fondo para la Reconstrucción de la Región del eje Cafetero)
FOVIS	Fund for the Family Subside of Well - Being Housing (Fondo para el Subsidio Familiar de Vivienda de Interés Social)
FPSF	Passive Social Fund of Railways (Fondo Pasivo Social de Ferrocarriles)
GDP	Gross Domestic Product
GIS	Geographic Information System
GMP	Good Manufacturing Practice
GNP	National Gross Product
GOC	Government of Colombia
GOJ	Government of Japan
GPS	Global Positioning System
GRE	Response Guide to Emergencies with Dangerous Materials (Guía de Respuesta a Emergencias con Materiales Peligrosos)
GTZ	German Technical Cooperation
HF	High Frequency
HMR	Hazardous Materials Regulation
HP	Horizontal Property
IAEE	International Association of Earthquake Engineers
ICA	Colombian Institute of Agriculture (Instituto Colombiano Agropecuario)
ICBF	Colombian Institute for Family Welfare (Instituto Colombiano de Bienestar Familiar)
ICONTEC	Colombian Institute of Technical Norms and Certification (Instituto Colombiano de Normas Técnicas y Certificación)
ICS	Incident Command System
ICT	Institute of Territorial Credit (Instituto de Crédito Territorial)
ICU	Intensive Care Unit
IDB	Inter-american Development Bank
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies (Instituto de Hidrología, Meteorología y Estudios Ambientales)
IDRD	District Institution of Sports and Recreation (Instituto Distrital de Recreación y el Deporte)
IDS	Information Distribution System
IDU	Institute of Urban Development (Instituto de Desarrollo Urbano)
IGAC	Geography Institute "Agustin Codazzi" (Instituto Geográfico Agustín Codazzi)
INGEOMINAS	Institute of Investigation and Geo-scientific, Mining-Environmental and Nuclear Information (Instituto de Investigación e Información Geocientífica, Minero Ambiental y Nuclear)

INURBE	National Institute of Housing of Social well – being and Urban Reform (Instituto Nacional de Vivienda de Interés Social y Reforma Urbana)
INVIAS	National Institute of Roads (Instituto Nacional de Vías)
INVEMAR	Institute of Marine and Coastal Investigations (Instituto de Investigaciones Marinas y Costeras)
IPC	Index of Consumer Prices (Índice de Precios al Consumidor)
ISA	Electric Interconnection (Interconexión Eléctrica)
ISO	International Organization of Standardization
JAC	Assembly of Community Actions (Junta de Acción Comunal)
JAL	Local Administrative Assembly (Junta Administradora Local)
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
KFW	German Development Bank
LPG	Liquefied Petroleum Gas
MMI	Modified Merçali Intensity
NFPA	National Association for the Protection Against Fires
NGOs	Non-Governmental Organization
NHP	Non Horizontal Property
NNE-SSW	Northeast - Southwest
NSR	Norm for Seismic Resistant
NPGA	National Association of LPG of the United States
NTC	Colombian Technical Norm (Norma Técnica Colombiana)
OCCEL	Telecommunications Company of Occident (Compañía de Telecomunicaciones de Occidente)
ODBC	Open Database Connectivity
OPAD	Office for the Prevention and Attention of Emergency and Disasters of Cundinamarca Department (Oficina para la Prevención y Atención de Emergencias y Desastres del Departamento de Cundinamarca)
OPES	Coordination Office for Prevention and Attention of Emergencies (Oficina de Coordinación para la Prevención y Atención de Emergencias)
OPVs	Popular Housing Organizations (Organizaciones Populares de Vivienda)
OSHA	Safety and Occupational Health Association
PBOT	Basic Territory Ordering Plan (Plan Básico de Ordenamiento Territorial)
PBX	Phone Box
PCM	Project Cycle Management
PGA	Peak Ground Acceleration
P.M.U.	Unified Control Post (Puesto de Control Unificado)
PNC	National Contingency Plan (Plan Nacional de Contingencia)
POT	Territorial Ordering Plan (Plan de Ordenamiento Territorial)
PS	Information Processing System
PSI	Pound per Square Inch
PSM	Process Safety Management
RPM	Risk Management Plan
RSS	Social Solidarity Network
S.A.	Public Limited Company (Sociedad Anónima)
SAE	Society of Automobile Engineers
SAMU	Service for Medical Attention of Urgencies (Servicio de Atención Médica de Urgencias)
SDE	Spatial Data Engine

SDH	Synchronous Digital Hierarchy
SDPAE	Distrital System for Prevention and Attention of Emergencies (Sistema Distrital para Prevención y Atención de Emergencias)
SEAOC	Structural Engineers Association of California
SENA	National Service of Vocational Training (Servicio Nacional de Aprendizaje)
SIRE	Information System for Risk Management and Attention of Emergency (Sistema de Información para el Manejo y Atención de Emergencias)
SISBEN	Selection System of Beneficiaries for Social Programs (Sistema de Selección de Beneficiarios para Programas Sociales)
SMLM	Monthly minimum legal salary (Salario Mínimo Legal Mensual)
SNPAD	National System for the Prevention and Attention of Disasters (Sistema Nacional para la Prevención y Atención de Desastres)
SPT	Standard Penetration Test
SQL	Structured Query Language
SUME	Unified System for Emergency Handling
SURATEP	Professional Risks Administrator of South American Insurances
STF	Colombian Society of Railway Transport (Sociedad Colombiana de Transporte Férreo)
STFO	West Colombian Society of Railway Transport (Sociedad Colombiana de Transporte Férreo del Occidente)
STT	Secretary of Transit and Transportation (Secretaria de Tránsito y Transporte)
TELECOM	National Company of Telecommunications (Empresa Nacional de Telecomunicaciones)
TLV	Threshold Limit Value
TOAD	Tools for Oracle Application Development
U.K.	United Kingdom
UBA	Basic Unit of Attention (Unidad Básica de Atención)
UBC	Uniform Building Code
UHF	Ultra High Frequency
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nation Development Program
UPA	Primary Unit of Attention (Unidad Primaria de Atención)
UPES	Unit for the Prevention and Attention of Emergencies (Unidad para la Prevención y Atención de Emergencias)
UPZ	Unit of Zone Planning (Unidad de Planeamiento Zonal)
USAID	United States Agency for International Development
USEPA	United States Agency for Environment Protection
UVR	Unit of Monetary Adjustment (Unidad de Valor Real)
VIS	Social Interest Housing (Vivienda de Interés Social)
VHF	Very High Frequency

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Chapter 1

Introduction

CHAPTER 1 INTRODUCTION

1.1 Background

The study area is composed of Bogotá City and eight municipalities in Cundinamarca, and formed a Bogotá Metropolitan Area. The Bogotá Metropolitan area has experienced rapid population increase since 1960s, when total population was only 1.7 million. Since then the population has increased to reach 5.3 million in 1993, more than three times comparing to 1960s. Total population reached 6.4 millions in year 2000. Based on the estimation of DAPD, Bogotá City will continue to increase population at a rate of 130,000 per year.

Rapid population increase has caused many problems, such as insufficient housing stock, infrastructure provision, transportation etc. It is pointed out that the urbanized area expanded to relatively weak soil condition areas of lake deposit as well as sandy soil area, where it is the problems of the liquefaction. Moreover, the edged of the mountain area has high risk of amplification of seismic intensity. The urbanization has brought about city's vulnerability to disasters.

The Bogotá Metropolitan Area suffered various natural disasters of earthquake, landslide, flooding and industrial hazard. As for large earthquake study by INGEOMINAS, the Study Area has experienced seven times of MSK intensity over VII since 1600. For slope disaster from 1996 to 2000 in the Bogotá Metropolitan Area, 404 events were occurred and consisting of landslides, falls and flows. The flooding damage can be observed whole study area, except Cota and Madrid municipalities. During 1979 to 1998, the industrial accidents related to spills, leaks, fires and explosions were occurred 204 events, of which 109 events were fires. The study area can be observed various disasters.

To cope with natural disaster prevention, the Bogotá City enacted natural disaster prevention and a state of emergency action laws and regulations in 1999 in accordance with the national laws of disaster management, which regulate the emergency action plan by the local governments. However, the existing disaster management system can be handled relatively small area of disaster. There isno integrated disaster management system for earthquake, which expects management system for earthquake damage of whole study area.

The Government of Colombia (hereinafter referred to as "GOC") need additional technology, knowledge and information to formulate an integrated Bogotá city disaster prevention plan. With this reason, the GOC requested the Government of Japan (hereinafter referred to as "GOJ") for the conduct of a study to formulate an optimum disaster prevention plan for the Bogotá metropolitan area. In response to the request of GOC, the GOJ has decided to conduct "The Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia (hereinafter

referred to as "the Study") through JICA, the official agency responsible for the technical cooperation program, in accordance with relevant laws and regulations in force in Japan.

1.2 Outline of the Study

1.2.1 Goals

The basic plan for disaster prevention aims to prevent and mitigate the effects of and safeguard Bogotá City against natural disasters. The specific goals of the basic plan are categorized as follows:

- To protect the life and asset of Bogotá City from natural disasters;
- To promote the stability of the social and economic activities after disaster; and
- To secure the administrative functions of the city of Bogotá and related organizations.

In order to achieve these goals, the Study Team prepares an optimum stage development plan of the disaster prevention measures.

1.2.2 Objectives

The objectives of the Study are:

(1) To formulate the plan for disaster prevention; and

(2) To carry out the technology transfer to Colombian counterpart personnel in the course of the Study.

1.3 Study Area

The Study Area is the Bogotá metropolitan area, consisting of Bogotá City and the eight municipalities of Chia, Cota, Facatativa, Funza, La Calera, Madrid, Mosquera and Soacha (Figure 1.1.1).

1.4 General

The Study conducted in the following two phases:

1) Phase 1: Basic Study and Analysis

Existing data collection, analysis and evaluation

The focus of the fieldwork during Phase 1 is collected and reviewed of the existing data and analysis. The Study Team found the previous study done by the DPAE and INGEOMINAS has no database for the analysis. In order to evaluate damage, the Study team decided to establish GIS database system for damage estimation. The Study Team collected various fields of existing data in cooperation with counterpart agencies. The list of collected data and organization that supplied the data is summarized as Table 1.1.1.

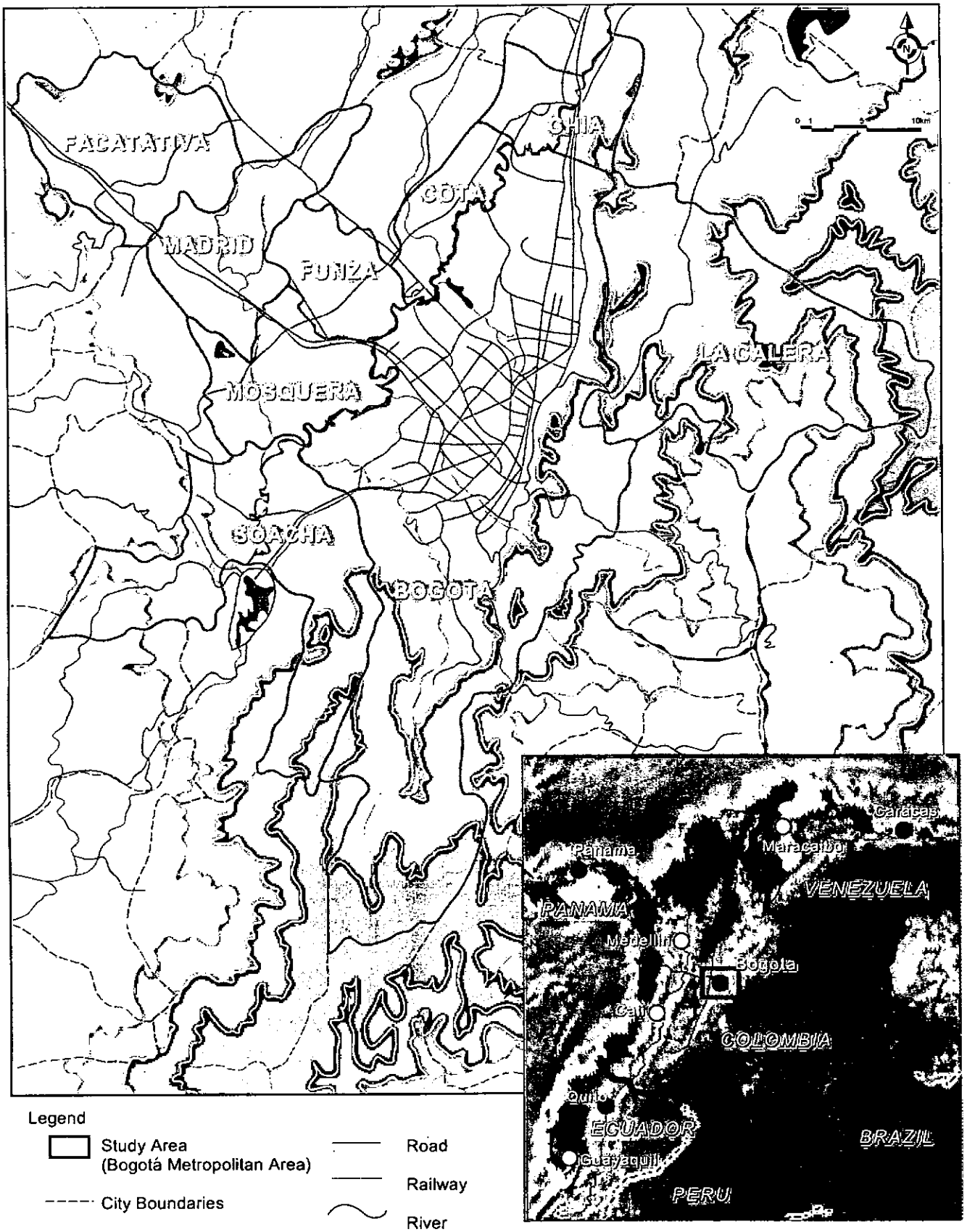


Figure 1.1.1 Study Area

Table 1.1.1 Summary of Collected Data

Items	Data Type	Organization
Earthquake	Earthquake data	INGEOMINAS
Population	Bogotá Cundinamarca	DAPD Each municipality and DANE
Building	Bogotá Cundinamarca	Bogotá City Cadastral Department IGAC
Infrastructure	Road network and bridge locations Water pipe distribution Telecommunication network Gas supply network Electronic supply network	IDU EAAB CAPTEL GAS NATURAL CODENSA
Others	Open space Public facilities (Fire fighting station, Civil defense, Red Cross, Police Station, Military station, Public and private hospital, Educational facilities)	IDRD Fire fighting Office, Civil Defense, Red Cross, Police Department, Ministry of Defense, Secretary of health, Secretary of Education, etc.

Workshop (1)

The Study Team held five Project Cycle Management: PCM and Stakeholder Workshops for the purpose of technical transfer and information spreading to people related to disaster management. Details of the workshops are summarized as follows:

Table 1.1.2 Summary of Workshop 1

Date	Participants	Activities
May 24, 2001 (Bogotá, Cundinamarca)	PCM Workshop (20 people)	
	- Government Officials - Official from Lifeline Agencies - Representatives of Districts and Cities	- Problem Analysis
	Stakeholders Workshop (30 people)	
	- Government officials - Official from Lifeline Agencies - Representatives of Districts and Cities	- Display of materials made by DPAE - Presentation of activities of DPAE/OPAD and JICA Study Team - Presentation of sufferers of disaster - Group discussions on recommendation to JICA Study Team
May 29, 2001 (Bogotá) June 8, 2001 (Cundinamarca)	PCM Workshop (40 people)	
	- Community leaders - Representatives of NGO - Representative of Hospital, Church	- Participants Analysis - Problem Analysis
	Stakeholders Workshop (60 people)	
	- Government officials - Officials from Lifeline Agencies - Representatives of Districts and Cities - Community leaders - Representatives of Mass media - Representative of NGOs	- Display of materials made by DPAE - Presentation of activities of DPAE/OPAD and JICA Study Team - Presentation of sufferers of disaster - Group discussions on recommendation and conclusion for future activities
May 30, 2001 (Bogotá) June 9, 2001 (Cundinamarca)	PCM Workshop (40 people)	
	- Community leaders - NGO - Hospital, Church	- Objective Analysis

As for stakeholder meeting, five subjects were discussed, namely, 1) infrastructure strengthening, 2) organizational and institutional strengthening, 3) people and community strengthening, 4)

mass media usage, and 5) information distribution system strengthening.

For the PCM analysis, the participants are agreed to formulate three types of project, 1) Disaster prevention and awareness improvement project, 2) Project for disaster prevention institution strengthen and 3) capacity building on disaster management. Those results are made use of formulation of the proposed projects.

Establishment of web site

The JICA study team constructed Web page in cooperation with counterpart organization. SIRE has already constructed Web page for DPAE-FOPAE. The Web page of study team was shared with counterpart's Web site and opened information on the study.

Surveys

The Study Team carried out field investigations with local consultants through hired by local consultants as well as subcontracting. Three important subjects, Socio-economic survey, Industrial survey and digital map making, are subcontracting to the local consultants. Those works are summarized as follows:

Table 1.1.3 Summary of Sub-contract

Name of Survey (Subcontracting Firm)	Outline	Results
Socio-economic survey (Urbanismo and Sistemas)	The objective of the survey is to collect data and information of buildings and population for database of the year 2000. The surveyed area covered whole study area, yet it focuses on Soacha municipality due to lack of information of building and population.	Before the field investigation, aerial photo interpretation was done by the local consultant team to determine the survey community and then field investigation was carried out for home interview of identified area. The results were used to determine population and the number of building in Soacha municipality.
Industrial facilities survey (Consejo Colombiano de Seguridad:CCS)	In order to identify industrial facilities in Cundinamarca eight municipalities, the Study Team carried out questionnaire survey of around 400 factories during Phase 1. The survey items are prepared discussion with JICA Study Team, as well as counterpart agency.	The local consultant collects total 375 questioners from eight municipalities in Cundinamarca. The collected information is combined with Bogotá's industrial facility database and constructed to integrate database for the study area.
Digital map and GIS database (Geo Spatial)	The purpose of the work is to establish digital map and GIS database covering the Bogotá City as well as adjacent eight municipalities.	The digital maps and GIS database are established within the whole study area.

The Study Team had done other field surveys through hiring local engineers. The covered areas are slope disaster identification, soil and ground data collection, building survey and infrastructure data collection. The collected data were integrated into the GIS database system and utilized for disaster damage estimation.

Public Awareness Survey

This was done by the interview survey. The targeted area for this survey was for Bogotá City and eight municipalities of Cundinamarca. Approximately 100 questionnaires were distributed, and about 50 of them were collected. This result shows that the public interest toward the disaster awareness can be improved.

2) Phase 2: Formulation of the Plan for Disaster Prevention and Mitigation

The Study Team explained the Phase 1 results to the counterpart agency as well as steering committee. Those agencies are agreed on the Phase 1 study results.

Seminar (1)

In order to introduce the results of the Phase 1, Seminar 1 was held by the study team as well as counterpart agencies. The Seminar 1 was intended to introduce disaster scenario, which was estimated within the study.

The summary of the seminar 1 is shown as follows:

Table 1.1.4 Summary of Seminar 1

Items	Descriptions
Data and Place	November 9, 2001 Cundinamarca Government
Attendants	Government officials, Professional and NGOs approximately 200 persons
Contents	Disaster scenario
Results	The study team explained the disaster scenario, which is estimated during Phase 1. The discussion with participants and the Study team concluded that the study results were important for the Bogotá Metropolitan Area to prepare disaster management system.

Workshop (2)

Workshop 2 contained two main objectives, 1) to promote the awareness to the disaster prevention education of the educational related personnel, and 2) to promote the awareness of communities to the disaster prevention by introducing participatory risk analysis and vulnerability reduction exercise.

The summary of the workshop is shown as follows:

Table 1.1.5 Summary of Workshop 2

Date	Participants	Activities
October 17, 2001	50 people (from Bogotá city and Cundinamarca) - Teachers (Elementary, Junior and High school) - Staff from the Educational Institutions	- Introduction of Japanese education on disaster prevention - Awareness promotion on the disaster prevention and the emergency response - Investigation on the potentials and issues for the disaster prevention and emergency response within the school education - Input of the educational planning on disaster prevention
October 24, 2001	50 people (25 from Bogotá city and 25 from Cundinamarca prefecture) - Members from each community	- Presentation of the results for "participatory risk analysis and vulnerability reduction exercise" which were prepared by each community previously. - Promotion of disaster prevention awareness among the community - Plan for the city strengthening

Preparation of the Basic Plan for disaster prevention

The basic plan for disaster prevention was established to formulate in the Bogotá Metropolitan Area. The plan shows the action program for next ten years and approximate costs for implementation. Since earthquake damage is far beyond the other disaster damages, the plan focused on the earthquake disaster prevention plan. The primary attention of the basic plan is to reduce earthquake damage through physical improvement, because the damage is far beyond the existing capacity of the government.

Seminar (2)

The second seminar was held on February 6, 2002 at the Cundinamarca government. The summary of the seminar 2 is shown as follows:

Table 1.1.6 Summary of Seminar 2

Items	Descriptions
Data	February 6, 2002
Attendants	Government officials, Professional and NGOs, approximately 300 people
Contents	Basic Plan for Disaster Prevention
Results	The study team explained the basic plan for disaster prevention to the Colombian attendance. During the discussion, the attendance emphasis on the importance of education and training aspect of disaster prevention. The attendance understood and agreed the contents of the basic plan.

1.5 Description of Individual Study Tasks

The work schedule of the tasks, interrelations among the tasks, and logical flow of the Study are shown in Figure 1.1.2.

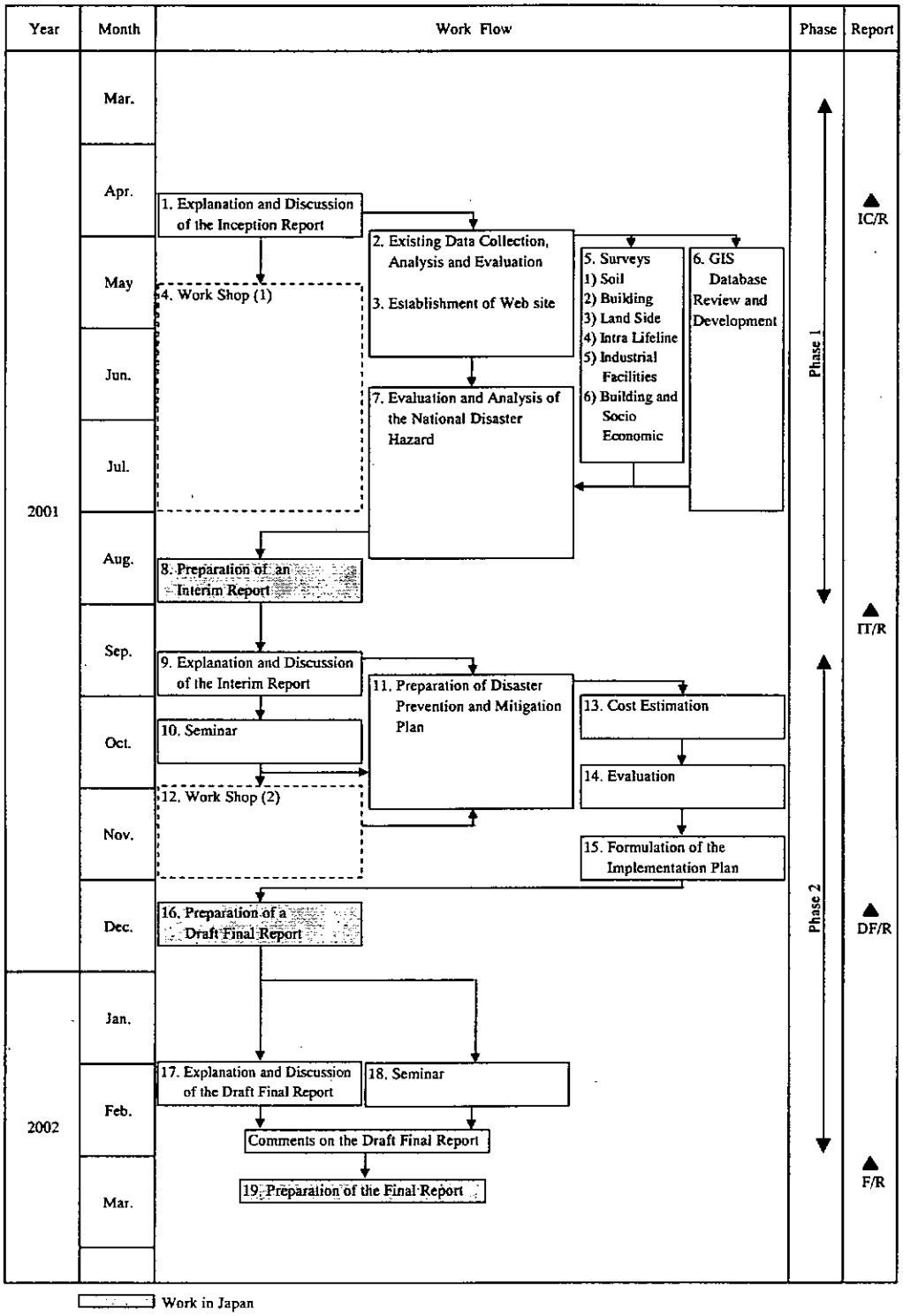


Figure 1.1.2 Work Flow of the Study

1.6 Study Organization

The Study was carried out by the joint efforts of the Study Team and Colombian counterpart personnel, which together form a study implementing body. The Study Team was composed of the members from Pacific Consultants International (PCI) and OYO Corporation. The Colombian counterparts were delegated from DPAE and Cundinamarca prefecture.

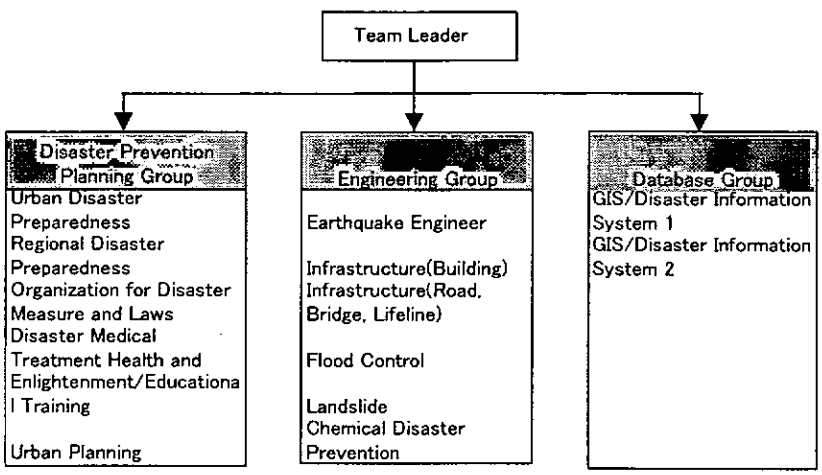


Figure 1.1.3 Study Team Organization

Members of the study team and their assignments are shown in Appendix 1.6.1. A Steering Committee was formed based on the agreement between the City of Bogotá and JICA. It was organized to guide and advise the Study Team and the counterpart team on overall study directions and policy-related matters. A list of steering committee is shown in Appendix 1.6.2 and a list of counterpart is shown in Appendix 1.6.3. Figure 1.1.4 shows the Study Organization.

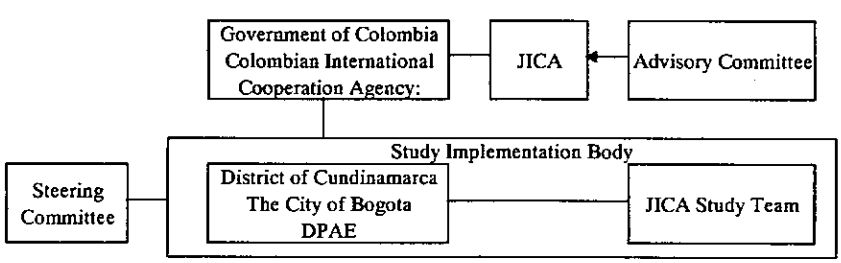


Figure 1.1.4 Study Organization

1.7 Composition of Reports

This report presents all results of the technical studies conducted during the period from April 2001 to March 2002, the Report consists of the following:

1. Summary Report
2. Main Report
3. Data Book
4. GIS Map

Chapter 2

Existing Situation

CHAPTER 2 EXISTING SITUATION

2.1 Natural Conditions

2.1.1 Topography

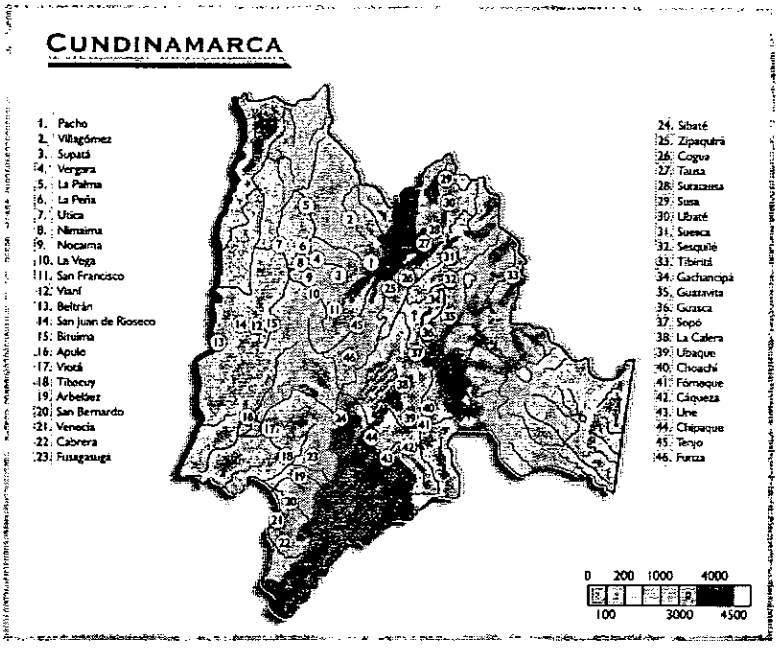
1) Topography in Colombia

The territorial area of the country is 1,141,747 km^2, ranging between latitude 4.2 degrees south and 12.4 degrees north, and between longitude 66.9 degrees west and 78.8 degrees west. From viewpoints of location, topography hydrology and climate, the territory is subdivided into five major regions, namely, Pacific region, Caribbean region, Andean region, Orinoco region and Amazon region. Among them, the Andean region has the largest share of the total population at 70%.

There are three distinct cordilleras, or ranges, - the Cordillera Occidental, the Cordillera Central, and the Cordillera Oriental - in Colombia running parallel in NNE-SSW directions, whose peaks are higher than 5,000m. Between the cordilleras, there are valleys or plateaus, in which major urban areas of Colombia are located. Separating the cordilleras are the deep valleys of the country's major rivers, the Magdalena and its tributary, the Cauca, flowing in a northerly direction into the Caribbean Sea.

2) Topography in Cundinamarca

Figure 2.1.1 shows the topography of the Prefecture of Cundinamarca, whose capital is Bogotá. The Cordillera Oriental runs in the midst of the Prefecture, and the western border has its limit with the Magdalena River.



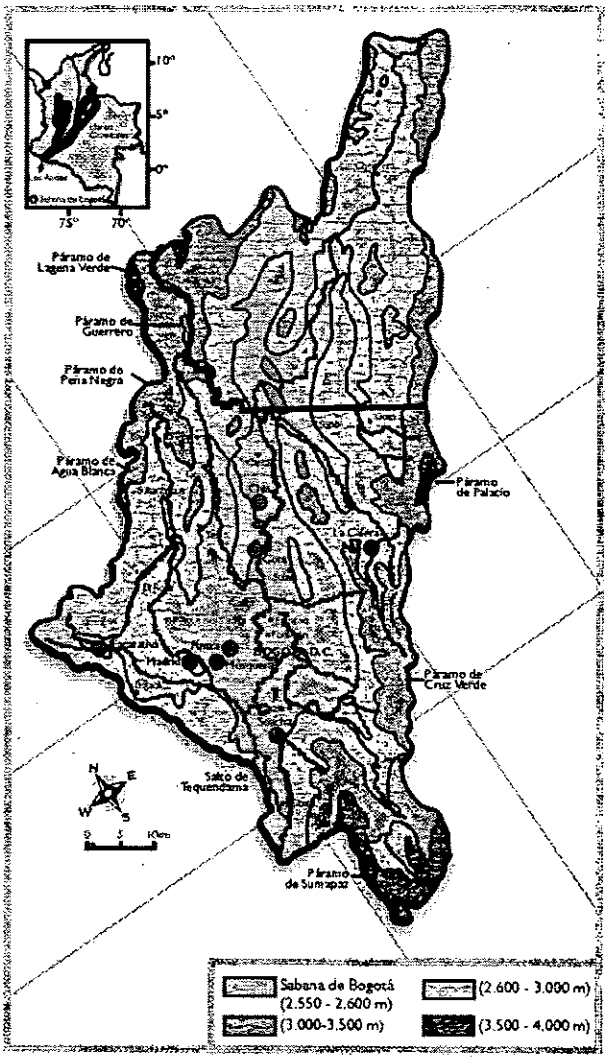
Source: Gobernacion de Cundinamarca

Figure 2.1.1 Topography of Cundinamarca

Sabana de Bogotá locates west of Cordillera Oriental and it is the largest plane within the Eastern Mountains ranges in Colombia.

3) Topography in the Study Area

The geographical location of the Study Area ranges between lat. 4.5 and 5.0 degrees north and between longitude 74 and 74.5 degrees west, with a total area of approximately 1,400km2. The average height of the Bogotá plane is 2,560m above mean sea level, and it reaches 3,000m high in the eastern mountain area. There are some hills of 3,000m high within the area such as Cerro Suba. Eastern hill locates 3,000m to 3,500m high, whereas the southern end of the plain reaches over 3,500m high as shown in Figure 2.1.2.



Source: Analysis Geograficos No. 24,
Plioceno y cuaternario del altiplano de Bogotá y alrededores IGAC, 1995

Figure 2.1.2 Topography of Sabana de Bogotá

Sabana de Bogotá is made of a lakebed, a lake formed in the western part of Cordillera Oriental. Due to its formation, the thickness of the lacustrine clay beneath the Sabana de Bogotá reaches more than 500m, whose thickness increases westward. The lake area has diminished as urbanization in Bogotá began to develop in the last century. As such, the groundwater level in Bogotá plain is still high in general, and differential settlement is seen elsewhere in Bogotá plain, though it is not observed qualitatively.

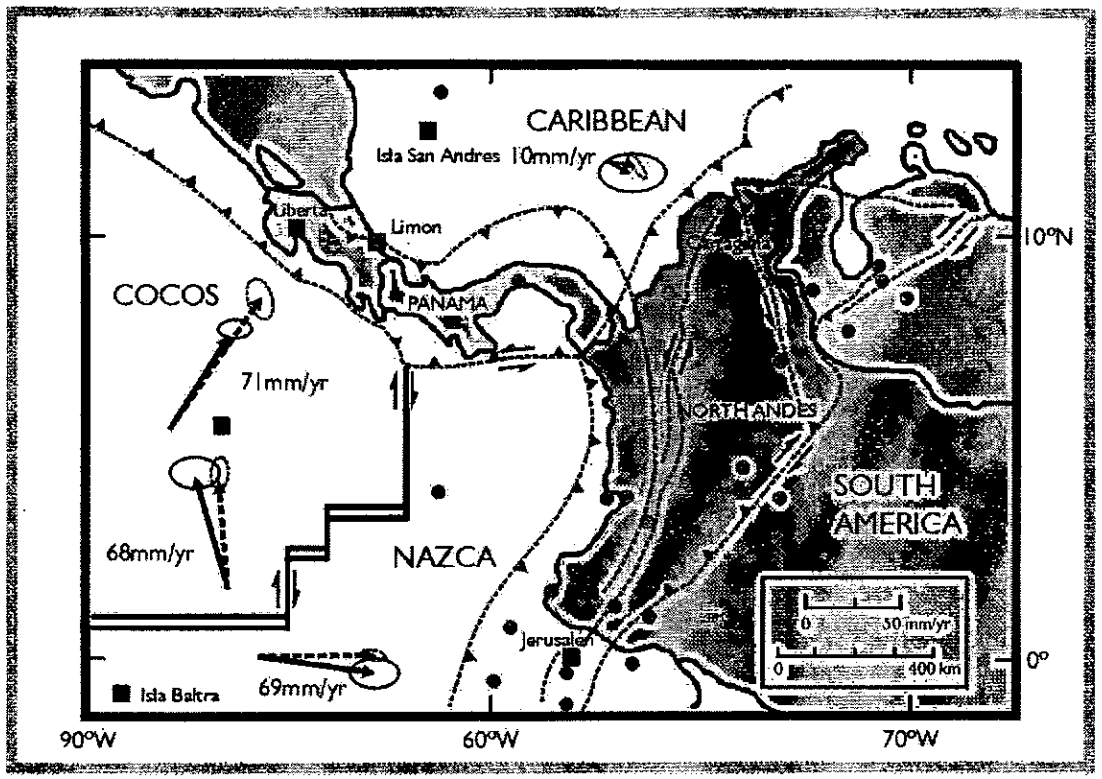
Most of Bogotá and surrounding municipalities for this study locates within Sabana de Bogotá, except La Calera and some part of Soacha. La Calera locates in a mountainous area and has its western boundary with Bogotá along Cordillera Oriental. Hilly area also extends in southeastern part of Soacha, where a vastly developed housing area exists.

2.1.2 Geology

1) Tectonics in Colombia

In the Colombian territory, the southeastern part is made of tectonically stable Guyana plateau. On the other hand, the northwestern part of the territory is the northern end of the Andean range, which is formed by collision of eastward subjecting Nazca plate with a rate of 69mm per year, and westward uplifting South American plate.

The schematic illustration of the plate movement is shown in Figure 2.1.3. This movement is part of the circum-pacific volcanic belt, where seismic and volcanic activity is very high.

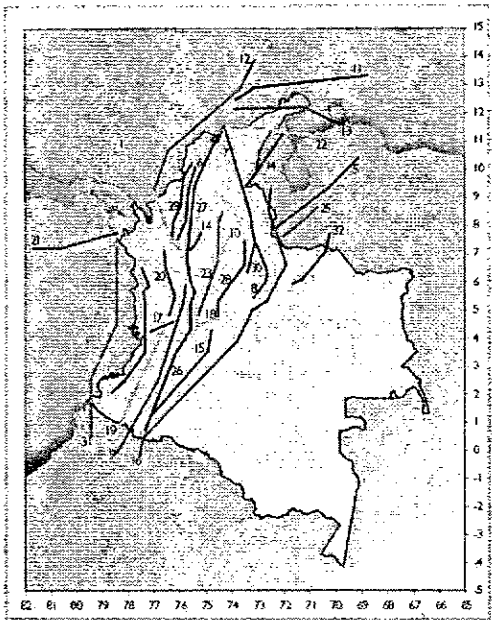


Source: Estudio General de Amenaza Sísmica de Colombia, AIS, 1996

Figure 2.1.3 Plates and Their Movement in South America

2) Fault Systems in Colombia

Due to the tectonic movement of the Nazca plate and South American plate, major fault systems such as Falla de la Cordillera Oriental or Falla Romeral are formed in the Colombian territory. Figure 2.1.4 shows the distribution of 32 major faults identified in Colombia. Using earthquake catalogue and regression analysis, the maximum magnitude of possible earthquake is calculated as shown in Table 2.1.1.



Source: Microzonificación sísmica de Bogotá city, INGEOMINAS, 1997

Figure 2.1.4 Distribution of Major Active Faults in Colombia

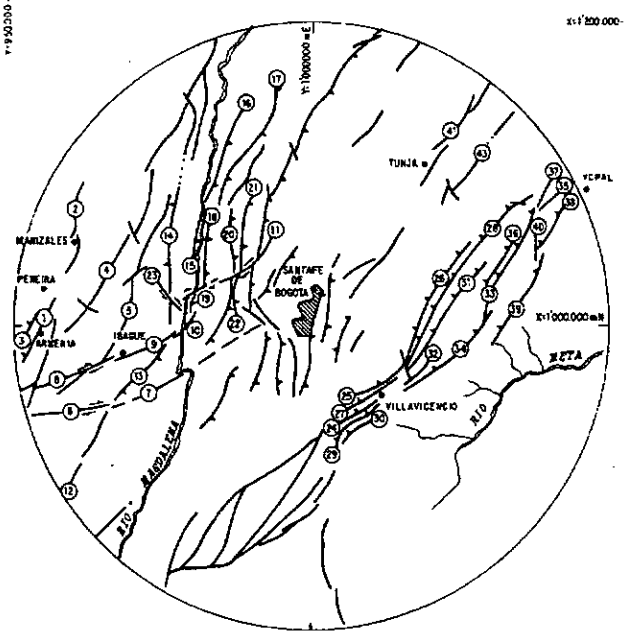
Table 2.1.1 Major Active Faults and Their Maximum Probable Magnitude[2-1-1]

No	Fault name	Maximum Probable Magnitude	No	Fault name	Maximum Probable Magnitude
1	Arco de Dabeiba	6.5	17	Garrapatas	6.5
2	Bahia Solano	7.5	18	Ibague	6.5
3	Benioff-Intermedia	8.0	19	Junin-Sanbiambi	7.0
4	Benioff-Profunda	7.5	20	Murindo Atrato	7.5
5	Bocono	8.0	21	Normal Panama Pacifico	7.0
6	Bolivar	6.0	22	OCA	7.4
7	Bucaramanga-Sta Marta North	6.5	23	Palestina	6.5
8	Bucaramanga-Sta Marta South	6.5	24	Perija	6.5
9	Cauca	7.0	25	Puerto Rondon	6.5
10	Cimitarra	6.5	26	Romeral	7.6
11	Compression South Caribe East	6.0	27	Romeral-Norte	6.5
12	Compression South Caribe West	6.0	28	Salinas	6.5
13	Cuiza	7.0	29	Sinu	6.0
14	Espiritu-Santo	6.5	30	Suarez	6.5
15	Faults of Magdalena	7.0	31	Subduccion	8.6
16	Frontal Cordillera Oriental	8.0	32	Uribante-Caparo	7.0

Source: Estudio General de Amenaza Sísmica de Colombia, AIS, 1996

[2-1-1]Maximum probable magnitude supposes that all segments within the fault are activated during one single event, and it gives superior number in the estimation of magnitude size of earthquake

Figure 2.1.5 shows the distribution of the active faults identified within a radius of 200km from Bogotá. In total, there are 40 active faults in the northwest and southeast direction of Bogotá. Characteristics of these faults such as fault length, activity rate, fault type direction and dip angle are studied for each faults, and most probable expected magnitude are estimated using empirical relationship based on fault characteristics. The most significant faults among them are listed in Table 2.1.2.



Source: Microzonificación sísmica de Bogotá city, INGEOMINAS, 1997

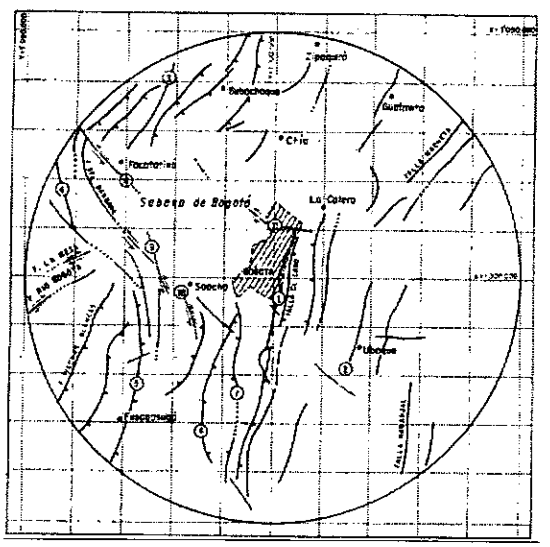
Figure 2.1.5 Map of Active Faults in Northwestern and Southeastern Region

Table 2.1.2 Characterization of Active Faults in Northwestern and Southeastern Regions

Fault system	No	Fault name	Length (km)	Activity rate	Fault type	Azimuth: dip	Maximum Probable Magnitude
Romeral	1	Armenia	60	High-Intermediate	Inversed dextral	30 W	6.8
Romeral	3	Montenegro	45	High-Intermediate	Inversed dextral	45 W	6.7
Ibague	8	Cocora	60	Intermediate	Dextral	65 V	6.9
Ibague	9	Ibague	45	High	Dextral	75 V	7.0
Ibague	10	Piedras	20	Intermediate	Dextral-Inverse	55 V	6.4
Samaria-La Colorada	13	Doima	35	High	Inversed dextral	30 E	6.7
Noroeste	23	El Palmar	20	Intermediate	Sinistral	150 V	6.2
Servia-Santa Maria	24	Colepato	40	Intermediate	Inversed	50 30W	6.7
Servia-Santa Maria	25	Servita	60	Intermediate-High	Inversed	45 40W	6.9
Servia-Santa Maria	27	Guayuriba	60	High	Inversed dextral	45 40W	7.0
Servia-Santa Maria	30	Acacias	30	Intermediate	Inversed	30 30W	6.6
Cuaicaramo	33	Guaicaramo Centro	80	High	Inversed dextral	35 35W	7.2
Cuaicaramo	34	Guaicaramo Sur	65	Intermediate	Inversed	35 35W	7.1
Cuaicaramo	37	Pajarito	60	Intermediate	Inversed dextral	30 50W	6.7
Yopal	38	Yopal	65	High	Inversed	40 40W	7.1
Yopal	39	San Pedro	80	High	Inversed	40 30W	7.2

Source: Microzonificación sísmica de Bogotá city, INGEOMINAS, 1997

Figure 2.1.6 shows the distribution of 10 active faults identified within a radius of 50km from Bogotá. These characteristics are studied and the most probable expected magnitudes from these faults are listed as shown in Table 2.1.3.



Source: Microzonificación sísmica de Bogotá city, INGEOMINAS, 1997

Figure 2.1.6 Maps of Active Faults in Central Region

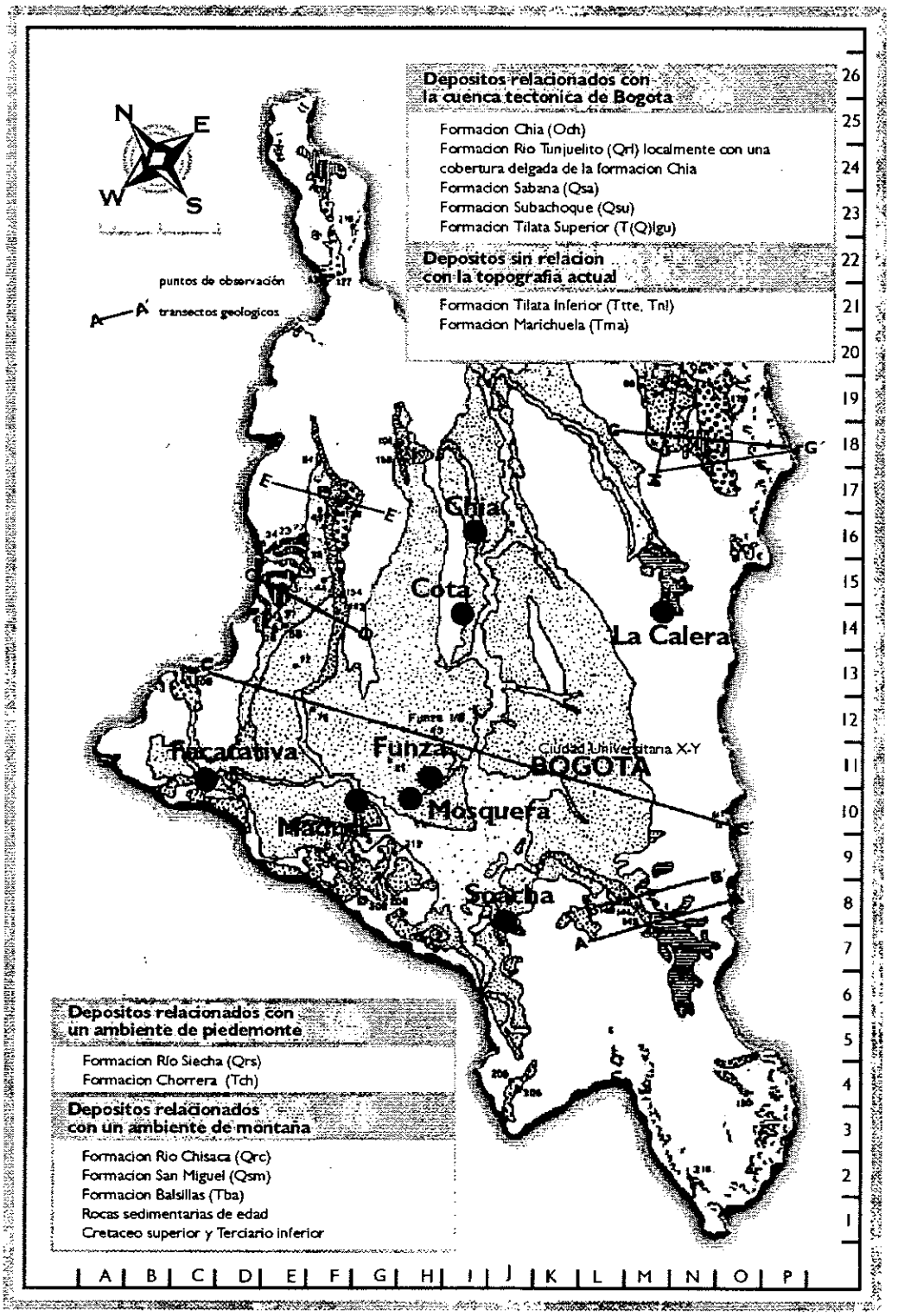
Table 2.1.3 Characterization of Active Faults in Central Region

Fault system	No	Fault name	Length (km)	Activity rate	Fault type	Azimuth: dip	Maximum Probable Magnitude	Distance to Bogota(km)
Oriente	1	Bogota	50	Low	Inverse	10 E	6.4	3
Sur	6	La Cajita	35	Intermediate	Inverse-Dextral	10 E	6.4	30
Sur	7	Rio Tunjelito	35	Intermediate	Inverse	5 W	6.4	25

Source: Microzonificación sísmica de Bogotá city, INGEOMINAS, 1997

3) Geology in the Study Area

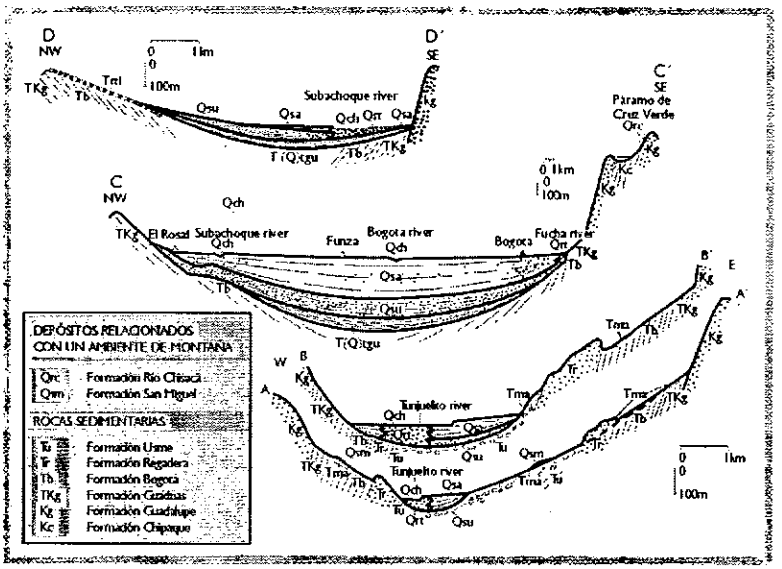
Figure 2.1.7 shows the distribution of distinct lithological units within Sabana de Bogotá. Quaternary sediment rock of marine and continent origin spreads in the central part, while the mountainous area in the east and south of Sabana de Bogotá is mostly composed of Cretaceous or Tertiary origin sediment rock. They have been excavated for construction materials for a long time, and abandoned old quarries exist elsewhere. They are made of mostly sandstone or siltstone; most of them are highly weathered and fractured, thus prone to collapse or landslide.



Source: Analysis Geograficos No. 24, Plioceno y cuaternario del altiplano de Bogotá y alrededores IGAC, 1995

Figure 2.1.7 Distribution of Distinguished Lithological Unit within Sabana de Bogotá

Figure 2.1.8 shows cross sections which correspond to the lines seen in Figure 2.1.7. Thickness of Quaternary sediment in the central part of the plain is over 500m deep above Tertiary silty clay stone.



Source: Analysis Geográficos No. 24, Plioceno y cuaternario del altiplano de Bogotá y alrededores IGAC, 1995

Figure 2.1.8 Geological Cross Section of Sabana de Bogotá

There are various geological classifications for the geology in the Study area, and Table 2.1.4 shows general stratigraphy in Sabana de Bogotá, as classified in the only one microzonation study in Bogotá.

Table 2.1.4 General Lithology in Bogotá

Age	Legend		Name
Upper Tertiary and Quaternary	Qb		Garbage fill
	Qr		Filled depost of excavation
	Qdp		Colluvion or erosion of slope
	Qrs		Residual soil
	Qlla		Innudation plane
	Qtb		Lower lacustrine deposit
	Qta		Upper lacustrine deposit
	Qcc		Complex of cones or fans
Tertiary	Tu		Usme formation
	Ter		La regadera sandstone
	Tpb		Bogota formation
	Tpc		Cacho formation
Cretaiccous	Ktg		Guaduas formation
	Ksg		Guadarupe formation
		Ksglt	Labor-tierna formation
		Ksgp	Plaeners formation
		Ksgd	Hard sandstone
	Ksch		Chipaque formation

Source: Microzonificación Sísmica de Santafé de Bogotá, Estudio geológicos subproyecto No2., INGEOMINAS, 1995

4) Geotechnical Properties of Soils in the Study Area

In the former microzonation study, locations of existing boreholes were identified and 38 new ones were systematically made in Bogotá to make a geological classification.

In this study, identification of existing boreholes is focused mainly in satellite cities and some additional boreholes were made in Bogotá, which includes groundwater and geotechnical boring.

5) Geophysical Properties of Subsurface in the Study Area

Vertical electric sounding, gravity and seismic exploration studies are made in Bogotá plain in the former microzoning study to detect the distribution of basement depth. In addition, seismic refraction survey and down hole seismic survey were also made to study shear wave velocity distribution within surface geology.

In this study, however, no additional study was made due to the time limitation, thus the result of former study shall was used as a reference to extend the geophysical model to satellite cities.

2.1.3 Meteorology and Hydrology

1) Temperature

The portion of Bogotá located in the tropical zone has an average temperature of about 13 °C (low: 7 °C and high: 18°C) the year round, because Bogotá is 2,600 m above sea level in the eastern Andes Mountains. The average temperature is shown in Table 2.1.5.

Table 2.1.5 Temperature of Bogotá City

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
L (°C)	6	7	8	8	8	8	8	7	7	8	8	7	7
H (°C)	18	18	19	18	18	17	17	17	18	18	18	18	18
Ave. (°C)	12	13	13	13	13	13	12	12	13	13	13	12	13

Source: International Station Meteorological Climate Summary, Version 4.0

2) Rainfall

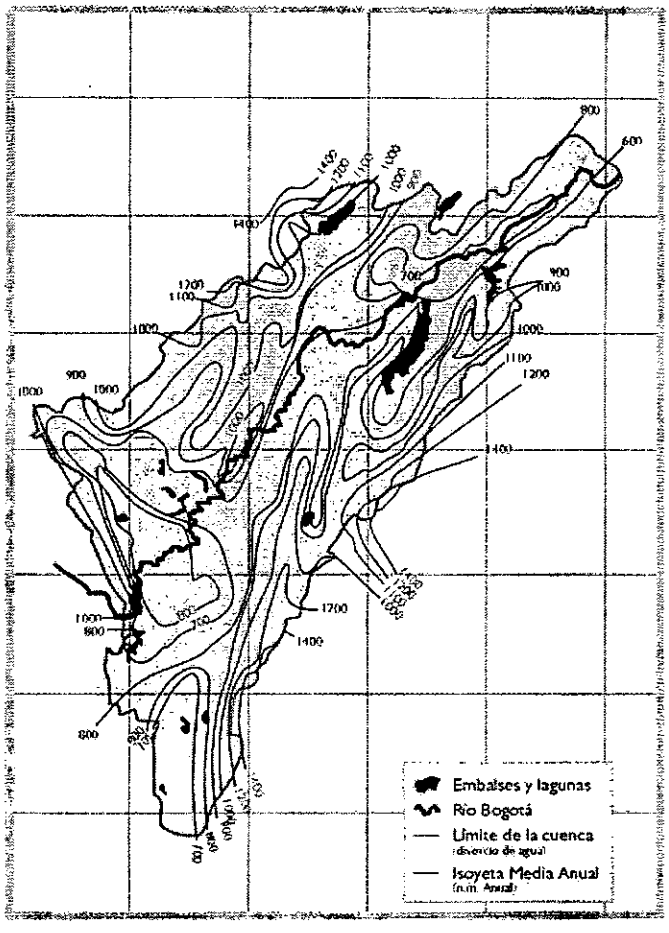
The area has two dry seasons and two rainy seasons per year. The main dry season is from December to March and the other is from July to August, which is shorter and less dry. The rainfall depth varies widely depending on elevation and location from less than 500 mm to over 1,500 mm. The average precipitation of Bogotá City is 960 mm as shown in Table 2.1.6.

Table 2.1.6. Precipitation of Bogotá City

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (mm)	48	50	81	119	101	60	45	48	58	142	114	68	960

Source: International Station Meteorological Climate Summary, Version 4.0

There are two rainy seasons such as April to June and October to November in this area. Annual rainfall depth varies from less than 500 mm to more than 1,500 mm (see Figure 2.1.9).



Source: POT Rio Bogotá Upstream Basin

Figure 2.1.9 Isohyetal Map of Upper Rio Bogotá Basin

There are many rainfall stations in the Study Area. Among them, ten stations of EAAB having longer observation period were selected for analysis of rainfall. The one-day rainfall data for these stations was collected and analyzed. Maximum one-day rainfall among the analyzed stations is at San Luis for one day rainfall of 129.0 mm (Apr. 12, 2000). Results of analysis are shown in 3.1.3 in this report.

3) River Systems

The largest river in the Study Area is the Rio Bogotá and the area is mostly covered by this catchment. The catchment area of the river at the Alicachin Gate, which is at downstream of Soacha municipality, is approximately 4,400 km^2. The river flows with a mild slope of less than 1/5,000 near Bogotá city.

Three major tributaries, namely the Rio Juan Amarillo, the Rio Fucha and the Rio Tunjuelo, flow into the Rio Bogotá from the eastern side (Bogotá city area) of the Study area. All the tributaries have a steep slope near the mountainous area of the city and it changes to a very mild of less than 1/1,000 near the junction of the Rio Bogotá.

Other major tributaries, such as the Rio Furio, the Rio Chicu and the Balsillas flow into the Rio Bogotá from the western side.

4) River Flow

Average flow of the Rio Bogotá is approximately 35 m^3/s in normal situation. Almost all water is taken for hydropower generation at Alicachin Gate.

2.1.4 Study Area

According to the Bogotá and Cundinamarca Governments, the metropolitan Bogotá is composed of city of Bogotá and 17 municipalities. 17 municipalities are composed of Bojacá, Cajicá, Chía, Cota, Facatativá, Funza, Gachancipá, La Calera, Madrid, Mosquera, Sibaté, Soacha, Sopó, Tabio, Tenjo, Tocancipá, and Zipaquirá. Bogotá city is composed of 20 administrative units, called localities, as seen in Table 2.1.7.

The Study area for this project is composed of the 19 localities of Bogotá City and surrounding eight municipalities of Cundinamarca, and it is stated as the Bogotá metropolitan area within this study. The 20th locality of Bogotá city, Sumapaz, is not included in this Study, because the population of the locality is less populas than other localities and categorized at a rural area.

Table 2.1.7 describes the area of each locality with urban and rural areas. The total area of Bogotá is 85,832 ha, of which the urban area comprises 42,115 ha and rural area comprises 43,718 ha. The proportion of urban area and rural area are approximately equal. Each area of municipality is shown in Table 2.1.8. Proportion of the urban area and the rural area is nearly one to seventeen. Total area of the study is calculated as 194,797 ha.

Table 2.1.7 Area of Localities in Bogotá City in 1990

Unit: Ha

	Localities	Urban	Rural	Total
1	Usaquén	4,277	2,257	6,534
2	Chapinero	1,349	2,497	3,846
3	Santa Fe	662	3,814	4,476
4	San Cristobal	1,677	3,176	4,853
5	Usme	2,220	9,684	11,904
6	Tunjuelito	1,062	-	1,062
7	Bosa	1,930	536	2,466
8	Kennedy	3,786	-	3,786
9	Fontibón	3,323	4	3,327
10	Engativá	3,612	-	3,612
11	Suba	9,140	915	10,055
12	Barrios Unidos	1,190	-	1,190
13	Teusaquillo	1,419	-	1,419
14	Mártires	651	-	651
15	Antonio Nariño	494	-	494
16	Puente Aranda	1,723	-	1,723
17	La Candelaria	164	17	181
18	Rafael Uribe	1,345	0	1,345
19	Ciudad Bolívar	2,089	20,819	22,908
	Sub-Total	42,115	43,718	85,832
20	Sumapaz	-	125,000	125,000
	Total	42,115	168,718	210,833

Source: Población, estratificación y aspectos, socioeconómicos de Santa Fe de Bogotá; Estadísticas Santa Fe de Bogotá, Departamento Administrativo de Planeación Distrital
Note: In case the data conflicts between the two sources, data of primary document was used.

Table 2.1.8 Area of Eight Municipalities

Unit: Ha

Municipalities	Urban	Rural	Total
Chía	722	7,292	8,014
Cota	138	5,231	5,368
Facatativá	698	15,085	15,783
Funza	542	6,483	7,024
La Calera	94	31,699	31,793
Madrid	593	11,346	11,939
Mosquera	1,074	9,508	10,582
Soacha	2,163	16,297	18,460
Total	**6,025**	**102,940**	**108,965**

Source: Digital data of the study team

2.2 Social and Economic Conditions

2.2.1 Administrative System

1) General

According to Article 286 of the constitution, the administrative system in Colombia is divided into four territorial entities: prefecture, district, municipality and territory inhabited by natives. Each territorial entity is autonomous as far as management of their interest along the by laws of the constitution. Article 298 stated that the prefectures would act as administration and perform coordination and complementary duties of municipal action and serve as intermediaries between the national government and municipalities.

The new constitution conceives the municipality as the "basic unit" of the state political and administrative division. The constitution grants the municipalities a priority position in the distribution of resources and competence (Articles 356 to 361).

2) Bogotá City

In 1945, Bogotá City became a special district in the municipal system. Bogotá is the capital city of the Republic of Colombia as well as the Cundinamarca prefecture. According to Article 322 of the constitution, the capital city of the Republic and of Cundinamarca prefecture is proclaimed as a capital district.

The central administrative sector of the city government of Bogotá is made up of secretariats and administrative departments. Secretariats consists of finance, government, health, transit and transportation (STT) and four others unit. Administrative departments are composed of planning (DAPD), environment (DAMA), communal action, and four other sections, as well as one administrative unit.

Bogotá has the following types of public corporations:

- Public Establishments: FOPAE, IDU, Fund of Popular Housing, Fund of Saving and Housing (FAVIDI), Institute of Recreation and Sports (IDRD), etc.
- Public Domestic Service Enterprises: EAAB, ETB, EEB.
- Industrial and Commercial Companies: Metrovivienda Company, Urban Renovation Company, etc.
- Public Societies: Transmilenio Company, etc.
- Mixed Economy Societies.
- Social Enterprises of the State: public hospitals, and other corporations.

Within Bogotá City there is a further division into 20 localities, and each locality forms a unit of administrative board, elected from the people, and the Local Mayor is selected by the Mayor of

Bogotá, with recommendation of the administrative board of the locality. A local mayor is responsible for the harmonious and integrated development of the locality.

3) Cundinamarca

Cundinamarca is divided into 15 provinces, which are administrative associations of municipalities. Each association has its head municipality that coordinates the member municipalities. The eight municipalities of the Study Area belong to four different provinces; Soacha, Sabana Occidental, Sabana Centro, and Guavio.

This Government is made up of the secretariat of government and 10 other secretariats, the administrative department of planning and other two departments, five special administrative units, and other public establishments and companies.

2.2.2 Population and Employment

1) Population Growth

(1) Population data

There have been several census-takings in Colombia in recent years: 1951, 1964, 1978, 1985 and 1993; however, all the estimation used for the present population is based on the Census 1993. The National Administrative Department of Statistics (DANE) was responsible for the Census 1993, and published the adjusted population after the Census to estimate the actual population. This was prepared by three forms, targeting the non-indigenous population, indigenous population, and special accommodating population. Through this operation, the census concluded the total number as 33,109,840. However, it was estimated that not all the population was covered by this census survey, thus, a supplemental survey was executed to achieve the direct estimate of people and houses. This survey was designed and selected according to the probability samplings throughout the nation. The houses in the targeted area were rigorously examined, and the result was compared with the numbers achieved by the former census. Comparing the two figures of the census and survey, the coefficient for the uncovered rate was obvious in the targeted area, making available the estimation of actual population in the prefecture, region, and nation. With the adjustment, DANE had publicized the population of 1993 in Colombia as 37,145,322. DANE concluded that the population of Bogotá City in 1993 was 5,355,979. In 1951, the population percentage to the national population was 5.9%, whereas in 1985, it increased to 14.8%, and 14.4% in 1993. This indicates that the population centralization to the large cities has progressed after then.

(2) Population growth in Colombia

A. Trend of population growth

Colombia's population has constant increase of approximately 2% to 3% annual growth rate since 1951, although, the rate of population growth has been slightly decreasing after 1985 as seen in Table 2.2.1. The table also indicates that although Colombia's national population increase has been constant, population growth in large cities are higher than that of nation. The population growth in the period of 1951 to 1985 was most rapid among all the cities, and among them, Bogotá City shows the largest population increase.

Table 2.2.1 Population Change in Colombia and Large Cities

	Population				Population Growth		
	1951	1985	1993 Adjusted Pop of 93	2000 Estimate	1951-1985	1985-1993	1993-2000
Colombia	11,454,760	30,062,207	37,145,322	42,209,299	2.88%	2.68%	1.84%
Santafe de Bogota DC	676,099	4,447,601	5,355,979	6,437,842	5.70%	2.35%	2.66%
Barranquilla	302,046	1,156,320	1,090,618	1,276,540	4.03%	-0.73%	2.27%
Cali	304,012	1,674,054	1,847,176	2,087,758	5.15%	1.24%	1.76%
Medellin	413,933	2,050,001	1,834,881	2,043,585	4.82%	-1.38%	1.55%

Source: Projection of Population by the area for Municipalities, Colombia 1995-2000, DANE

The population distribution for Colombia recently is indicated in Table 2.2.2. Population proportion of the four major cities of Bogotá City, Barranquilla, Cali, and Medellin as per the national population is approximately 30%, and Bogotá City comprises one half of the major city population.

Table 2.2.2 National Population Distribution of Colombia

	1993 Adjusted Pop of 93	2000 Estimate	1993-2000	Prefectural Population to Total Population(%) 2000
National				
Colombia	37,145,322	42,209,299	1.84%	
Capitals & Cities				28%
Santafe de Bogota DC	5,355,979	6,437,842	2.66%	15%
Barranquilla	1,090,618	1,276,540	2.27%	3%
Cali	1,847,176	2,087,758	1.76%	5%
Medellin	1,834,881	2,043,585	1.55%	5%
Prefectures				85%
Amazonas	55,689	70,489	3.42%	0%
Antioquia (Medellin)	4,856,519	5,377,854	1.47%	13%
Arauca	183,536	240,190	3.92%	1%
Atlantico (Barranquilla)	1,817,014	2,127,567	2.28%	5%
Bolivar	1,683,527	1,996,906	2.47%	5%
Boyaca	1,298,833	1,365,110	0.71%	3%
Caldas	1,017,038	1,017,627	0.01%	2%
Caqueta	363,256	418,998	2.06%	1%
Cesanare	208,670	285,416	4.58%	1%
Cauca	1,113,475	1,255,333	1.73%	3%
Cesar	864,053	961,535	1.54%	2%
Choco	401,086	407,255	0.22%	1%
Cordoba	1,220,114	1,322,852	1.16%	3%
Cundinamarca (Sife Bogota)	1,851,566	2,142,260	2.11%	5%
Guainia	28,122	37,162	4.06%	0%
Guaviare	96,397	117,189	2.83%	0%
Huila	833,121	924,968	1.51%	2%
La Guajira	428,593	483,107	1.73%	1%
Magdalena	1,115,392	1,284,134	2.03%	3%
Meta	610,611	700,506	1.98%	2%
Narino	1,425,403	1,632,093	1.95%	4%
Norte de Santander	1,147,693	1,345,697	2.30%	3%
Putumayo	260,979	332,434	3.52%	1%
Quindio	488,942	562,154	2.01%	1%
Risaralda	833,438	944,298	1.80%	2%
San Andres y Providencia	60,365	73,465	2.85%	0%
Santander	1,788,609	1,964,361	1.35%	5%
Sucre	693,456	794,631	1.96%	2%
Tolima	1,269,909	1,296,942	0.30%	3%
Valle del Cauca (Cali)	3,688,277	4,175,515	1.79%	10%
Vaupes	24,362	29,942	2.99%	0%
Vichada	61,298	83,467	4.51%	0%

Source: Projection of Population by the area for Municipalities, Colombia 1995-2000, DANE

B. Population growth in the urban areas

Urban population growth in Colombia was in an aggressive manner for the past 50 years. The population in urban area compared to the total population was only 30% in 1938; in 1985, it had grown to 70%.

Table 2.2.3 gives the percentage change of population in major metropolitan areas in Colombia. Four major cities have more than 40% of the urban population. Among these four cities, Metropolitan Bogotá has the highest rate of urbanized population, since around 1973, at 20% or more.

Table 2.2.3 Percentage Change of Population in Major Metropolitan Areas in Colombia

	1951	1964	1973	1985	1993
Bogota Metropolitan *1	676,099	1,702,378	2,926,966	4,447,601	5,355,979
Ratio to total population	5.9%	9.8%	12.8%	14.8%	14.4%
Ratio to total urban population	15.2%	18.4%	21.4%	22.7%	20.3%
Medellin Metropolitan *2	413,933	983,283	1,524,051	2,050,001	2,355,676
Ratio to total population	3.6%	5.7%	6.7%	6.8%	6.3%
Ratio to total urban population	9.3%	10.6%	11.2%	10.4%	8.9%
Cali Metropolitan *3	304,012	751,097	1,169,502	1,674,054	1,943,301
Ratio to total population	2.7%	4.3%	5.1%	5.6%	5.2%
Ratio to total urban population	6.8%	8.1%	8.6%	8.5%	7.4%
Barranquilla Metropolitar *4	302,046	543,439	789,430	1,156,320	1,301,419
Ratio to total population	2.6%	3.1%	3.4%	3.8%	3.5%
Ratio to total urban population	6.8%	5.9%	5.8%	5.9%	4.9%
Other 5 Metropolitans *5	443,169	949,826	1,318,453	1,914,979	2,428,814
Ratio to total population	3.9%	5.5%	5.8%	6.4%	6.5%
Ratio to total urban population	9.9%	10.3%	9.7%	9.8%	9.2%
Total of four urbanized area	1,696,090	3,980,197	6,409,949	9,327,976	10,956,375
Ratio to total population	14.8%	23.0%	28.0%	31.0%	29.5%
Ratio to total urban population	38.0%	43.1%	46.9%	47.5%	41.5%
Total of nine metropolitan	2,139,259	4,930,023	7,728,402	11,242,955	13,385,189
Ratio to total population	18.7%	28.5%	33.8%	37.4%	36.0%
Ratio to total urban population	48.0%	53.4%	56.6%	57.3%	50.8%
Total Population	11,454,760	17,319,110	22,886,290	30,062,207	37,145,322
Total urban population	4,459,345	9,239,211	13,656,107	19,628,417	26,373,179
Ratio of urbanization	38.9%	53.3%	59.7%	65.3%	71.0%

*1 Santa Fe de Bogotá, Cajica, Chia, Funza, La Calera, Madrid, Sibate, and Soacha, *2: Medellin, Barbosa, Bello, Caldas, Copacabana, Envigado, Girardota, Itagui, LaCeja, La Estrella, Marinilla, Rionegro and Sabaneta, *3: Cali, Candelaria, Jamundi, Palmira, and Yumbo, *4: Barranquilla, Malambo, Puerto Colombia, Soledad, *5:Manizales, Cucuta, Armenia, Pereira, Bucaramanga.
Source: Urbanization and Community Organization of Latin America; Colombia Projecciones Municipales de Población por Area, 1995-2005, DANE

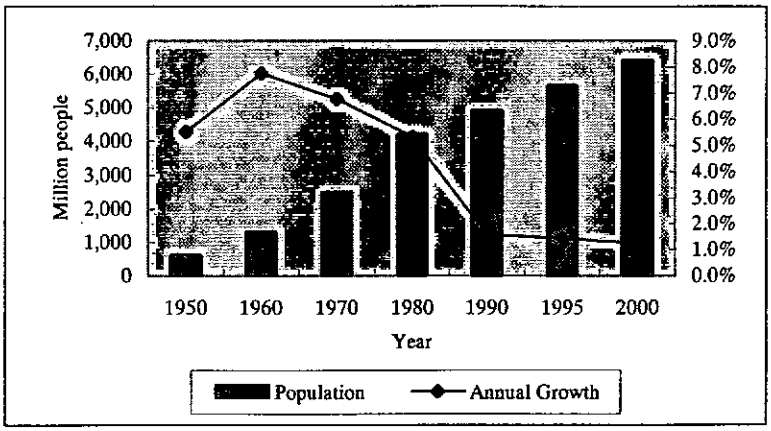
(3) Population growth in the study area

A. Population data

Several corrections have been applied to the adjusted population of Colombia within DANE, however, the District Planning of Administrative Department (DAPD) had concluded to use the total population of Bogotá City in 1993 was 5,440,401. With this figure, DAPD had projected the number of total population for year 2000 as 6,378,928.

B. Overall population growth

Figure 2.2.1 shows the changes of Bogotá City population and its annual growth for the past 50 years. Bogotá's population growth had shown the largest increase between 1950 and 1960, and after 1960, the annual growth had decreased. However, the annual growth was still high until the 1980s, but in the1990s, rate of increase had dropped to approximately 1.5%.



Source: DANE

Figure 2.2.1 Changes of Bogotá City Population and Its Annual Growth

The rapid population increase in the 1950s to the 60's can be attributed to two factors. One is the natural factor arising from the decreased percentile of infant mortality. The rate of mortality for infants had been decreased almost 80% during this era. The other is the social factor, with the effect of civil war called *La Violencia* between 1946 and 1964, which caused the domestic migration to Bogotá[2-2-1]

C. Population distribution of the study area

The population distribution and its growth rate within Bogotá City in the 1990 to 2000 are presented in Table 2.2.4.

[2-2-1] Referred to "Urbanization and Community Organization of Latin America, Noriko Hataya", page 142

Table 2.2.4 Population Change in Bogotá City

	Year / Locality	Population			Growth Rate	
		1993*	1997*	2000**	1993-1997	1997-2000
1	Usaquén	348,852	387,271	421,320	2.65%	2.85%
2	Chapinero	122,991	122,991	122,991	0.00%	0.00%
3	Santa Fe	107,044	107,044	107,044	0.00%	0.00%
4	San Cristobal	439,559	445,535	455,028	0.34%	0.71%
5	Usme	200,892	222,915	244,270	2.63%	3.10%
6	Tunjuelito	204,367	204,367	204,367	0.00%	0.00%
7	Bosa	215,816	311,698	410,099	9.63%	9.58%
8	Kennedy	758,870	840,036	912,781	2.57%	2.81%
9	Fontibón	201,610	241,372	278,746	4.60%	4.92%
10	Engativá	671,360	712,040	749,068	1.48%	1.70%
11	Suba	564,658	634,669	706,528	2.97%	3.64%
12	Barrios Unidos	176,552	176,552	176,552	0.00%	0.00%
13	Teusaquillo	126,125	126,125	126,125	0.00%	0.00%
14	Los Mártires	95,541	95,541	95,541	0.00%	0.00%
15	Antonio Nariño	98,355	98,355	98,355	0.00%	0.00%
16	Puente Aranda	282,491	282,491	282,491	0.00%	0.00%
17	Candelaria	27,450	27,450	27,450	0.00%	0.00%
18	Rafael Uribe	379,259	382,801	384,623	0.23%	0.16%
19	Ciudad Bolívar	418,609	498,177	575,549	4.45%	4.93%
	Total	**5,440,401**	**5,917,430**	**6,378,928**	**2.12%**	**2.53%**

Source: *DAPD Poblacion, estratificacion y aspectos socioeconomicos de Bogotá, **Informacion para el Plan Local 2001, Informacion social basica

The eight surrounding municipalities, which are Chia, Cota, Facatativa, Funza, La Calera, Madrid, Mosquera, and Soacha, comprising the Study Area, have their population distributions and growth rates shown in Table 2.2.5.

Table 2.2.5 Population Change in the Eight Municipalities

	Year	Population						Growth Rate		
		1993*			2000**			1993-2000		
	Cities	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
1	Chia	41,632	4,064	45,696	56,522	5,261	61,783	4.46%	3.76%	4.40%
2	Cota	5,071	6,400	11,471	6,665	8,119	14,784	3.98%	3.46%	3.69%
3	Facatativa	63,237	6,315	69,552	82,409	7,857	90,266	3.86%	3.17%	3.79%
4	Funza	34,612	3,162	37,774	47,670	4,138	51,808	4.68%	3.92%	4.62%
5	La Calera	11,765	6,087	17,852	15,637	8,551	24,188	4.15%	4.98%	4.43%
6	Madrid	33,347	5,865	39,212	44,485	7,625	52,110	4.20%	3.82%	4.15%
7	Mosquera	17,774	2,666	20,440	24,227	3,526	27,753	4.52%	4.07%	4.47%
8	Soacha	222,565	7,770	230,335	278,665	5,224	283,889	3.26%	-5.51%	3.03%
	Total	**430,003**	**42,329**	**472,332**	**556,280**	**50,301**	**606,581**	**3.75%**	**2.50%**	**3.64%**

Source: * Censo 1993 Republica de Colombia, Cundinamarca, DANE; **Colombia Proyecciones Municipales de Poblacion por Area, 1995-2005, DANE

From these tables, it can be concluded that Bogotá City has population increase of 2.12% during 1993-1997 and 2.53% during 1997-2000. Bogotá City has increased approximately 2.5% annually for the past 10 years, while the surrounding municipalities have, on the average, approximately 3.6% annual increase as shown in Tables 2.2.5. In Bogotá City, the locality of

Bosa has an extreme population increase of approximately 10% annually, followed by Fontibón and Ciudad Bolivar. It shows that the localities in the southwestern to the western area of the city have a high rate of population increase. The eight surrounding municipalities have higher population growth rates comparing to the average of Bogotá City, however, most of the municipalities' population growth in the urban area are between 3 to 5 percent. Figure 2.2.2 shows the population growth from 1993 to 2000. It is easily noticeable in this figure that the population increased in the surrounding areas of the city center. Areas classified in the higher estrato are found and no population increase is registered. Also, localities adjoining the city center have only a slight increase in population. On the other hand, as localities and municipalities expand toward the outer side of the city, population growth becomes increasingly higher in the urban area.

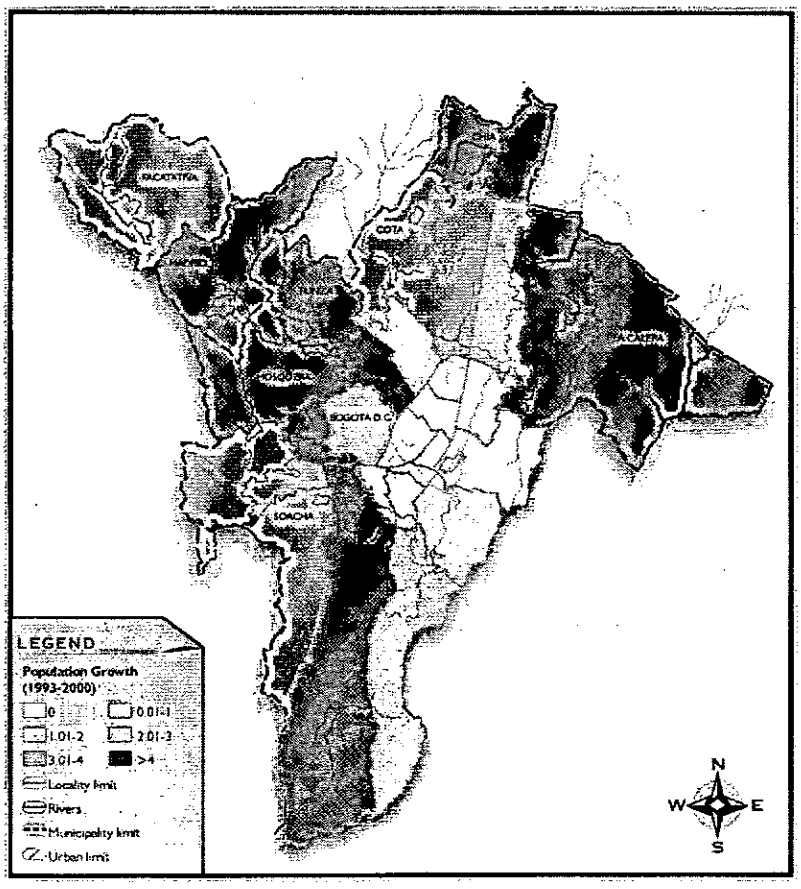


Figure 2.2.2 Population Growth of the Study Area, 1993 - 2000

Table 2.2.6 represents the population density of each locality in Bogotá City for 2000, with respect to the urban area. Localities with high number of population are Kennedy, Engativá, Suba, Ciudad Bolivar, and San Cristobal. High population density areas are Rafael Uribe, San Cristobal, Ciudad Bolívar, and

Kennedy, which are located in the southeastern part of the city, while the low density areas are Suba, Fontibón, and Teusaquillo, located in the northeastern part of the city.

Table 2.2.6 Population Density by Locality of Bogotá

No	Locality	2000 Population	Urban Area (ha)	Density (Population/ ha)
1	Usaquén	421,320	4,277.07	98.51
2	Chapinero	122,991	1,349.39	91.15
3	Santa Fe	107,044	662.05	161.69
4	San Cristobal	455,028	1,677.40	271.27
5	Usme	244,270	2,220.35	110.01
6	Tunjuelito	204,367	1,062.33	192.38
7	Bosa	410,099	1,930.11	212.47
8	Kennedy	912,781	3,786.16	241.08
9	Fontibón	278,746	3,323.03	83.88
10	Engativá	749,068	3,612.27	207.37
11	Suba	706,528	9,139.60	77.30
12	Barrios Unidos	176,552	1,190.35	148.32
13	Teusaquillo	126,125	1,419.32	88.86
14	Los Mártires	95,541	650.67	146.83
15	Antonio Nariño	98,355	493.74	199.20
16	Puente Aranda	282,491	1,723.13	163.94
17	Candelaria	27,450	164.14	167.24
18	Rafael Uribe	384,623	1,344.71	286.03
19	Ciudad Bolívar	575,549	2,088.78	275.54
	Total	**6,378,928**	**42,114.60**	**151.47**

Source: DAPD Poblacion, estratificacion y aspectos socioeconomicos de Bogotá

Table 2.2.7 shows the density of the population for the eight municipalities. According to this table, the high dense urbanized areas are La Calera, Soacha, and Facatativa. These municipalities in urban areas have the population density of more than 100 people per hectors.

Table 2.2.7 Density of Population for the Eight Surrounding Municipalities

	Municipality	Urban Population 2000	Urban Area (ha)	Density
1	Chia	56,522	722	78.29
2	Cota	6,665	138	48.30
3	Facatativa	82,409	698	118.06
4	Funza	47,670	542	87.95
5	La Calera	15,637	94	166.35
6	Madrid	44,485	593	75.02
7	Mosquera	24,227	1,074	22.56
8	Soacha	278,665	2,163	128.83

Source: Population by DANE Projection for Municipalities 1996-2005

Figure 2.2.3 shows the distribution of population density. Comparing this figure with population growth, it can be noted that Ciudad Bolivar and Kennedy already have high rates of population, and they are still growing.

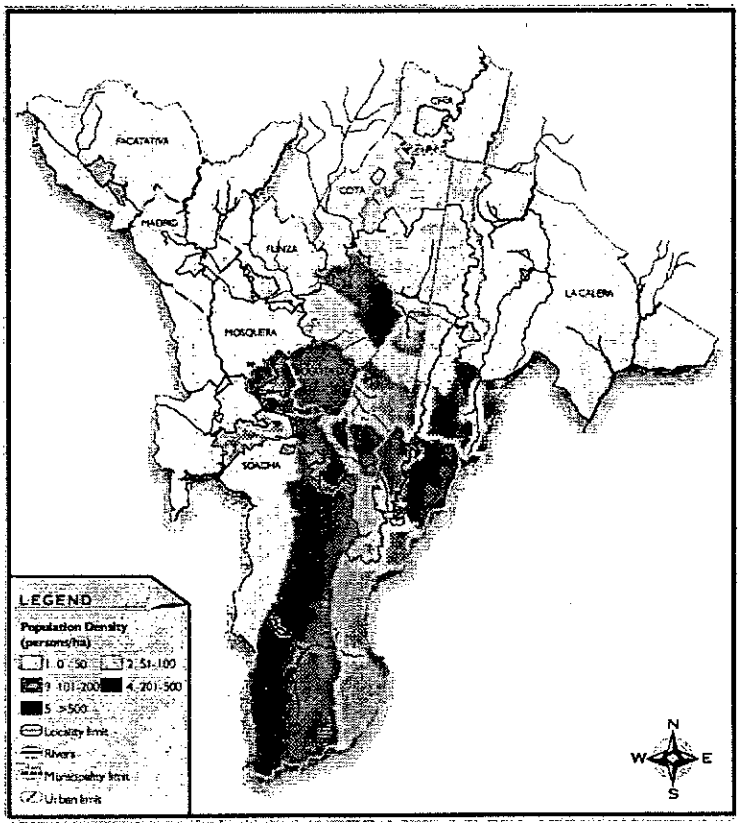


Figure 2.2.3 Population Density by Locality and Municipalities

2) Employment

(1) Employment data

According to DANE, the employment data are defined as follows.

- Total Population: Total population estimated through projections based on the population census of 1993.
- Working Population: All population including 12 years old or older for the urban areas, and 10 years old or older for the rural areas.
- Labor Force: Population contributing or able to contribute to the goods production or rendering services, which can be classified into employed and unemployed. For the term of employed, it is defined as the population contributing to the production or to the services, and as to the unemployed, it is defined as population looking work, or have not looked for the work in the last 4 weeks but have been looking for work for the last 12 months.
- Economically Inactive: Population that is within the working population, but does not participate for the goods production or rendering services. This category includes population whom do not need work, or can not or is not interested in working.

Data prepared by DANE is categorized by 5 geographical regions, which are Atlántica, Oriental, Bogotá D.C., Central, and Pacifica. Each region is classified with several departments as follows.

- Atlantica: Atlantico, Bolivar, Cesar, Cordoba, La Guajira, Magdalena, Sucre (7).
- Oriental: Boyaca, Cundinamarca, Meta, Norte de Santander, Santander (5).
- Bogotá D.C.: Bogotá D.C. (1).
- Central: Antioquia, Huila, Quindio, Risaralda, Tolima (5).
- Pacifica: Cauca, Choco, Narino, Valle (4).

(2) Employment condition

Transition of the labor force within the last five years is shown in Table 2.2.8. From the table, it can be said that the changes of labor force population is not constant, but the population growth for the last five year in each region is somewhat close, approximately 3.5%. Taking in the consideration of the urban and rural population growth, both shows the plus growth for the term of 5 years, but the growth in urban area is higher than that in rural. Five regions within Colombia do not show much of the difference regarding the labor force.

Table 2.2.8 Transition of the Labor Force

Unit: thousands

Region	Labor Force					Change of Labor Force (%)				
	1996	1997	1998	1999	2000	96-97	97-98	98-99	99-00	96-00
Atlantica	**3,162**	**3,299**	**3,430**	**3,587**	**3,842**	**4.3%**	**4.0%**	**4.6%**	**7.1%**	**4.0%**
Urban	2,200	2,313	2,430	2,538	2,758	5.1%	5.1%	4.4%	8.7%	4.6%
Rural	962	986	1,000	1,049	1,084	2.5%	1.4%	4.9%	3.3%	2.4%
Oriental	**3,068**	**3,084**	**3,310**	**3,303**	**3,636**	**0.5%**	**7.3%**	**-0.2%**	**10.1%**	**3.5%**
Urban	1,862	1,874	1,997	2,021	2,270	0.6%	6.6%	1.2%	12.3%	4.0%
Rural	1,206	1,210	1,313	1,282	1,366	0.3%	8.5%	-2.4%	6.6%	2.5%
Bogotá D.C.	**2,788**	**2,903**	**2,926**	**3,131**	**3,330**	**4.1%**	**0.8%**	**7.0%**	**6.4%**	**3.6%**
Central	**4,218**	**4,270**	**4,318**	**4,570**	**4,817**	**1.2%**	**1.1%**	**5.8%**	**5.4%**	**2.7%**
Urban	2,886	2,971	2,926	3,298	3,533	2.9%	-1.5%	12.7%	7.1%	4.1%
Rural	1,332	1,299	1,392	1,272	1,284	-2.5%	7.2%	-8.6%	0.9%	-0.7%
Pacifica	**3,056**	**3,275**	**3,480**	**3,631**	**3,774**	**7.2%**	**6.3%**	**4.3%**	**3.9%**	**4.3%**
Urban	1,988	2,169	2,301	2,442	2,550	9.1%	6.1%	6.1%	4.4%	5.1%
Rural	1,068	1,106	1,179	1,189	1,224	3.6%	6.6%	0.8%	2.9%	2.8%
National	**16,292**	**16,831**	**17,464**	**18,222**	**19,399**	**3.3%**	**3.8%**	**4.3%**	**6.5%**	**3.6%**

Source: DANE webpage

Table 2.2.9 shows the distribution of the labor force within the large cities in Colombia. From this figure, labor force in urban area for each region is approximately 15% and 7% in rural area, about.

Table 2.2.9 Distribution of Labor Force in year 2000

Unit: thousands

Region	Total Population	L.F.Pop of Year 00	Regional L.F./Total L.F.
Atlantica	**9,008**	**3,842**	**20%**
Urban	6,327	2,758	14%
Rural	2,681	1,084	6%
Oriental	**7,558**	**3,636**	**19%**
Urban	4,637	2,270	12%
Rural	2,921	1,366	7%
Bogotá D.C.	**6,450**	**3,330**	**17%**
Central	**10,242**	**4,817**	**25%**
Urban	7,372	3,533	18%
Rural	2,870	1,284	7%
Pacifica	**7,496**	**3,774**	**19%**
Urban	4,943	2,550	13%
Rural	2,553	1,224	6%
National	**40,754**	**19,399**	**100%**

Note: L.F. stands for Labor Force
Source: DANE webpage

Employment rate is described as number of employed personnel divided by working population. Table 2.2.10 represents the employment rate and the proportion of the employed population to the sectors of primary, secondary, and tertiary. Among five areas within Colombia, employment rate, which is a little bit more than 50%, is almost equal to each other weather if it is in the urban or rural area. Regarding the proportion of employed population to each sector, urban areas among the country has the most employment rate in the tertiary sector, with high percentage of more than 70%. Approximately 25% composes the secondary sector, and approximately 7% composes the primary sector. This proportion is applied to all the urban areas among Colombia, including Bogotá City. For the rural area, employment rate in the primary sector predominates by approximately 65 to 70%, tertiary sector next by approximately 25%, and then the secondary sector by approximately 8%.

Table 2.2.10 Employment Rate and its Proportion for Year 2000

Unit: thousands

Region	Working Population	Employed Population				Proportion			Employed Rate
		Total	Primary	Secondary	Tertiary	Primary*	Secondary*	Tertiary*	
Atlantica	**6,842**	**3,288**	**830**	**431**	**2,027**	**25%**	**13%**	**62%**	**48%**
Urban	4,796	2,281	176	375	1,730	8%	16%	76%	48%
Rural	2,046	1,007	654	56	297	65%	6%	29%	49%
Oriental	**5,798**	**3,079**	**1,006**	**525**	**1,548**	**33%**	**17%**	**50%**	**53%**
Urban	3,526	1,843	135	428	1,280	7%	23%	69%	52%
Rural	2,272	1,236	871	97	268	70%	8%	22%	54%
Bogotá DC	**5,060**	**2,650**	**34**	**617**	**1,999**	**1%**	**23%**	**75%**	**52%**
Central	**7,965**	**4,189**	**1,155**	**792**	**2,242**	**28%**	**19%**	**54%**	**53%**
Urban	5,735	2,860	198	714	1,948	7%	25%	68%	50%
Rural	2,230	1,329	957	78	294	72%	6%	22%	60%
Pacifica	**5,722**	**3,103**	**779**	**595**	**1,729**	**25%**	**19%**	**56%**	**54%**
Urban	3,783	2,019	101	465	1,453	5%	23%	72%	53%
Rural	1,939	1,084	678	130	276	63%	12%	25%	56%
National	**31,387**	**16,308**	**3,804**	**2,959**	**9,545**	**23%**	**18%**	**59%**	**52%**

*Primary Sector: 1) Agriculture, farming and fisheries, 2) Mining, Secondary Sector: 1) Manufacturing industries, 2) Electricity, gas and water, 3) Construction, Tertiary sector: 1) Commercial, restaurants, and hotels, 2) Transportation and communication, 3) Financial services, 4) Social services, 5) Indirect Services
Source: DANE webpage

According to DANE, unemployment rate is defined as the number of unoccupied population divided by labor force. Table 2.2.11 describes the changes of unemployment rate between years 1996 to 2000. It shows that the unemployment rate has started to increase in 1998 in the urban area, and in 1999 for the rural area.

Table 2.2.11 Changes of Unemployment Rate

Unit: thousand

Region	Labor Force					Unemployed Population					Unemployment Rate				
	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000	1996	1997	1998	1999	2000
Atlantica	**3,162**	**3,299**	**3,430**	**3,587**	**3,842**	**272**	**291**	**332**	**458**	**552**	**8.6%**	**8.8%**	**9.7%**	**12.8%**	**14.4%**
Urban	2,200	2,313	2,430	2,538	2,758	226	238	275	383	475	10.3%	10.3%	11.3%	15.1%	17.2%
Rural	962	986	1,000	1,049	1,084	46	53	57	75	77	4.8%	5.4%	5.7%	7.1%	7.1%
Oriental	**3,068**	**3,084**	**3,310**	**3,303**	**3,636**	**263**	**219**	**335**	**437**	**553**	**8.6%**	**7.1%**	**10.1%**	**13.2%**	**15.2%**
Urban	1,862	1,874	1,997	2,021	2,270	200	165	281	340	422	10.7%	8.8%	14.1%	16.8%	18.6%
Rural	1,206	1,210	1,313	1,282	1,366	63	54	54	97	131	5.2%	4.5%	4.1%	7.6%	9.6%
Bogota D.C	**2,788**	**2,903**	**2,926**	**3,131**	**3,330**	**288**	**287**	**389**	**604**	**676**	**10.3%**	**9.9%**	**13.3%**	**19.3%**	**20.3%**
Central	**4,218**	**4,270**	**4,318**	**4,570**	**4,817**	**404**	**410**	**507**	**790**	**780**	**9.6%**	**9.6%**	**11.7%**	**17.3%**	**16.2%**
Urban	2,886	2,971	2,926	3,298	3,533	328	343	453	655	672	11.4%	11.5%	15.5%	19.9%	19.0%
Rural	1,332	1,299	1,392	1,272	1,284	76	67	54	135	108	5.7%	5.2%	3.9%	10.6%	8.4%
Pacifica	**3,056**	**3,275**	**3,480**	**3,631**	**3,774**	**340**	**450**	**592**	**678**	**670**	**11.1%**	**13.7%**	**17.0%**	**18.7%**	**17.8%**
Urban	1,988	2,169	2,301	2,442	2,550	268	350	466	528	532	13.5%	16.1%	20.3%	21.6%	20.9%
Rural	1,068	1,106	1,179	1,189	1,224	72	100	126	150	138	6.7%	9.0%	10.7%	12.6%	11.3%
National	**16,292**	**16,831**	**17,464**	**18,222**	**19,399**	**1567**	**1657**	**2155**	**2967**	**3231**	**9.6%**	**9.8%**	**12.3%**	**16.3%**	**16.7%**

Source: DANE webpage

In Bogotá, the unemployment rate has started to increase from 1998. For year 2000, Bogotá's unemployment rate is the highest than any other region in the nation. This trend might put the brakes on inflows of population, but can not be prospected because other social factors can affect the population increase.

2.2.3 Economic Conditions

1) Economic Growth

(1) Colombia

A. Position of Colombia in the world and Latin America

According to the data of the World Bank for year 2000, Colombia's GNP per capita is estimated as US$ 2,080. Out of 206 countries registered to World Bank, Colombia ranks 101st. With this figure, Colombia is classified to lower middle income country within their classification. Within the Latin America & Caribbean region, Colombia ranks 12th out of 20 countries.

B. National trends

Colombia has been in an economic progress since after the negative growth in the first quarter in the 1980s. Gross Domestic Product (GDP) per capita had showed the growth of more than 4% during the mid 1990's, though the situation turned adverse in 1998. One of the factors is the Armenian earthquake in 1999, which hit directly to the coffee industry worsening the economic situation of Colombia.

Table 2.2.12 shows the trend of GDP and GDP per capita of Colombia for the term of 30 years.

Table 2.2.12 Changes of GDP in Colombia

(Constant Price in 1994)

	Total GDP		GDP per Capita	
Year	Mil COP in 1994	Growth Rate	Mil COP in 1994	Growth Rate
1970	23,864,764	-	1,115,401	-
1973	29,057,029	6.78%	1,231,057	3.34%
1975	31,440,432	4.02%	1,254,283	0.94%
1978	37,201,189	5.77%	1,367,332	2.92%
1980	40,804,622	4.73%	1,427,609	2.18%
1983	42,792,602	1.60%	1,400,749	-0.63%
1985	45,600,609	3.23%	1,433,534	1.16%
1988	52,913,800	5.08%	1,571,152	3.10%
1990	57,063,451	3.85%	1,634,273	1.99%
1993	63,821,419	3.80%	1,734,761	2.01%
1995	71,046,217	5.51%	1,843,363	3.08%
1998	75,412,448	2.01%	1,847,130	0.07%
1999	72,357,004	1.84%	1,739,810	-5.62%

Source: Colombia Statistics 1993-1999 DANE and DANE website

C. Trends in Bogotá City

Table 2.2.13 shows the transition of the total GDP in Bogotá City. It shows that Bogotá City had experienced an average annual growth of GDP approximately 7% during the 1970s to 1980s, slowing down in the mid 1980s and then picking up again to register a growth of more than 5%. In 1995, Bogotá City's regional GDP reached approximately 16,665,172 million pesos. In the

pesos. In the same year, the national GDP was 71,046,217 million pesos, meaning that GDP of the city comprised approximately 25% of the national's.

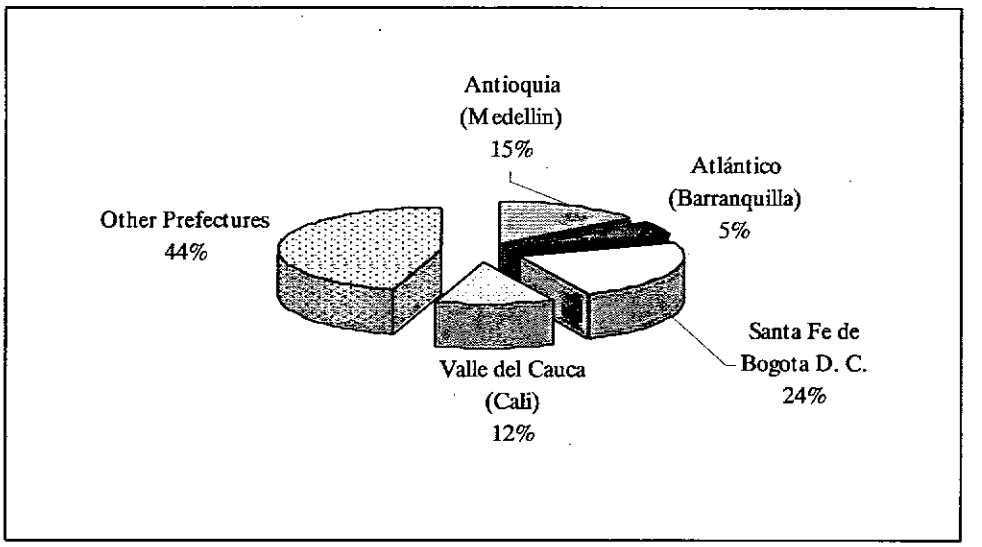
Table 2.2.13 GDP Growth in Bogotá City

Unit: Million Pesos as of 1994 fixed rate

Year	Total GDP	Avg Annual Growth Rate
1970	4,492,097	-
1975	6,349,231	7.17%
1980	8,445,638	5.87%
1985	9,496,560	2.37%
1990	11,971,082	4.74%
1995	16,665,172	6.84%

Source: Historic Statistics Bogotá City 1950-1999, Department of Planning

Figure 2.2.4 describes the proportion of the national GDP in 1998. With this figure, prefecture with major cities which are Antioquia (Medellín), Atlántico (Barranquilla), Santafé de Bogotá, and Valle del Cauca (Cali) composes 56% of the total Economy. Out of these prefectures, Bogotá City composes 24% of the total economy.



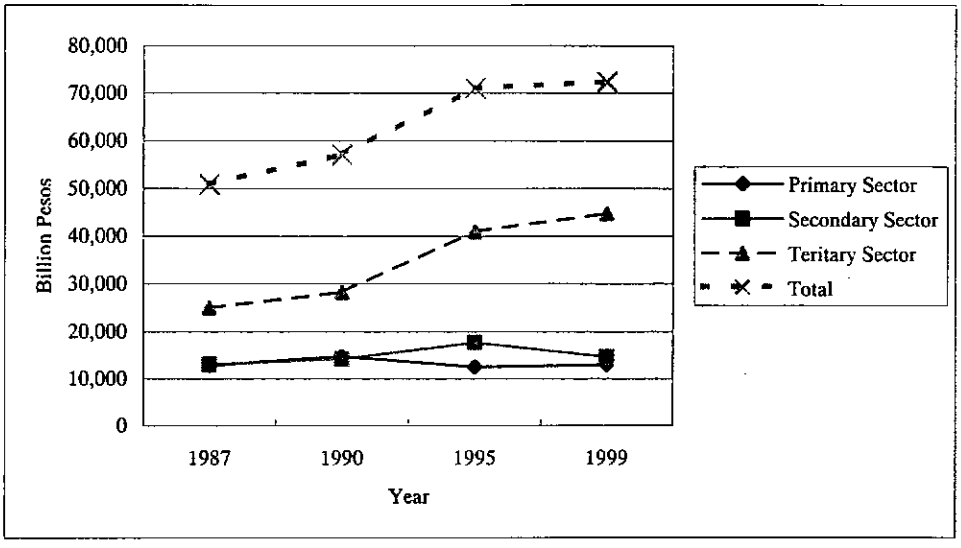
Source: DANE web page

Figure 2.2.4 Distribution of National GDP in 1998

(2) Economical development by the sectors

A. National trends

Figure 2.2.5 shows the transition of the amounts of GDP by the sectors. From the figure, it is obvious that the tertiary sector dominates GDP, and secondary sector comes next, competing with the primary sector. As total GDP has increased, the shared tertiary sector has increased to reach 62% of GDP in 1998. Also, the total GDP of primary sector has been dropped off around 18% of the total GDP in 1995.



Source: Colombia Statistics 1993-1999 DANE Website

Figure 2.2.5 Changes of National GDP

As Table 2.2.14 describes, agriculture, farming and fisheries sub sector has been dropped for the primary sector. In the secondary sector, the sub sector of manufacturing industries has dropped, while the other two sub sectors had grown. In the tertiary sector, major service sub-sectors has not changed much, while the social service and indirect service has been increasing.

Table 2.2.14 National Trend of GDP per Sector

Unit: Million COP as of Constant Price in 1994

Year	1987		1990		1995		1999	
Primary Sector	**12,816,426**	**25%**	**14,698,755**	**26%**	**12,447,587**	**18%**	**12,952,762**	**18%**
Agriculture, farming and fisheries	10,720,194	21%	12,116,826	21%	9,750,754	14%	9,102,251	13%
Minings	2,096,232	4%	2,581,929	5%	2,696,834	4%	3,850,511	5%
Secondary Sector	**13,012,360**	**26%**	**14,160,305**	**25%**	**17,634,361**	**25%**	**14,622,834**	**20%**
Manufacturing industries	10,641,199	21%	11,893,386	21%	10,267,878	14%	9,042,475	12%
Electricity, gas and water	535,441	1%	613,535	1%	2,161,286	3%	2,631,840	4%
Construction	1,835,720	4%	1,653,384	3%	5,205,197	7%	2,948,518	4%
Tertiary Sector	**25,018,492**	**49%**	**28,204,391**	**49%**	**40,964,268**	**58%**	**44,781,408**	**62%**
Commercial, restaurants, and hote	5,847,579	12%	6,407,638	11%	8,397,069	12%	7,699,574	11%
Transportation and communicatio	4,357,740	9%	4,808,848	8%	4,997,947	7%	5,741,726	8%
Financial Services	6,947,979	14%	8,112,591	14%	12,336,684	17%	11,221,211	16%
Social Services	6,597,317	13%	7,336,637	13%	11,434,264	16%	16,841,114	23%
Indirect Services	1,267,877	2%	1,538,677	3%	3,798,305	5%	3,277,783	5%
Total	**50,847,278**	**100%**	**57,063,451**	**100%**	**71,046,217**	**100%**	**72,357,004**	**100%**

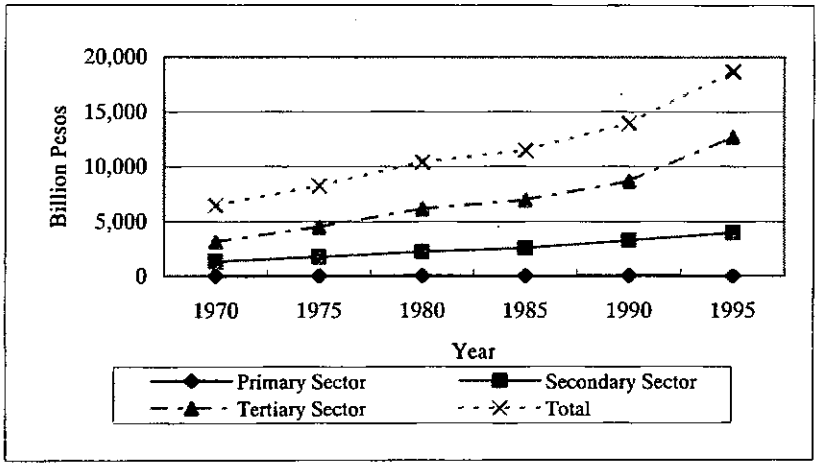
Source: Colombia Statistics 1993-1999 DANE and DANE website

It can be analyzed that GDP proportion of pure industries such as agriculture, farming and fisheries, as well as manufacturing industries have been decreasing. Among the tertiary sectors, social service and financial service has increased while other sectors has a little change.

B. Trends in Bogotá City

Characteristic of the economical proportion is similar to the national one, where tertiary sector dominates, secondary sector follows and then the primary sector comes as seen in Figure 2.2.6

However, the proportion is quite different from the nationals, that in 1995, tertiary sector composed 75%, secondary sector 24%, and primary sector less than 1%. This can lead to the idea that Bogotá City is an area where economically depended solely onto the tertiary sector.



Source: Historic Statistics Bogotá City DC 1950-1999, Department of Planning, Bogotá City

Figure 2.2.6 Growth of GDP in Bogotá City

With the Table 2.2.15, it is clear that primary and secondary sector has gradually decreased since 1970's, and the tertiary sector has been increasing since then.

Table 2.2.15 Trend of GDP by Sector in Bogotá City

Unit: Millon Pesos

	1970	%	1975	%	1980	%	1985	%	1990	%	1995	%
Primary Sector	8,356	0.2%	9,125	0.1%	35,507	0.4%	14,893	0.2%	36,938	0.3%	4,037	0.02%
Secondary Sector	1,331,347	29.6%	1,820,382	28.7%	2,236,039	26.5%	2,546,551	26.8%	3,273,319	27.3%	3,969,201	23.8%
Tertiary Sector	3,150,424	70.1%	4,517,750	71.2%	6,172,111	73.1%	6,933,130	73.0%	8,658,835	72.3%	12,689,939	76.1%
Total	4,492,097	100.0%	6,349,231	100.0%	8,445,638	100.0%	9,496,560	100.0%	11,971,082	100.0%	16,665,172	100.0%

Source: Historic Statistics Santa Fe de Bogotá 1950-1999, department of planning, Bogotá

2.2.4 Socio Economical Indicators

1) Basic Understanding of the Estrato

(1) General idea of Estrato

The *estrato* is the index of the urban residential variables that are classified into six, from class one (lowest) to class six (highest). This classification was first done in 1995 through the "Stratification program", planned and guided by the National Department of Planning (DNP), directly executed by DAPD and other related municipalities. After 1996, it has been obligated to each municipality of the administration to keep updating the data of the stratification project, and some revision has been made in Bogotá City.

Estrato is applied to all the urban area throughout Colombia, through the manzana census and its evaluation, based on the stratification model published by DNP. It is classified in to four, as shown below.

- Type Bogotá: Applied only to Bogotá City.
- Type 1: Applied to the city with population more than 200,000.
- Type 2: Applied to the city with population up to 200,000.
- Type 3: Applied to the city with population up to 5,000.

The difference between all these four types are the variety of evaluating variables, for example, type Bogotá does not include the variable of contamination while type 1 includes this index. Though small items vary between these models, the results between these models are not large.

(2) Process

Estrato classification is basically based on the criteria for present condition of the manzana and land use classification by the variables set by DNP. Variables used for evaluation of manzana are the 1) land use, 2) planning of the settling, 3) materials of the construction, 4) density pertaining to real estate, 5) quality of the public space, and 6) degree of deterioration of the housing. The other variables, land use classification, are described as Table 2.2.16 with the 20 zonings.

Table 2.2.16 Zoning Categories and Descriptions

New Zone	Description	Estrato
Zone 1	Poverty (-)	1
Zone 2	Poverty (+)	1
Zone 3	Social Deviation and Tolerance Zone	1-2
Zone 4	Progressive Development without Consolidation (-)	2
Zone 5	Progressive Development without Consolidation (+)	2
Zone 6	Urban Deteriorating	2
Zone 7	Industrial	2-3
Zone 8	Consolidated Progressive Development (-)	3
Zone 9	Consolidated Progressive Development (+)	3
Zone 10	Commercial Predominating (-)	3
Zone 11	Commercial Predominating (+)	3
Zone 12	Intermediate Residential Zone (-)	4
Zone 13	Intermediate Residential Zone (+)	4
Zone 14	Residential Zone with Special or Compatible Commerce	5
Zone 15	Exclusive Residential (-)	5
Zone 16	Exclusive Residential (+)	6
Zone 17	Low Residential Density	6
Zone 18	Institutional	-
Zone 19	Lots and others without housings	-
Zone 20	Green Zone	-

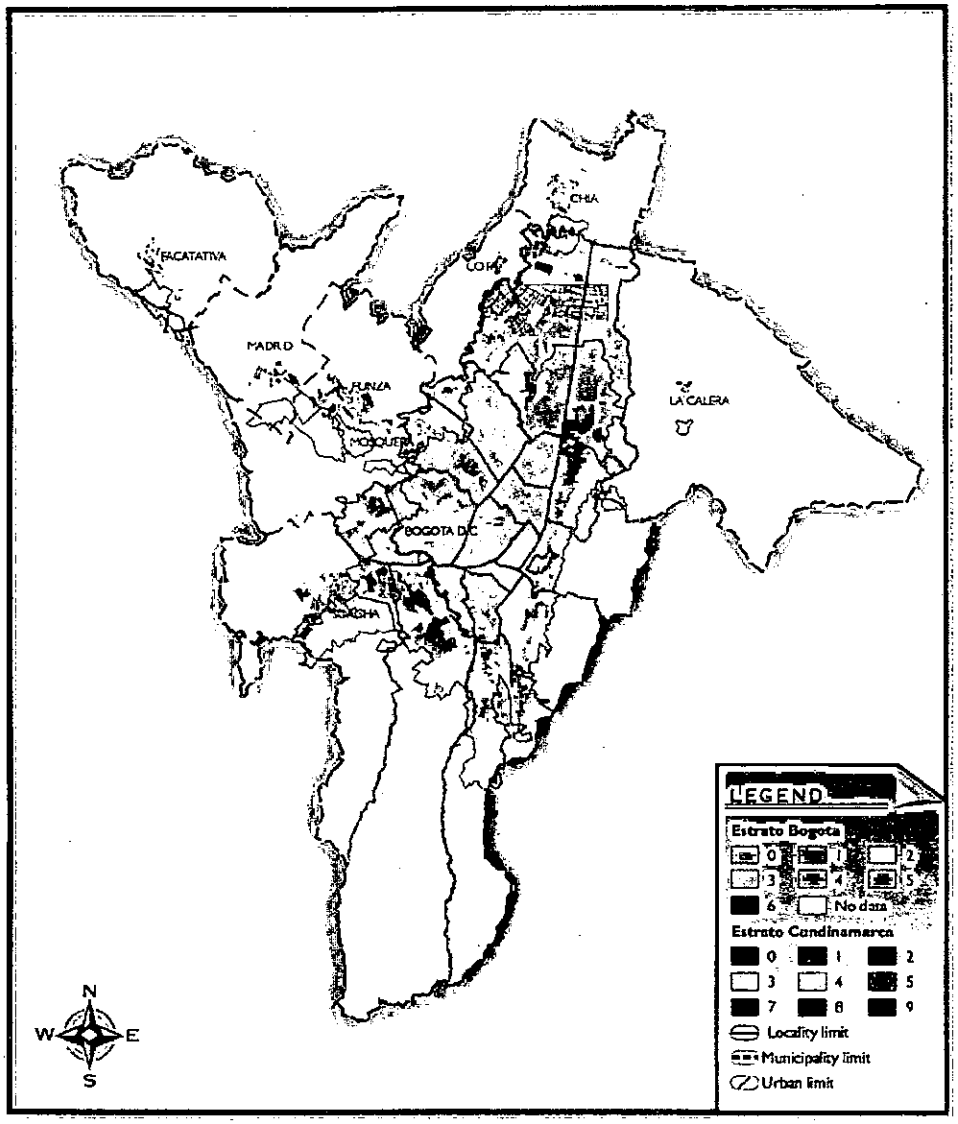
Note: + meaning more progressed, - meaning less progressed
Source: DAPD

For Bogotá City, first *estrato* process was done between June 1995 and December 1996, and passed by the district decree of 009 of January 1997. Then, the upgrade process was done by the decree 737 of October 1997, adding 1,600 manzana to the former one. There will be several upgrades in 2002, and new census is planned to be taken by year 2003.

2) Estrato in Bogotá City and Surrounding Cities

(1) General analysis of the Estrato distributions

Figure 2.2.7 shows the distribution of the *estrato* in the Study Area. From that figure, it is obvious that the highest *estrato* in the Study Area is set in the north-central part of Bogotá City, comprising the most of the part of Chapinero and a part of Suba for *estrato* 6. Surrounding the area of estrato 6, area of estrato 5 is distributed including Barrios Unidos. Semi circle in the center-north surrounding the estrato 6 and 5 is composed of estrato 4, and the rest in the northern part of Bogotá is mainly estrato 3. Central Bogotá to south is mainly composed of estrato 3 and 2, lower estrato as far as to the southern expansion. For the eight municipalities in Cundinamárca are mainly *estrato* 2, according to the classification set by the DNP.



Note: Estrato 0 is defined by DAPD, where the buildings exist, but no reside are found.

Figure 2.2.7 Distribution of the Estrato

The distribution of the estrato in 1996 is described as following table. It can be noted that in Bogotá City, the major estrato is estrato 2 and 3.

Table 2.2.17 Actual Situation of Estrato (by Manzana)

Estrato	Percentile of Manzana
1	9.3
2	42.7
3	30.2
4	9.1
5	3.7
6	1.7
No estrato classification	3.3

Source: Estadísticas Santa Fe de Bogotá D.C, Departamento Administrativo de Planeación Distrital

3) Basic Services Tariff and Estrato

Public service tariff to the residential area are established by the following committees.

- Regulation committee for energy and gas: CREG: Ministry of Mining.
- Regulation committee for water: CRA: Ministry of Development.
- Regulation committee for telecommunication: CRT: Ministry of Communication.

In these committees, the estrato is taken into consideration for determining the tariffs of public services, under the District Decree 347 of May 10, 1997. The main ideas for these tariff values are to cover the residents of estrato 1 and 2 by the residents of estrato 5 and 6.

The established amount of tariff is imposed directly by the public facility companies, of the energy (EEB), telecommunications (ETB), and aqueduct and sewage (EAAB).

2.3 Bogotá City Development

2.3.1 Development of Urbanized Area in the Study Area

There have been three different patterns of expansion in Bogotá's development history:

- Dwelling block-based development phase.
- Barrio-based development phase.
- Block-based development phase.

Each development phase is described below:

1) Dwelling Block-Based Development Era

The *Manzana*, which means a dwelling unit, is a basic unit of development in Bogotá City in the 16th century until the first decade of the 20th century. The *Manzana* forms the old city where events of historical significance took place, as well as the most important administrative and political institutions located. The area was constructed a grid type network without any road hierarchy system, and that defines the *Manzanas* with constant dimensions. This pattern was developed three hundred years before.

This pattern of development has progressed in the La Candelaria area. It is located in the center of Bogotá City.

2) Barrio-Based-Development Era (1910 – 1970)

During 1910 to 1970, the development of Bogotá City was based on the Barrio, which comprises several *Manzanas*. Each barrio became an autonomous unit.

Between 1910 to 1930, the population in Bogotá doubled in size and, between 1910 to the 1960s, some 4,427 hectares were added to the City's urbanized area where it composed mainly of residential neighborhoods. The construction and development of some barrios were planned, yet illegal development had progressed at the edge of the City.

The City was expanded along the road network. The urban center developed long the important road sections and formed a hierarchical road network. One of the characteristics of the development was that the urban area expanded to the North - South direction in a relatively narrow corridor that was limited by the topographical conditions of the City. Complementary to this axis, other important road corridors were constructed in the East - West direction because of limitation of the urban land.

Illegal housing developments continued in more distant and isolated places from the city in such a way that a marginal area of huge dimensions appeared in the peripheral zones of the City. The illegal development was carried out by organized action by the community members.

3) City Development from 1980s to Present

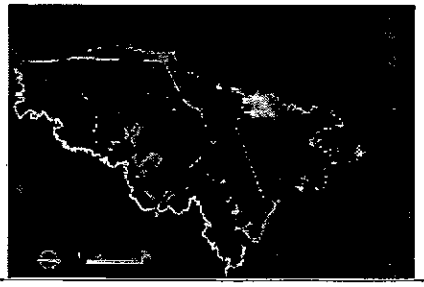
This stage is characterized by the expansion of high and high-medium *estrato* toward the periphery on the North, creating neighborhoods of low densities. For low and low-medium estrato, there was a settlement process in the high areas of the mountains and in the flood areas of the rivers. Roads connected these new developed areas to the city center

The present urban situation is the result of the superimposition of the already described ways of expansion, their interrelations and the common areas between each system. Additionally to these processes, an important change has happened because of the recent increasing density of residential areas which is represented in the demolition of old houses in order to construct tall buildings. This increase in density of about 10 to 20 times the original ones was not done together with the upgrading of lifelines, the addition of public spaces and the improvement of other urban aspects. Furthermore, new illegal settlements are established in places far form the city periphery, which represents a repetition of the colonization process of the first barrios. Figure 2.3.1 shows the urbanization process in Bogotá City.

Year: 1894-

Population: approx. 100,000 inhabitants (year 1900)
Developed Area: 570 ha
Density: 175 people/ha
Characteristics:

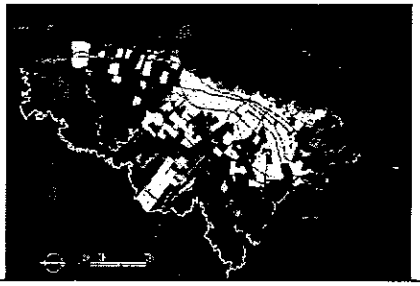
- Developed area was less than 2% of the current area of the city
- Urbanization toward Chapinero, northern part of Bogotá, progressed rapidly
- Railways, Avenida Caracas, and Carrerra 7 were constructed

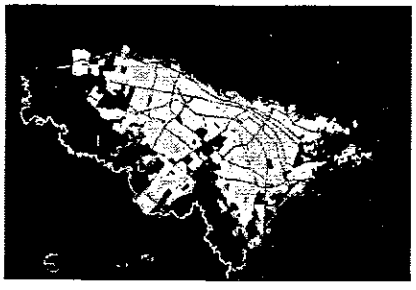


Year: 1960-

Population: 1,697,311 inhabitants (year 1964)
Developed area: 7,915 ha (year 1964)
Density: 214.4 people/ha
Characteristics:

- Population increase between 1890 and 1964 was 4.52% annually
- Developed area increased 13 times more, compared with that in 1894
- Density increase was more than 120%, compared with that in the 1900s
- Social population growth was rapid due to the migration owing to the threat of guerrillas
- Basic plan of arterial road consolidation was introduced

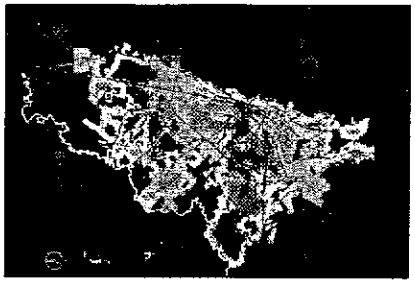




Population: 4,315,309 inhabitants (year 1985)
Developed Area: 24,046 ha
Density: 179.5 people/ha
Characteristics:

- Population increase between 1973 and 1985 was 3.46% annually
- Developed area increased 1.7 times more, compared with that in 1973.
- Density increase was approximately 87.5% compared with that in 1973.
- Informal urbanization continued representing a very high proportion of the urban expansion.
- Population with higher estrato occupied the north and northeastern area, lower estrato occupied south and southeastern area of the city

Year 1980-



Population: 6,322,000 inhabitants
Developed area: 29,308 ha
Density: 199.9 people/ha
Characteristics:

- Population increase between 1985 and 1996 was 2.82% annually.
- Developed area increased 1.2 times more, compared with that in 1985
- Density increase was approximately 110%, compared with that in 1985
- Territory Ordering Plan was created for the appropriate use of land in 2000

Year 1990-

Source: Museo de Desarrollo Urbano, instante memoria espacio

Figure 2.3.1 Urbanization Process in Bogotá City

2.3.2 Urban Planning Aspects

1) Review of Existing Laws and Regulations for Urban Planning

The following table shows the important laws and regulations for the urban planning field in Bogotá City.

Table 2.3.1 Laws and Regulations in Urban Planning Aspects

Decree or Law	Summary
Ley 9 de 1989	The present law regulates aspects of social housing projects such as financial aids, construction licenses for social housing, etc. Furthermore, the law also regulates how to proceed in the acquisition of land or facilities in order to construct social housing projects.
Agreement VI of 1990	The agreement regulates the land use of the East border of Bogotá City and its influence area, as well as some areas in Suba, and Ciudad Bolivar localities; specifically it tries to control the land use in the mountainous areas. The plan settled in the document is referred to the conservation of the orographic system by means of the introduction of land uses that guarantees the preservation of the environment, and the balance between city development and natural resources.
Ley 3 de 1991	This regulation creates the National System for Socialized Housing , the subsidy for family houses, and the Institute for the Territorial Credit is reformed and acquires the new name of INURBE. The law explains how the organization of the National System must be performed, and the functions of each institution involved in the system. Additionally describes which kind of houses are to be the target of the system, and the procedures and general requisites to apply for a Family Subsidy. This law also regulates the objectives and responsibilities of the INURBE.
Ley 388 de 1997	This law promotes the territorial organization through the implementation of plans of land use. For doing so, the law gives the POT as an instrument to develop the municipal and district territorial ordering, which includes the guidelines or studies to follow in order to perform the following task: Disaster prevention, environmental protection, infrastructure and vital lines management. This law only gives guidelines about how to perform the POT.

Source: Summarized by JICA Study Team

With regard to the land use control, there is Ley 388 of 1997 as the main law to be considered. This Ley 388 is the basic and most important law for Colombia in terms of land use.

This law states that territorial ordering plans should be planned at the initiative of each city and municipality. The plans should contain the basic concept of whatever components each entity includes in the plan. It can be concluded that the land use in Bogotá metropolitan area is basically regulated by Ley 388, 1997 and specific land use is controlled by each entity.

2) Land use Classification of Bogotá

With the above-mentioned decree, it is defined that the Territorial Ordering Plan (POT) must classify the land of municipalities and the districts into three categories of urban, rural, and urban expansion. Also, under the rural land category, the classification for suburban and protection areas can be established. Each of the land could be described as follows.

Urban Land: This land has road infrastructures and primary energy networks, water supply and sewerage system. Also, the zones under urbanization process could belong to this category, if this was approved under the POT of the area. The urban land would include the populated centers for the suburban area, and it must be delimited by the perimeters. In any case, the urban perimeter is greater than the set perimeter of the public service.

Urban Expansion Land: This land is constituted by the municipal land designated to urban expansion, which will be set aside for urban use upon approval by the POT of the programs to be implemented. This land will be defined by the POT, with the provision of land development, and also with the possibility of public service expansion.

Rural Land: Land not intended for urban use falls under this category. This type of land is usually used for agricultural, livestock, forest, natural resources, and analogue activities. The possible categories of sub urban and environmental protection land can be defined as the mixed land use of country and city life forms, and possess characteristics environmentally not appropriate for living.

2.3.3 Urban Structure

1) Urban Transportation Development

Le Corbusier planned the basic arterial road network in 1951, and based on his plan, the government of Colombia reviewed its road network plan in 1958. As the results of revision, the road plan was formulated. The basic concepts of the roads are shown as follows:

- To define a ring road structure in order to organize the land use and the transport system.
- To correct the city expansion process through a homogeneous and nested road network.
- To establish an expansion tendency in the peripheral areas.

Since then, Bogotá City government has constructed a broad network along the development plan established in 1958.

The recent development in the field of urban transportation development is the introduction of Transmilenio in the center of Bogotá City.

Transmilenio company started with the Agreement 4 issued by the Bogotá Council, authorizing the Mayor of Bogotá to create the Empresa de Transporte del Tercer Milenio, Transmilenio. On October 13th of 1999 the statutes and norms to control the company such as mission, responsibilities, functions and actions were settled through the Public Scripture No. 1528. Since December 18th of 2000 the company has started rendering the transport service after a process of construction that took less than two years. At that time the corridors of Calle 80 and partially the Avenida Caracas were opened to traffic.

The system of corridors is developed gradually in order to cover the total demand of transport public service. The plan is to create 22 corridors with a total length of 388 Km to be developed in 15 years as follows:

Table 2.3.2 Development Plan for Transmilenio

Stage	Name of the Street or Avenue	Length (Km)	Remarks
1998 – 2001	Calle 80	8	Under operation
	Avenida Caracas	17	Under operation
	Autopista Norte	10	Under operation
2002 – 2005	Avenida Las Americas	17	Under preparation
	Avenida Suba	11	Under preparation
	Corredor Férreo del Sur	12	Under preparation
	Avenida Norte-Quito-Sur	35	Under preparation
2006 – 2010	Avenida Boyacá	35	Future plan
	Avenida Primero de Mayo	15	Future plan
	Viaducto Caracas	21	Future plan
	Avenida Longitudinal de Occidente	48	Future plan
	Avenida Villavicencio	10	Future plan
	Avenida 68	16	Future plan
	Calle 63	9	Future plan
	Calle 200	7	Future plan
	Carrera 10	13	Future plan
	Carrera 7	11	Future plan
	Calle 6	5	Future plan
	Calle 170	10	Future plan
	Calle 26	10	Future plan
	Avenida Ciudad de Cali	31	Future plan
	Viaducto del Norte	10	Future plan

Source: Transmilenio S.A.

The total estimated amount of money planned to be invested for the whole project is US$ 1,970 million.

Transmilenio has 411 buses at the present time, 56 of 62 stations in operation, 22 feeder routes form neighborhoods to the main corridors, and the average number of passengers in peak hour is 57,196, while the average per day is around 600,000 passengers.

2) Open Space

(1) Open space ratio in the study area

It is important to secure the open spaces in the Study Area for the safety of victims in a disaster.. The open spaces include parks, sport grounds, green space, vacant land, agricultural land, etc. The open spaces are made use of as an evacuation place, an emergency response center, and an emergency response location for the public service companies as well as a temporary housing location.

The study team analyzes open spaces for public parks and roads of the Study Area. The summary of the open space classification is shown as follows:

Table 2.3.3 Open Space for Bogotá City

Unit: Ha

	Bogotá City	Cundinamarca
Public Parks	2,220.3	57.8
Roads	4,845.8	-
Total	**7,066.1**	**57.8**
Open Space Ratio	8.2 percent	0.05 percent

Source. JICA Study Team

(2) Parks in the study area

The information of the open space is collected from the District Institute of Sports and Recreation (IDRD), which is responsible for the maintenance of the parks. The Department of District Planning has responsibility of the planning aspects of the park, while the construction is carried out by the other organization. The information includes only public parks in the Study Area. According to IDRD, the parks can be classified into six categories as shown follows:

Table 2.3.4 Classification of Parks

Category	Description
Regional Parks	These parks are natural spaces with relatively huge areas and located totally or partially outside the urbanized area of Bogotá City. They provide good environmental values.
Metropolitan Parks	The purposes of these parks are recreational and active uses to attract the people and they provide good environment and landscape. Infrastructure should be provided for these purposes.
Urban Parks	These parks are distributed at strategic locations of the Capital District area with an historical and symbolic value for the city. They are of intermediate scale.
Zonal Parks	Zonal parks have variable sizes. They provide opportunities for locality personnel of recreation and activities. They could have recreational infrastructure. The parks also have good landscape and management.
Barrio Parks	This park is for the neighborhood unit. The objectives of the parks are mainly public in nature–for recreation and integration of the community.
Pocket Parks	These are neighborhood parks with an area less than 1,000 square meters. The purpose of the parks is to provide opportunities for the community people for recreation and other activities.

Source: Inst Distrital de Recreccion y Deporte

The summary of the parks in the Study Area is shown in Table 2.3.5. There are more than 2,500 parks with an area of 2,600 ha in total in the Study Area. The Barrio Park shares more than 83% of the total number, while the total area is 1,085 ha, or 41.4%, of the total park area. The metropolitan park numbers only 16 in the Study Area, yet it shares 19% of the total park area.

The distribution of parks shows that open space per person is more than $10m^2$ in Usaquén, Barrios Unidos and Teusaquillo localities. Three localities, Los Mártires, La Candelaria and Ciudad Bolivar, in Bogotá City show that the open area per person is approximately $1.0m^2$. In the eight municipalities in Cundinamarca, open space in the urban area is relatively small at less than 0.7 m^2.

Table 2.3.5 Summary of Parks in the Study Area

Locality	*Population*	*Number of Parks*						*Area (Ha)*						*Open Space Per Person (m^2)*
		Metropolitan	*Urban Park*	*Regional Park*	*Barrio Park*	*Zonal Park*	*Pocket Park*	*Metropolitan*	*Urban Park*	*Regional Park*	*Barrio Park*	*Zonal Park*	*Pocket Park*	
Bogota City														
1 - Usaquén	421,320	1		2	221	4	17	12.0		353.5	92.4	12.3	1.8	**11.2**
2 - Chapinero	122,991		1		116	2	13		17.7		32.9	1.5	1.6	**4.4**
3 - Santa Fé	107,044	1	1		54	2	7	14.1	4.4		18.4	1.5	0.7	**3.7**
4 - San Cristóbal	455,028		1		138	5	17		23.0		62.3	18.1	1.7	**2.3**
5 - Usme	244,270	1			102	5	18	20.5			30.0	11.4	1.3	**2.6**
6 - Tunjuelito	204,367	1			31	1	8	66.0			17.2	2.7	0.2	**4.2**
7 - Bosa	410,099	1			124	5	13	20.4			41.7	18.7	1.6	**2.0**
8 - Kennedy	912,781	1	3		257	5	31	49.2	35.2		163.2	11.9	2.3	**2.9**
9 - Fontibón	278,746		1		82	4	7		30.1		35.6	25.9	0.8	**3.3**
10 - Engativá	749,068	3		1	190	6	27	45.6		278.9	180.4	22.4	3.9	**7.1**
11 - Suba	706,528		2		183	4	15		13.8		124.9	8.3	1.1	**2.1**
12 - Barrios Unidos	176,552	4	1		52	2	13	146.1	4.7		21.9	2.7	2.6	**10.1**
13 - Teusaquillo	126,125	2			101	1	10	115.5			44.8	2.7	0.4	**13.0**
14 - Los Mártires	95,541		2		25	2	7		5.3		10.9	3.6	0.8	**2.1**
15 - Antonio Nariño	98,355	1			25	5	7	10.8			14.0	18.7	0.4	**4.5**
16 - Puente Aranda	282,491				97	5	15				81.8	24.9	1.3	**3.8**
17 - La Candelaria	27,450				10	2	1				1.8	0.9	0.7	**1.2**
18 - Rafael Uribe	384,623		2		125	5	16		33.4		47.0	9.7	1.9	**2.4**
19 - Ciudad Bolívar	575,549		2		144	4	17		0.9		64.2	6.1	2.4	**1.3**
Municipalities in Cundinamarca														
Chia	61,783		3		7		8		3.4		2.8		0.4	**1.1**
Cota	14,784													**0.0**
La Calera	24,188													**0.0**
Facatativá	90,266		1		10		7		7.5		3.3		0.4	**1.2**
Funza	51,808		3		4		13		2.9		0.8		0.5	**0.8**
Madrid	52,110		2		10		17		7.2		5.2		1.0	**2.6**
Mosquera	27,753		1		11		14		11.6		3.4		0.5	**5.6**
Soacha	283,889		2		7		3		1.1		5.8		0.2	**0.2**

Source: JICA Study Team

2.4 Existing Plan

2.4.1 National Development Plan

The National Development Plan is prepared by the president of Colombia in accordance with Article 340 of the Constitution. The plan becomes a Law after approval by the congress. The Department of National Planning (DNP) is responsible for the formulation of the plan.

The most recent national development plan covers 1998-2001, which is the term of office of President Pastrana. The objective of the plan is to change for peace. Moreover, the plan addresses for the first time disaster prevention in the country. The main focus is to reconstruct the coffee-growing region, which was hit by an earthquake in 1999. The development plan shows the direction of the rehabilitation of the affected area.

2.4.2 Disaster Management Plan

The disaster management plan is established in late 1980s and 1990s, when the Colombian government recognized the importance of the plan. The following section gives a summary of the disaster management plan at the national level.

1) National Level

The government of Colombia decided to address the disaster management of the country after the volcanic disaster in Ruiz in 1985, and established the National Office for the Attention of Disasters. The government also enacted several laws and regulations for disaster management from 1988 to 1992. In 1996, the National Office for the Attention of Disaster changed its name to the General Directive Office for Prevention and Attention of Disasters (DGPAD) and became an attached office to the Ministry of Interior.

The DGPAD prepared the national disaster management plan in 1998. The objective of the plan can be summarized as follows:

- Reduction of risks and prevention of disaster.
- Quick and effective response after disaster.
- Quick recovery of the affected area.

The national disaster plan shows the basic concepts to deal with the disaster management.

(1) Decentralization

According to the ordinance law 919 of 1989, the responsibility of the disaster management is decentralized to the municipalities and territories. The municipality should prepare its own disaster management plan. The DGPAD has prepared the model of contingency plan to support the municipality.

(2) Scope of the competition

The disaster management field shall keep an efficient and effective environment through competition of the related organizations.

(3) Coordination

The disaster management shall require close coordination with national, regional and local governments as well as the internal government sections. The plan urges to formulate a regional and a local level coordination body for the implementation of the disaster management system.

(4) Participation

The disaster management shall guarantee participation of the community personnel because of the nature of the project.

There are four strategies to achieve the objectives:

- To gain the knowledge of risks of natural disaster.
- To formulate prevention plan to reduce the risks.
- To promote institutional development; and
- To socialize disaster management.

The summary of the program recommended by the national disaster plan is shown as follows:

Table 2.4.1 Summary of the National Program on Disaster

Name of the Program	Sub-Program
Natural disaster risk mitigation program	Establishment of warning system Evaluation of the risks
Establishment of prevention and mitigation plan	Formulation of prevention plan in the development plans Human and infrastructure management plan Formulation of environmental management plan
Institutional development plan	The national level institutional development Regional and local level institutional development Implementation level organizational development Upgrade of the infrastructure Formulation of the emergency plan Plan of efficient infrastructure reconstruction Establishment of integrated information system
Community level disaster management activities	Community level disaster management education Disaster management and environmental protection Human development program for national level personnel Community level organizational development

2.4.3 Territorial Ordering Plan (POT)

1) Bogotá City

(1) General understandings

A. Background

Bogotá City had several urban plans and decrees as follows:

Pilot Plan of 1951 of Le Corbusier, Regulator Plan of 1954 of Wienner and Sert, Agreements 30 of 1961, 65 of 1967, 7 of 1979 and 6 of 1990, and Phase II of 1972-73. All these lacked the legal necessary instruments to guide the public investment in medium and long-term, searching for the territory ordering.

a) Legal frameworks

Law 152 of 1994 established two basic planning mechanisms for the cities: Municipality Development Plan and Territorial Ordering Plan (Art. 41 law 152 of 1994). Law 388 of 1997 of Territorial Development was issued, as the set of principles, instruments and arrangements about planning and territorial proceedings

The P.O.T for Bogotá was adopted with the signing of Decree No. 619 of 2000.

(2) Elements included in the POT

The Bogotá City's development presents four basic tendencies which were used as reference frame for the performance of the document: Bogotá's supremacy in the National order, the

persistence of a weak integration of the regional space, the need of achieving an environmental bearing, and finally, the growth tendencies of the size of the population.

(3) Existing estimations

- Great imbalance in the migration distribution, resulting in a segregated city. The territory reflects high levels of space inequality, because the areas occupied by the poorest groups of the city have grown without regulation or order and out of the parameters and principles of the planning.
- Absence of a massive transportation system and the lack of a road network hierarchy, which affects specially the access of the peripheral areas. Due to inefficiency reasons in the routes, roads and transportation type, a commuter from Bogotá spends approximately 4 hours per day to travel from their home to work.
- Weakening of the public amenities and the incapacity of defending and constructing the public space. This deterioration is due to the occupation and privatization of sidewalks, parks and cession areas, as well as the fact of ignoring the importance of the collective property, such as the urban patrimony.
- Lack of houses for the quantity of habitants in the city corresponding to the population growth.
- The city still presents incomplete coverage in the supply of the sanitation and potable water services. In addition, health equipment, educational facilities, jails, sport and community facilities are deficient.
- The urban development of Bogotá has neglected the construction of the zone scale. A zone scale is composed by a great city, in which basic needs such as housing, employment, commercial services, health, education and recreation are met.
- Most of the residential zones have been deteriorated by changes in uses, without any regulation or parameter, as consequence of the market laws of the land rent, without urban development considerations or coherence with the pre-existent services capacity.

(4) Territorial Ordering Model (Desirable Future Image of the Municipalities)

A. Urban area

The Model proposes a continuous, compact and dense urban area, ordered by a structure composed by urban pieces and hierarchical general systems from the metropolitan scale to the local one.

B. Rural area

The Territorial Model searches to consolidate the rural area as a new water, biotic, stage and productive reserve and as a proper habitat for the rural population of the District.

The water sources and the existent natural resources will be valued. The populated centres will be strengthened by means of the supply of public services and equipment that reinforce activities related to the rural productivity.

C. Others

The objective is to recognize and to consolidate the importance of the Capital at National Level.

(5) POT in practice

A. Projects

a) Main ecological structure projects

The projects regarding the Ecological Structure are referred to the district sanctuaries of fauna and flora, the forest urban and rural reserves, and the urban and rural recreational ecological parks.

In order to put in practice a valorization and preservation process of the elements that compose the Main Ecological Structure, a group of policies of regional integration and environmental sustainability were defined, as well as programs about the treatment plants and hills protection, in addition to the intervention of the Rio Bogotá and its affluent.

b) Projects regarding rural territory

These projects refer to the sanctuaries and rural ecological parks protection and valorization.

c) Projects regarding the urban structure

These projects are divided into those that refer to the urban pieces and those that affect the general systems.

- Projects for the urban pieces: They are intended to find an answer to the POT's objectives and consolidate an urban structure of high life quality, balance, and efficiency and that which makes easier coexistence with the citizens. To reach this, a group of complementary projects were defined in each one of the urban pieces.
- Projects in the general systems: In order to guarantee the construction of an integrated and equitable territory, the required projects in each one of the infrastructure systems or networks of the city are established.

B. Programs

The Urban Programs define the performances the District Administration must render or promote in four topics relevant to the city development and the starting of the Ordering Model. (These are the Patrimony Valorization and Protection, Housing (which includes New Housing, Integral Improvement, Human Resettling, and Neighborhoods Recovery), the Urban Renewal and the Eco-efficient Production.)

a) Patrimony valorization and protection

This program establishes incentives for the maintenance and preservation of the goods of cultural interests. Its objectives are the following:

- To design and perform urban development on the built patrimony that stimulates the private intervention, valorize the surrounding and revitalize the properties and surrounding sectors.
- To allow interventions in the protected properties, with the purpose of improving their housing conditions without losing any main patrimonial values.
- To reorganize the District institutional structure to allow patrimony recovery projects to proceed and be performed.

These objectives are concrete in the following situations:

- Special Plan for the Historic Downtown Protection.
- Valorization and Preservation of the Foundational Centre areas of the annexed municipalities (Usaquén, Suba, Engativá, Fontibón, Bosa and Usme).
- Performance in the patrimonial interest neighborhood.
- Compensations for the preservation of cultural interest goods.

b) Housing

This program has the objective of establishing the mechanisms to provide proper attention to the demand, both quantitative as qualitative, for houses of lower income families in the city. This is done by means of the promotion and provision of incentives to the urban land, programs and new housing solutions, the development of integral improvement programs in urban sectors with deficit, the performance of programs of resettling of families in non-mitigable high risk areas and the recovery of neighborhoods.

Its goal, during the validity of the Plan, is to generate urban land to address the lack of 400,000 housing units in *estrato* 1, 2 and 3.

c) Integral improvement

This program has as objective to guide the required actions in order to complete, reorder or adequately address both the urban space and the housing units that compose the illegal settlements located in the periphery of the city. Its purpose is correcting physical, environmental and legal deficiencies. The priority intervention in Zone Planning Units - UPZ- was defined, which present critical poverty and overcrowding situations.

Its goal, during the plan validity, is to attend to 600,000 people, of *estrato* 1 and 2, located in illegal developments in eight locations, in an urban area of 3,600 hectares.

d) Resettling of families in non-mitigable high risk areas

This program has as objective to transfer the families that are settled in zones declared as non-mitigable high risk areas of floods or landslides, in zones that are the object of intervention by public works or those that required any territorial re-ordering intervention. Its goal is to resettle at least 1,400 families per year.

e) Urban renewal

This program proposes the performance of direct actions of public management; it also promotes private performances in strategic zones of the city. For this effect, the interventions in the public services infrastructures will be coordinated, as well as the viability and pedestrian public space with the intervention of private lands. The program aims to identify the zones where to develop projects or undertake urban renewal and to give priority to public performances to propel their execution.

In these actions, the District will be attended to through the Urban Renewal Company and its objectives are:

- To define the zones propitious for being renewed.
- To start strategic renewal projects by means of the instruments established in the POT.

f) Eco-efficient production

This program has as objective to guarantee the transformation of the city into one that is sustainable, productive and with high environmental quality ecosystem, strengthening the industry settled in the District, with an eye to convert it into one of the elements that contributes to achieve a high urban competitiveness. Two classifications have been established:

- Eco-efficient Industrial Parks.
- Mining-Industrial Parks.

2) Eight Municipalities in Cundinamarca

The summary of POTs in surrounding municipalities is shown in Table 2.4.2. The POT for Facatativá has not been authorized yet.

Table 2.4.2 Summary of POT for Eight Municipalities (Cundinamarca)

Municipality	La Calera	Chía	Funza	Madrid	Mosquera	Soacha	Cota
POT or PBOT	P.O.T.	P.O.T.	P.B.O.T.	P.B.O.T.	P.B.O.T.	P.O.T	P.B.O.T.
Year of Adoption	Agreement No. 043 of 1999.	Agreement 17 of 2000.	Decree No. 000140 of September 13th of 2000.	Agreement 024 of 2000.	Agreement No. 001 of February 23rd of 2000	Agreement No. 046 of December 26th of 2000.	Agreement No 021 from October 20th of 2000
Dev't Direction	Land use and infrastructure.	Land division and infrastructure, but principal projects are addressed to health.	Infrastructure.	Land use and land division, but objectives oriented to infrastructure.	Environment and Urban Infrastructure	Infrastructure	Agricultural housing and environmental protection activities.
Back ground	The norm before the P.O.T. was the Agreement 024 of 1995.	The actual POT replaces the Agreement 03 of 1994, the Agreement 38 of 1998, and the chapter 4 of Agreement 011 of 1996.	The Agreement No. 002 of January 24th of 1997 determines the opening of industrial zones inside the urban and rural areas. Probably still in function.	The P.B.O.T. derogates the Agreement 044 of 1994; probably it was about land division and land use.	Before POT the regulation of land was dictated by the Agreement 038 of 1993, which includes land use and cession areas.	Without reference.	For industrial areas: Agreement No. 16 of December 4th 1991, agreement No. 9 of June 30th 1995. The industrial area was set there by the laws 99 of 1993, 388 of 1997 and the agreement No. 16 of 1998.
Future Direction	Improvement of Infrastructure in the municipality	Recover and maintain historical and cultural places Explore and protect land and natural resources Explore the tourist potential of the municipality.	Concentration of the urban development and to strengthen the agro industrial development of the municipality.	Integration of urban area with the environment. Protection of the rural space with its conservation and development.	To organize the road network and transportation. To be a center of storing of agricultural products. To save the waters of Rio Bogotá and their tributaries. To define the land use in zones within the capital city.	To consolidate Soacha as the first industrial and mining city in the Department. To promote the balanced development of goods and environmental services.	To avoid the immigration of people from Bogotá to be established as a "dormitory city" To obtain the best strategy in accordance with an agricultural, natural and a well controlled urban development.
Area of implementation	Environment Socialize housing Construction of new lifelines Basic Reparation of Environment Attention and prevention of disasters Public Space and Recreation To guarantee Transport Improvement of Rural Equipment	Health Transport and Roads Infrastructure Public Services Infrastructure Education Environment and livestock Culture Employment Security and civic protection Recreation and Sport Institutional Development	Urban infrastructure and equipment Traffic Ordering Public Services Administration, Creation of institutions Occupation by determining areas and their uses Environment, recuperation humid soils and river borders	Roads infrastructure Water resources Socialized Housing Public Services Urban Equipment	Environment Physical Infrastructure Roads Public Services Housing Health Education Land Use	Transit and Transport, by massive media Public Services Housing Equipment Public Space generation Environment Administrative reform	Housing improvement Land distribution Foment of agricultural activities

Note: POT is defined as the Territory Ordering Plan, which is performed and adopted by the authorities of the districts and municipalities with population larger than 100,000, PBOT, is defined as the Territory Ordering Basic Plan, which is performed and adopted by the authorities of the municipalities with population between 30,000 and 100, 000 inhabitants.

2.5 Laws and Regulations for Disaster Management

2.5.1 Disaster Management System

1) Disaster Legislation

According to Law 46, November 1988, the government of Colombia established a national system for prevention and attention of disaster. The important disaster legislation was enacted for the first time in Colombia in 1989. Decree No 919 of 1989 regulated the national disaster management system to define the responsibility for the public sector, private sector and community organizations in disaster situations. The Colombian government enacted several disaster related laws and regulations. Table 2.5.1 shows the important disaster related legislation since 1988.

Table 2.5.1 Summary of Important Disaster Management Legislation

Law and regulation	Descriptions
Decree 1547, 1984	Creates the National Fund for catastrophes as a special account of the nation. This account will provide money for the required attention of disasters, social assistance, control of secondary effects such as diseases, and to finance the installation and operation of equipment for prevention of disasters as well as to implement measures to prevent them.
Decree 919, 1989	The National System for Prevention and Attention of Disasters is created. This law defines the institutions that conform the system, the scope and actions of the plan, and the guidelines to be followed by regional and local committees.
Ley 99, 1993	This law creates the Ministry of Environment. In respect to disasters, one of the tasks of the Ministry is to perform studies and to follow up their advance, in order to prevent and to control disasters related to the environment such as erosion control and management of streams. These procedures must be performed in agreement with local administrations, municipal governments) in programs of land adaptation in zones of high risk.
Decree 969, 1995	The decree specifies that IDEAM will participate in the National System for Prevention and Attention of Disasters, and its role will be as a scientific and technical institution in charge of advisory. IDEAM must supply hydrological and meteorological information to regional and local institutions for planning and land use aspects.
Decree 322, 1996	This law creates the National System of Fire Brigades, which has the responsibility of prevention and attention of fires, explosions and related situations. The law regulates its functions and responsibilities, organizational aspects in the national, regional and local levels.
Ley 388, 1997	This regulation specifies the land use according to three principles: Social and ecological function, the prevailing of public interest over the private one, and the fair distribution of responsibilities and benefits. The law does not regulate aspects related to attention of disasters, but within the POTs there must be done maps of risks areas, where constructions are forbidden.
Ley 400, 1998	This law regulates the norms of design and construction of houses and buildings, materials used for construction, and procedures to follow for a seism resistant design, in order to reduce human life casualties and damages to buildings.

Source: Summarized by JICA Study Team

Since 1989, the Colombian government has applied the disaster management system from the central to the local governments. The establishment of the regional committee for the disaster management for the region will be the most important for the national system. Bogotá City and

Cundinamarca governments have developed a cooperation agreement for the disaster management area on May 22, 1999. The agreement has been limited to infrastructure and lifeline areas and is a big step toward regional cooperation between Cundinamarca and Bogotá D.C, because a disaster situation will not be limited to administrative boundaries.

According to Article 3 of Decree No 919, 1989, the National Office for the Prevention and Attention of Disasters was established within the Ministry of Interior. The National Office for the Prevention and Attention of Disasters prepared a National Plan for Prevention and Attention of Disasters, which was approved by the National Committee for Prevention and Attention of Disasters. In 1998, the plan became Decree No 93 of 1998, now it is called National Disaster Plan.

The regional level governments, Cundinamarca and Bogotá City governments have started disaster management regulations in the late 1990s. According to Law 919, 1989 as well as Agreement 11, 1987 issued by the Bogotá Council, the city government established a Fund and Coordination Office for Prevention and Attention of Emergencies, currently the Direction of Prevention and Attention of Emergencies (DPAE) of Government Secretary's Office.

According to Decree 919, 1989, the Cundinamarca government created a prefecture disaster management system by the prefecture assembly in Ordinance No 021 dated 1998 and it became a Prefecture Decree No. 3019 of 1998. The Decree stated that the prefecture disaster management system includes public sector, private sector, community organizations and non-governmental organizations. These four entities have become important in the area of disaster management.

The Cundinamarca and Bogotá City governments agreed to cooperate in the following activities: prevention, preparedness, mitigation, attention and control, recovery and rehabilitation of the areas of infrastructure affected by emergency and disasters. The fourth clause of the agreement stated that both governments agree to formulate an action program for the following aspects:

- Risk appraisal and reduction and disaster prevention on potential scenario and influenced area:
- Strengthening of implementation capacity and effective response in the case of emergency or disaster situations;
- Definition of technical, administrative and financial processes needed in order to recover and rehabilitate lifelines in a community;
- Formulation of projects and their study and implementation; and
- Development of contingency, emergency plans, establishment of an integrated information system and communication network with immediate benefit for each party.

2) Roles and Responsibilities of the Organizations

For the disaster management, the roles of the organizations are defined by Decree 919 of 1989, and are summarized in Appendix 2.5.1. The organizations, which are in charge of disaster management, can be categorized into the three administrative levels: national level, prefecture level, local level, and other governmental organizations level. In the disaster management, the other organizations such as television and radio stations, public transportation companies, medical associations, should be included in the list.

3) Fund for Disaster Management

(1) General

Budget for disaster management is regulated by the laws and regulations. There are separate funds that available for disaster and calamity or similar situations. As for the disaster prevention and mitigation, the government established funds for the national and district levels. In the study area, each government organization has established laws for the disaster management budgets. The usage of the funds is also defined at the laws and the usage of the funds are disaster prevention and mitigation. There is no permanent fund for disaster response and recovery.

The government was established a fund for disaster recovery just after the disaster has happened. It is true in case of Armenia earthquake rehabilitation. The government established *Fondo para la Reconstruccion y Desarrollo Social del Eje Cafetero*:FOREC on January 30th of 1999, just five days after the earthquake. The rehabilitation was carried out through the funds of the FOREC.

As for public services companies, the president of the republic has the responsibility to control, inspect and watch the public service entities by way of superintendent (Art.370, Constitution). Public Service Enterprises (*E.S.P. - Empresa de Servicio Público*, Art.19, Law142/1994) giving services such as drinking water, sewage, cleaning, electricity, combustible gas and telecommunication have obligation to operate continuous service with good quality regardless of their business form whether public or private (Art.136, Law142/1994). Public Service Enterprises are exempted from compensation for loss caused by interruption of service occurred by of an act of God like disasters (Art.137 Law 142/1994).

Regulation Commission of Drinking Water and Basic Sanitation (CRA), Regulation Commission of Energy and Combustible Gas (CREG) and Regulation Commission of Telecommunications watch, control and instruct the Public Service Enterprises in their tariff systems and other regulations (Art.69, Law142/1994). Superintendent of Domestic Public Services (SSPD) controls inspects and watches the Public Service Enterprises in their quality of service (Art.75, Law142/1994).

(2) Budget for the Emergency Response Organization

The budget for the emergency response organization is determined by the each organization. The amount of the disaster management related budget is limited because of the shortage of the budgets as well as low priority of the disaster management. The following shows the summary of budget for the disaster related organization.

Table 2.5.2 Summary of Budget for Disaster Prevention

(Unit: million pesos)

	2000		2001	
	Revenue	Expenditure	Revenue	Expenditure
Fund				
National Calamity Funds	9,734	9,734	6,407	6,407
FOPAE	9,972	9,972	11,888	11,888
Lifeline companies (Disaster prevention related budget)				
IDU	-	(757,899)	-	(588,517)
EAAB	1,715	1,709 (483,707)	-	1,947 (881,439)
Gas Natural	-	370	-	450
ETB	-	800	-	4,408
TELECOM	-	(346,014)		(360,888)

Note: () shows the investment budget.

Source: JICA Study Team, Data are provided by each organization

2.5.2 Review of National Disaster Management System

1) National Disaster Management Plan

The national disaster management plan includes and determines all policies, actions and programs in the disaster management in Colombia. The plan addresses the following aspects:

- Prevention, emergency response, reconstruction and development phase in connection with the different types of disasters and public calamity situations;
- Topics of economic, financial, community, juridical and institutional order;
- Education, training and community participation;
- Integrated systems of information and communication at national, regional and local levels;
- Inter-institutional and inter-sectorial coordination; and
- Necessary scientific investigation and technical studies.

The plan points out that the private sector should play an important role in disaster management and calls for the involvement of non-governmental organizations to participate in the implementation of the plan. The plan also urges prefecture and municipal governments to enact their own disaster management plans, taking into consideration the situation and development direction of the territories.

2) Organization

The national system for disaster management is composed of the following organizations:

- The National Committee for Prevention and Attention of Disasters;
- The Regional and Local Committee for Prevention and Attention of Disasters;
- The National Office for the Attention of Disasters;
- The National Technical Committee for Prevention and Attention of Disasters;
- The National Operative Committee for the Attention of Disasters;
- Ministry and Administrative Departments;
- Other governmental organizations;
- Local governments;
- The Colombian Red Cross National Society; and
- Private entities and persons who due to their purpose and functions are related to disaster management.

According to Article 52 of Decree 919, 1989, the local governments shall prepare their own disaster management systems on the basis of their situations. Each of Bogotá City and Cundinamarca governments has enacted a law for the disaster management system in each of their territories. The next section reviews the disaster management system in both territories.

3) Organizational Chart of Disaster Management System

On the basis of Decree 919, 1989, the disaster management system in Colombia can be stratified as three governmental levels: national, regional and local. The functional responsibility in disaster management can be classified as preparedness, response and recovery. The disaster management system and functional diagram in Colombia is shown as follows:

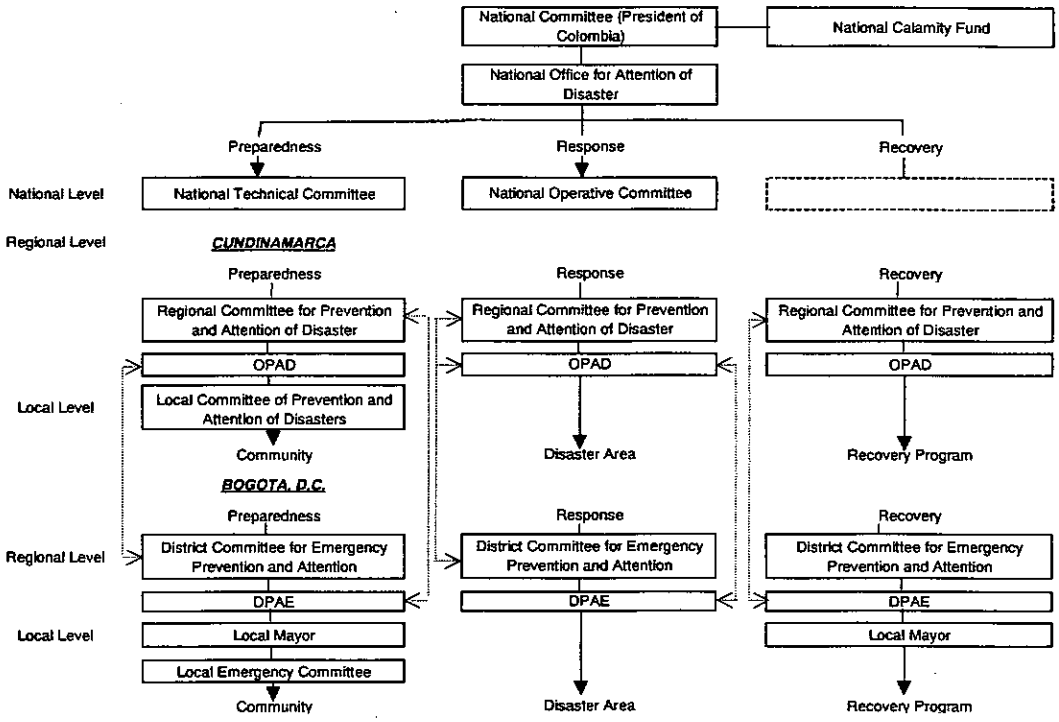


Figure 2.5.1 Disaster Management System

4) Funds for National Level

National Calamity Fund (FNC or *Fondo Nacional de Calamidades*) is an independent national budget account, with public interest and social assistance purposes, and devoted to the attention of disaster, calamity or similar situations (Art.1, Decree 1547/1884; Art.70, Decree-Law 919/1989).

Fund resources are destined to: 1) Offer economic support for the attention of declared disasters and calamities, 2) Control their effects, 3) Maintain environmental sanitation, 4) Finance the installation and operation of information systems, 5) Take the necessary steps in order to prevent disasters or mitigate its effects (Art.2, Decree 1547/1884; Art.70, Decree-Law 919/1989).

The FNC has as its sub-accounts Fond of Attention of the Displaced and National Fund of Fire Fighting, the latter of which has resources of 1 % of paid fire insurance fees (Art.2, 3, Decree 2211/1997).

2.5.3 Bogotá City Disaster Management System

1) Disaster Management Plan

There is no integrated disaster management plan in Bogotá D.C. until now, yet the Bogotá City government has enacted Decree No 723 of 1999 to regulate district disaster management system in Bogotá City.

2) Organization

Three committees compose the district disaster management system:

- District Committee for Prevention and Attention of Emergencies
- Operation, Technical and Educational Inter-institutional Committee
- Emergency Local Committee

DPAE shall play the role of coordinator and advisor of the district system.

(1) District committee for emergency prevention and attention

The district committee for the prevention and attention of Emergencies is constituted by at least 14 members from the Bogotá City government. The member list is shown in Appendix 2.5.2. The director of the District Planning of Administrative Department is the secretary of the district committee and the director of DPAE is the operation coordinator.

(2) Operation, Technical and Educational Inter-institutional Committee

A. Operation Committee

The purpose of the Operative Committee is developing a scheme of effective and coordinate response in front of an emergency arising in the Capital District, through the design and commissioning of plans, programs and projects that maximize the availability of technological, administrative, logistic, methodological and human resources. In order to raise the technical level of the respective bodies, unify the operative criteria and the procedures addressed to manage and attend the arising situations.

B. Technical Committee

Technical Committee's purpose is jointly promoting, arranging and developing projects and activities with the respective entities on the subject by increasing knowledge and treatment of threats and vulnerabilities, mitigation and monitoring of risk generating factors. It is the implementation of systems and procedures addressed to gathering, consulting and providing district information related to the issue to achieve its systematization and standardization.

C. Educational Committee

The Educational Committee's purpose is incorporating the issue of emergency prevention and attention to the culture of the inhabitants of the Capital District, through the design and put into practice of policies, strategies, plans and projects and methodologies, in coordination with district entities.

(3) Emergency Local Committee (CLE)

An emergency local committee is organized in each locality in the capital district. According to Article 26 of Decree 723 of 1999, the local mayor has the responsibility in emergency situations.

The emergency local committee is constituted by at least 12 members from local government, Bogotá City government and public service companies.

3) Emergency manual

Bogotá City government prepared the Unified System for Emergency Handling (*Sistema Unificado para Manejo de Emergencias*: SUME) in 1995. The objectives of the plan are to clarify technical and operational action criteria for the related institutions under emergency situations and to coordinate the institutional activities through institutional orders. An operational emergency committee (COE) is proposed to establish under the system and has a responsibility to provide support to the operation commander and logistical cooperation.

SUME divided the operational sections into five areas: health, security, operation, infrastructure and information. Each section in turn is divided into several sub-sections and shows a detailed procedure to follow during emergency situations.

4) Fund for the Bogotá City

The budget of FOPAE in 2001 is 11,500 million pesos for investment out of 11,888 million pesos in total. The 6,500 million pesos, 57 % of investment, are allocated to various prevention projects like relocation of housing in the menace of land slides, control of unstable slopes, and so on, under the Priority Items with slogans like "Let's be situated solidarity", "Let's make better the quarters and houses".

The 5,000 million pesos, 43 % of investment, are reserved specially for an urgent attention of disasters and emergencies, and maintained until the end of fiscal year (No.7240 project; Art.68, District Decree 1148/2000). FOPAE is only one organization that has reserve budget, though the 5,000 million pesos are just a little for 6 million inhabitants, 833 pesos per person.

However, if nothing happens and there is no utilization of this budget, the sum cannot be carried forward to the next fiscal year because of regulation (Art.13, District Decree 714/1996). It should be diverted to other investments, not always to disaster prevention programs, and again new budget will be compiled for the next year. 2,000 million pesos program the budget item for 2002, which is 60 % less than that for 2001. This budget item is not stable, depending on temporal policy for prevention and attention of disasters.

When a large disaster occurs diverting of budget will be needed. Diversion of budget without change of total sum can be done flexibly by the decision of Directive Board and approval of Secretariat of Finance. Additional budget needs accordance of Secretariat of Government, Department of Planning, Secretariat of Finance and CONFIS. The District Council for legislation as Accordance will approve the budget plan. Manifestation of Urgency case will be declared by the mayor (Art.42, Law 80/1993) and an extraordinary Council will be convoked.

2.5.4 Cundinamarca Disaster Management System

In accordance with Decree No 919, 1989, the Cundinamarca government enacted the disaster system for Cundinamarca prefecture as Prefecture Decree No. 3019, 1998. The prefecture system for the disaster management is composed of administrative, institutional and supply systems.

1) Administration

(1) Regional Committee for Prevention and Attention of Disaster of Cundinamarca Prefecture (CREPAD)

The CREPAD consists of 14 members from the government of Cundinamarca, the mayor of Bogotá City, representatives of Bogotá City government as well as of the national government. The director of OPAD is the committee's secretary. The responsibilities of the organization are disaster coordination, prevention, and operation and rehabilitation of the affected area. Under the CREPAD three commissions, namely, technical and planning, public education and information, operational and health commissions, are created to support these activities. For the technical and planning commission, the department of planning in Cundinamarca is responsible for the coordination, while public information is the responsibility of the department of education. The coordinator of the operation and health commission is in charge of the civil defense of the Cundinamarca branch.

(2) Office for Prevention and Attention of Emergencies and Disaster of Cundinamarca Prefecture (OPAD)

OPAD is under the Secretary of Government and acts as the professional resource group.

(3) Municipal Committee of Mutual Assistance for Prevention and Attention of Emergencies (CAM)

Through decree 3019 of December 11th of 1998, the Prefecture System for Prevention and Attention of Emergencies is created, as well as other issues. The third article specifies the composition and organization of the System, and makes reference to the Municipal Committee of Mutual Assistance for Prevention and Attention of Emergencies (CAM). So far, such committees have not been regulated and their objectives, mission, scope and organization have not been established.

(4) Local Committees for Prevention and Attention of Municipal Disasters (CLOPAD)

Other organizations in Cundinamarca government also take part in the prefecture disaster management system, such as the planning department in the prefecture and municipalities, commissions and the other organizations, which are related to disaster management.

2) Support organization

a) The funds allocated by the National Fund of Calamity.

b) A fund account for calamities and disasters.

c) A reserve center for emergency attention and immediate response.

d) A radio communication of prefecture network.

e) Territorial entity budgets addressed to disaster prevention and attention.

f) Emergency prefecture network.

g) Technical and material human resources addressed by the nation, the prefecture and the municipalities.

3) Emergency Response Plan

Cundinamarca government also prepared the emergency response plan with cooperation of the operational committee in CREPAD. The objective of the plan is to show the guideline and strategies under emergency situations. The plan provides guideline for procedure, institutional guideline, the resources and organization for emergency situations.

4) Fund for Cundinamarca

Calamity Fund of Cundinamarca is a special account of the prefecture government budget (Art.10, Prefecture Decree 3019/1998). Fund resources are destined to attend inherent tasks of prevention, preparation, mitigation, attention, recuperation and rehabilitation of affected areas or communities. Secretariat of Government manages the Fund, and OPAD directs, coordinates and controls the projects of the Fund. The budget of the Fund (2001) is 370 million pesos for investment out of 570 million pesos in total. There is no other project of prevention of disasters. There is no reserve budget defined to attend immediate response to disasters

2.5.5 Analysis on Key Organizations

1) National Organization

At the national level, the General Direction of National Office for the Attention of Disasters (DGPAD) is the key organization of the disaster management system. The role of the organization is to coordinate related organization at the national level. The national technical committee and the national operational committee are the most important organization for the coordination. At the regional level, the regional committee for the disaster prevention and attention is coordinated by the prefecture organization. The fund for calamity situation was created at the national level for DNPAD as well as rehabilitation of the affected area.

Since DGPAD is attached to the Ministry of Interior, approximately half of the staff comes from the ministry. The rest are working on contract bases and are paid from the national disaster fund. DGPAD intends to facilitate information networking in disaster situations and provide links

among the central government ministries and agencies, as regulated by Decree 919, 1989, but it is facing insufficient financial resource to complete the information system.

2) Direction of Prevention and Attention of Emergencies (DPAE)

(1) General

The Bogotá City government enacted disaster related law and regulation since 1987. The first step is to create fund for the disaster management system. The summary of the legal background is shown as follows:

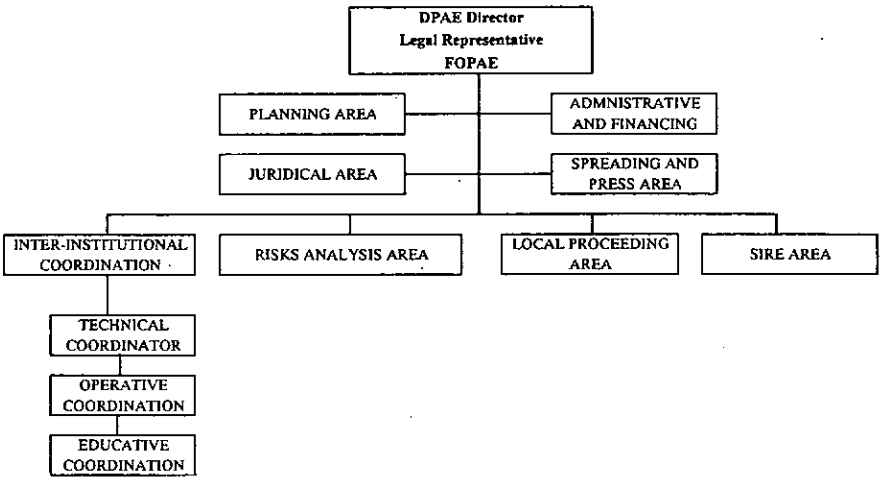
Table 2.5.3 Summary of Legal Background of DPAE

Law and regulation	Description
Agreement 11, 1987	The fund and the coordination office for the prevention and attention of emergencies were created in Bogotá City. The organization is attached to Mayor's office.
Agreement 13, 1990	According to the Agreement 11, 1987, the Agreement 13 puts into operation for the fund and organization.
Decree 652, 1990	This decree regulates the Fund of Prevention and Attention of emergencies in Bogotá.
Decree 657, 1994	This decree assigned the coordination office to carry out technical investigation of the existing risks in Bogotá City.
Decree 951, 1994	The coordination office is restructured to attach the general secretary.
Decree 382, 1995	The Unit of Prevention and Attention of Emergencies (UPES) is integrated into the government secretary's office.
Decree 485, 1996	The ownership is changed form the UPES to the government secretary.
Decree 069, 1999	By the Bogotá City's organizational change, the name is change to Direction of Prevention and Attention of Emergency (DPAE).

The objectives of both FOPAE and DPAE are summarized in Appendix 2.5.3.

(2) Organizational Chart

Since FOPAE does not have its own administrative staff, the director of DPAE is the same as the director of the FOPAE, as shown in the organizational chart of DPAE in Figure 2.5.2.



Source: Prevencion Y Atencion De Emergencias en Bogotá, D.C. 1998 – 2000, P.33 FOPAE

Figure 2.5.2 Organizational Structure of DPAE

DPAE is divided into four sections: technical sub-division, inter-institutional coordination, risk analysis, local community and SIRE, which is the disaster information network in DPAE. The inter-institutional coordination section is further divided into the technical coordination, operation and education. An organizational change is underway based on the new Bogotá City Development Plan, which is formulated in 2001.

(3) Budget and personnel

The budget allocation and spending of DPAE is shown below.

Table 2.5.4 Budget Allocation and Spending in DPAE

(Unit: Million Peso)

Descriptions	1997	1998	1999	2000
Allocation	12,359	19,165	20,099	10,013
Total expense	10,667	17,518	19,774	7,831
Operational expense	180	342	403	347
Investment	10,486	17,176	19,370	7,484
Items				
Improvement of quality of life		5,354	10,050	3,425
Safety and living together		8,553	5,673	1,613
Institutional reform		2,128	1,564	2,413

Source: DPAE

As of 2001, the personnel of DPAE are approximately 100 , yet the permanent staffs are only eight, while the others are on contract bases. The permanent staff is dispatched from the Government Secretary's Office of Bogotá. The personnel of DPAE are composed of several backgrounds (refer to Appendix 2.5.4). Approximately 30 percent of professional are a civil engineer followed by lawyer. The most predominant professional experience is five to ten years of 40 percent, followed by one to five years of 27 percent. More than 90 percent of staff is less than five years experience in DPAE.

3) Office for Prevention and Attention of Disasters (OPAD)

OPAD was established in 1995. The objective of the organization is to coordinate, plan and guide administrative requirements for the disaster prevention, mitigation, preparedness and rehabilitation phase. It also plays an important role during emergency response phase.

The functions of OPAD are regulated by Prefecture Decree No 2186, 1998, Article 12. They are as follows:

- To organize and coordinate the Prefecture system for disaster management.
- To design and advise the actions related to disaster management with reference to the national system.
- To elaborate and keep updated the information on the risk maps of the Prefecture for the contingency plan.
- To develop the knowledge and ability of the Cundinamarca officers for the disaster management; and
- To promote the activity participation and commitment for actions, programs and projects to mitigate the risks.

4) Organization

OPAD is composed of two experts and two technicians. The organizational chart of OPAD is shown below:

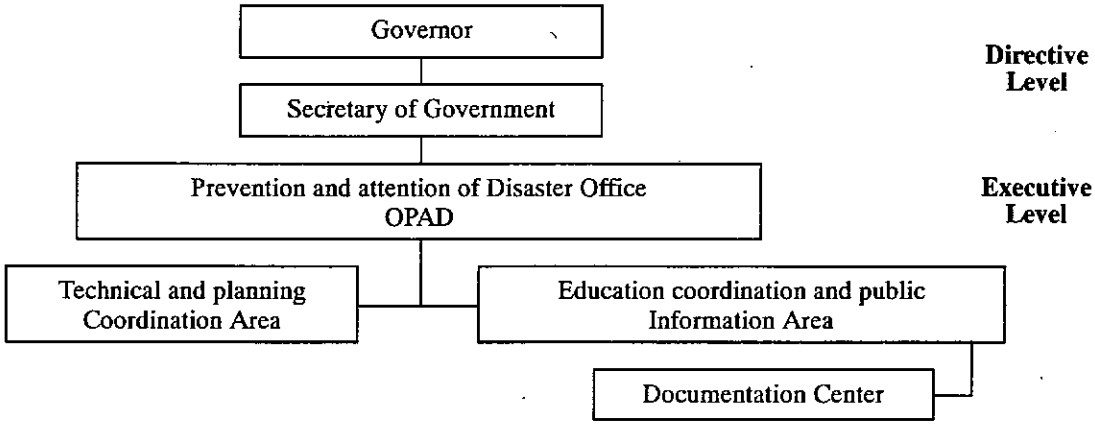


Figure 2.5.3 Organizational Chart of OPAD

The budget for disaster management is distributed among Cundinamarca government organizations.

2.5.6 Problems and Issues of the Disaster Management

1) Unclear Disaster Management Policy and Direction

According to the disaster management, Decree 919, 1989 Article 52, each territorial organization has to prepare its own disaster management plan. To cope with the national laws, the Bogotá City government established Decree 723 of 1999, regulating the disaster management system, and the Cundinamarca government established Decree No. 3019 of 1998. The establishment of laws, however, has not yet contributed in organizing the disaster management system.

DPAE has prepared the basic concepts to deal with disaster management in Bogotá City, but these have not been incorporated into the whole disaster management system. In Bogotá City a new development plan is formulated under the new mayor, and a disaster management plan should follow the concept of the City's development plan.

It is pointed out that a comprehensive disaster management plan is required to include all subjects of the disaster management system in Bogotá. It covers preparedness, emergency response, recovery and reconstruction of the disaster management and recommends program of disaster management. The general plan should prioritize policy alternative based on the disaster management plan as well as program and projects.

2) Improvement of Emergency Response Manual

The emergency response manual is only SUME in the Bogotá City government. The plan of Bogotá City, however, has not been updated since 1995, although the situations of the disaster management system in Colombia have changed recently.

Cundinamarca government also prepared the emergency response plan, which was established by OPAD. The plan is called "Regional Disaster Management System in Cundinamarca." The Regional Committee approves the plan for Disaster Management and Attention and Civil Defense of Cundinamarca.

The cooperation between Bogotá City and Cundinamarca government is little mentioned in the manual and plan. The emergency response system should be reviewed and prepared based on the seismic disaster responses, which are proposed in the Study. The new emergency response plan should consider the Bogotá Metropolitan Area.

3) Insufficient Coordination between Cundinamarca and Bogotá City

Although the Cundinamarca government and Bogotá City government reached an agreement on the disaster management treaty in 1999, the cooperation between the two governments has little progress. It is important for both of the governments, Bogotá City and Cundinamarca prefecture, to establish a coordination mechanism for the Bogotá Metropolitan Area.

2.6 Disaster

2.6.1 Earthquake

1) Existing Situation

(1) INGEOMINAS

Currently, INGEOMINAS has two seismic monitoring systems, national seismological network and national accelerograph network. The features are summarized in Table 2.6.1.

Table 2.6.1 Features of Seismic Monitoring Systems

	National Seismological Network	National Accelerograph Network	Bogota Accelerograph Network
No. of stations	20	120 (30 stations in RAB included)	30 (20 more to be installed in 2003)
No. of stations in study area	2	33 in Bogota	33 in Bogota
Initial operation	N/A	1987	1997
Data transfer	Sattelite, radio	Manually collected	Manually collected. To be connected by radio to DPAE in 2002
Instruments	Wide band 3 components, Short period vertical component	Digital 3+ components (Etna, K2, SSA-1, SSA-2)	Digital 3+ components (Etna, K2)
Object	Epicenter, Magnitude determination	Ground response, seismic design, seismic microzoning	Ground response, seismic design, seismic microzoning
Data publish	Web page, noticed to SNPAD, Red Cross, News agencies	Report, CD, partially on web page	Fully on web page
Owner	INGEOMINAS	INGEOMINAS	UPES
Data process	Automatic and manual processing at INGEOMINAS	INGEOMINAS	By contractor at DPAE
Maintenance	INGEOMINAS	INGEOMINAS, to be localized in the future	INGEOMINAS (untill 2002)

Source: INGEOMINAS, DPAE

A. National Seismological Network

a) Background

National Seismological Network of Colombia is realized by the cooperation by Canadian International Development Agency, United Nation Development Program, Colombian National Company of Telecommunications, and INGEOMINAS. It is operated by National System of Disaster Prevention and Attention to provide information to civil community as well as to scientific associations.

b) Object of Network

The objects of national seismological network are:

- To provide rapid and reliable information about Seismicity via National System of Disaster Prevention and Attention to investigator in earth science, engineers, and community in general.
- To investigate cause and process of earthquake, and to identify seismogenic zones and its potential hazard to the Colombian people.
- To study the propagation of seismic waves, its attenuation, and behavior of rocks and soils under seismic movement.
- To establish an adequate database to help the study of seismic hazard, the update of Colombian code for seismic resistant building and seismic microzonation of the cities.

c) Instrumentation and system

The network has 20 stations in total, one station of wide band three components, and 19 stations of vertical component with short period. The stations are distributed as shown in Figure 2.6.1 and listed as Table 2.6.2. The recording at each station is triggered independently.

The acquired data are transmitted to master station in Bogotá by satellite and radio telemetry in real time in digital form. Two computers, one in operative and one standing by, to secure the redundancy of a system, receive the transmitted data.

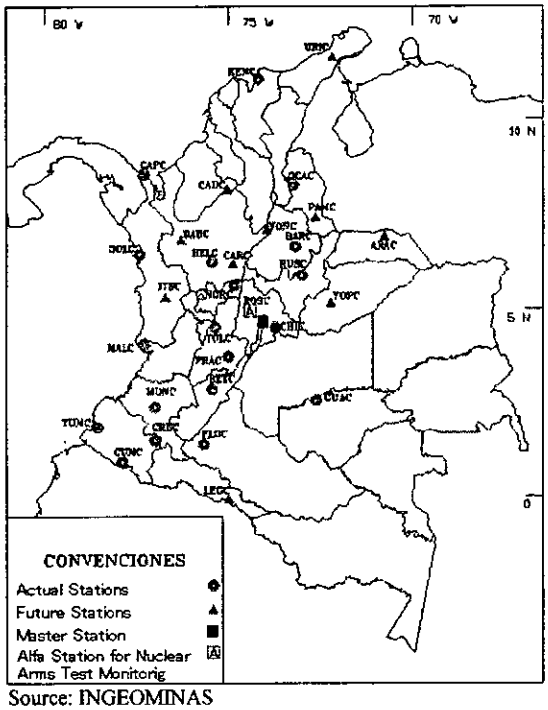
The data transmission system has a capacity of receiving 48 channels at a time. Epicenter is calculated automatically and manually. Determined earthquake locations are plotted by program HYPO71 and LOC.

The system has universal power system to prevent electricity interruption, and has power generator capable to run the system for six days by itself in case of emergency.

d) Data publishing

Determined earthquake parameters are catalogued, and then plotted epicenter distribution are published on INGEOMINAS website using web based mapping system, for a nation wide scale or department scale. Figure 2.6.2 shows an example of seismic activities in Cundinamarca during last nine years. Such information is useful to understand recent seismicity in a given region.

When a major earthquake happens, its parameters are also published on its website. Such report is also sent to related organizations such as National System of Disaster Prevention and Attention, Red Cross, and news agencies etc, to serve as basic information for disaster attention at the time of a major earthquake.



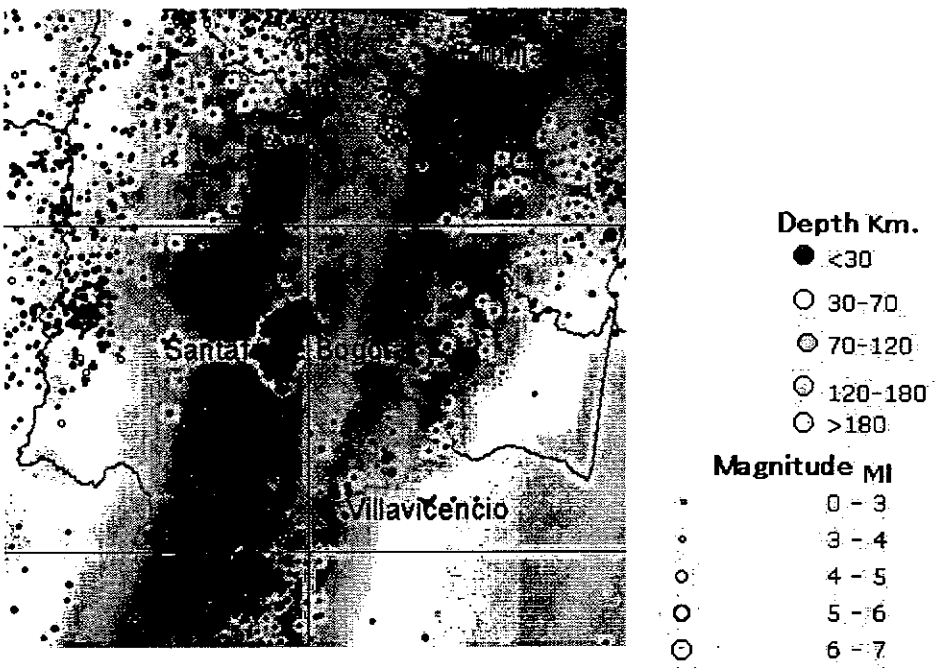
Source: INGEOMINAS

Figure 2.6.1 National Seismological Network Stations

Table 2.6.2 National Seismological Network Stations

Code	Name	Department	Lat. N	Lon. W	Height (m)
HELC	Santa Helena	Antioquia	6.23	75.55	2790
RUSC	La Rusia	Boyacá	5.93	73.08	3360
NORC	Norcasia	Caldas	5.60	74.89	510
FLOC	Florencia	Caquetá	1.51	75.63	360
MUNC	Munchique	Cauca	2.47	76.96	3010
SOLC	Bahía Solano	Chocó	6.37	77.46	50
CAPC	Capurganá	Chocó	8.30	77.20	50
ROSC	El Rosal	Cundinamarca	4.86	74.33	3020
CHIC	Chingaza	Cundinamarca	4.63	73.73	3100
GUAC	San José del Guaviare	Guaviare	2.60	72.68	200
BETC	Betania	Huila	2.68	75.44	540
KENC	Cerro Kennedy	Magdalena	11.11	74.05	2560
OCAC	Ocaña	N. Santander	8.20	73.40	1200
CUMC	Cumbal	Nariño	0.86	77.84	3420
CRUC	La Cruz	Nariño	1.50	76.95	2740
TUMC	Tumaco	Nariño	1.83	78.77	50
BARS	Barichara	Santander	6.64	73.18	1860
PRAC	Prado	Tolima	3.70	74.90	410
TOLC	Nev. Tolima	Tolima	4.59	75.34	2520
MALC	Bahía Málaga	Valle	4.10	77.35	50

Source: INGEOMINAS



Source: INGEOMINAS

Figure 2.6.2 Seismicity in Cundinamarca during June, 1993 to April, 2001

B. National Accelerograph Network

a) Development of network

Motivated by the tragedy by volcanic eruption of Nevado del Ruiz in 1985 that killed over 20,000 lives, members in INGEOMINAS proposed installations of seismological and accelerograph stations in 1987 in order to study, to prevent, and to mitigate natural disasters.

In 1987, INGEOMINAS took charge of maintenance of 18 out of 24 analogue existing accelerograph in Colombia. In 1993 the project of Colombian national accelerograph network had started under the support of National Foundation of Calamity via United Nations Development Program and INGEOMINAS.

In the beginning, INGEOMINAS, which is in charge of the project, purchased 35 digital accelerographs and installed 17 stations in lines of east west. In 1994, rest of 18 stations was installed in northeastern part of the country. During 1995, five more complementary stations were installed.

The network had recorded major earthquakes such as Tauramena earthquake (ML=6.5) in January 19 1995, and Calima earthquake in February 8, 1995 (ML=6.2). In 1996, 52 digital accelerographs (ETNA) were purchased.

b) Objects of network

The objects of national accelerograph network are the followings:

- To record intensive earthquakes in Colombian territory by operation and maintenance of national network and portable network.
- To offer processed earthquake information to serve as basis of seismic hazard study in national level
- To provide necessary information to maintain and update parameters for Colombian seismic resistant design code for construction
- To promote study of seismic microzonation in local level

c) Instrumentation of network

The national accelerograph network has currently 120 stations in total, among which 30 exists in Bogotá operated under conventions with DPAE. Besides, there are 22 accelerographs in Medellín and 5 in Pereira operated by another entities.

The instruments of National accelerograph are products of KINEMETRICS, such as SSA-1, SSA-2, and SSA-2MC with resolution of 12 bits, ETNA with resolution of 18 bits and K2 with resolution of 19 bits. ETNA and K2 has a PCMCIA memory card of 1 to 5 Mbytes capacity for recording.

The instrument at one station costs approximately 10,000 USD, and installation of housing costs about 1,000 USD.

Among them, at Tumaco station along the pacific coast, a piezo meter is included with the system so that it can record the change of pore water pressure during possible liquefaction phenomena.

d) Service of network

The national accelerograph network provides services as followings:

- To publish annual bulletins of strong motions with information of accelerogram and response spectra.
- To realize study of aftershock of intensive earthquake through operation of portable accelerograph network.
- To realize a study to evaluate the effect of ambient vibrations different from earthquake.
- To realize a study of microtremor to characterize dynamic properties of subsoil for the study of seismic microzoning.

- To satisfy consultation for scientific community, college students, universities, community in general.
- To install local networks.

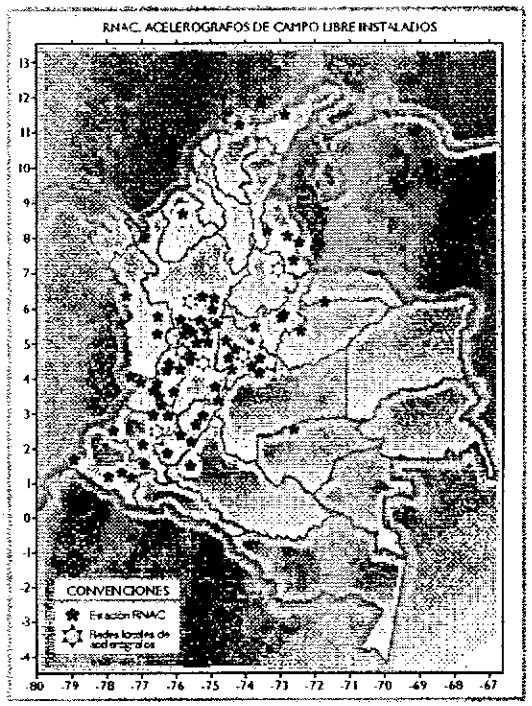
The national Accelerograph Network Stations are shown in Figure 2.6.3, and those in Cundinamarca are listed in Table 2.6.3.

e) Records of network

The observed records are processed and published in its printed report; "Bulletin of strong motion" Recorded data are also available in digital form. There are three volumes published since 1993. Major events are also published in its web site.

f) Maintenance of network

INGEOMINAS maintains all the stations by themselves in every four months, spending four hours per stations by specially assigned staffs.



Source: INGEOMINAS

Figure 2.6.3 National Accelerograph Network Stations

Table 2.6.3 National Accelerograph Network Stations in Cundinamarca Department

No	Stration name	Station code	Model	Lat. N	Lon. W	Geology	Topography	Owner
1	ANAPOIMA	CANAP	ETNA	4.586	-74.518	Rock	Waved	INGEOMINAS
2	ARBELAEZ	CARBE	ETNA	4.280	-74.430	Rock	Waved	INGEOMINAS
3	BOGOTA, INGEOMINAS	CBOG1	K - 2	4.642	-74.080	Rock and soil	Plane	INGEOMINAS
4	GAVIOTAS	CBOG2	ETNA	4.640	-74.080	Colluvion	Waved	INGEOMINAS
5	EMBALSE DE CHINGAZA (Galería)	CCHIN	ETNA	4.554	-73.631	Rock	Tunnel	INGEOMINAS
6	EMBALSE DE FÚQUENE	CFQNE	ETNA	5.472	-73.739	Rock	Waved	INGEOMINAS
7	GUADUAS	CGUAD	ETNA	5.065	-74.590	Rock	Waved	INGEOMINAS
8	QUETAME	CQUET	SSA - 2	4.328	-73.861	Rock	Waved	INGEOMINAS
9	EL ROSAL	CROSA	ETNA	4.848	-74.326	Rock	Waved	INGEOMINAS
10	EMBALSE SAN RAFAEL (Túnel)	CSRA1	SSA - 1	4.704	-73.986	Rock	Tunnel	EAAB
11	EMBALSE SAN RAFAEL (Cresta)	CSRA2	SSA - 2	4.737	-73.986	Soil	Plane	EAAB

Source: INGEOMINAS

(2) DPAE

Since 1997, DPAE began installation of accelerograph in Bogotá by convention with INGEOMINAS. DPAE's netowork is part of national accelerograph network.

A. Object of network

The objects of the network are followings:

- To register earthquakes felt near Bogotá.
- To process and analyze the recorded information
- To compare the result with the study of seismic microzoning in Bogotá
- To establish a database for the organization of recorded information

B. Instrumentation

The distribution of stations together with geotechnical zone is shown in Figure 2.6.4. The location and its characteristics of each station are listed in Table 2.6.4.

Two stations have simultaneous observation system at ground surface and borehole.

Among them, six stations have GPS clock system to assure the absolute timing in the record. Clock at other stations are calibrated at the time of maintenance.

C. Maintenance

Maintenance of the network is currently done once in every four months by INGEOMINAS through convention with DPAE. However, by the time the convention expires in 2002, DPAE will be likely to have its responsibility of maintenance.

D. Obtained records

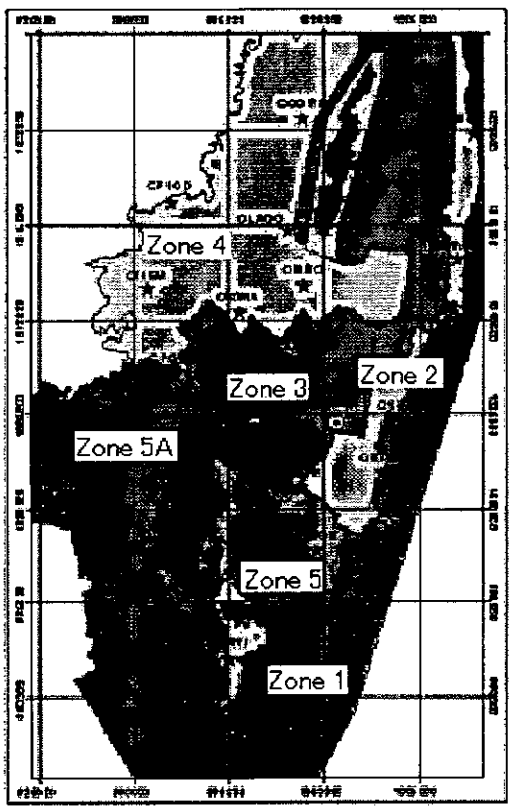
Since its installation in 1997, the network has recorded 66 records of 17 earthquakes as shown in Table 2.6.5. The magnitude of recorded events varies from 4.43 to 6.35, and epicenter distance varies from 45 to 499 km. There records are published in SIRE, a web site for DPAE.

E. Subsoil study at stations

Two stations have borehole study during the period of microzoning study of Bogotá in 1997, to study shear wave velocity of subsoil.

INGEOMINAS executed microtremor measurements at all the accelerograph sites in Bogotá. They then compared predominant period of microtremor with predominant period of the 20 sites obtained from 32 earthquake records during the period from 1994 to 2000.

The result of comparison is illustrated in Figure 2.6.4 according to the geotechnical zone defined in MZSB97. The predominant period varies from 0.2 second to 1.2 second, which reflects the thickness of subsurface soil. The predominant period of microtremor and that of earthquake has a good correlation in general, which shows the usefulness of microtremor measurement to evaluate the predominant period of ground.



Source: INGEOMINAS

Figure 2.6.4 Location of Accelerograph in Bogotá and Geotechnical Zone

Table 2.6.4 Location and Characteristics of Accelerograph Stations in Bogotá

No.	Station name	Code	Lat. N	Long. E	Geology	Geotechnical zone*	Topography	Model
1	Escuela de Ingeniería	CEING	4.7833	-74.0458	Soil	3	Plane	ETNA
2	Universidad La Salle	CUSAL	4.7559	-74.0264	Soil	2	Plane	ETNA
3	Colegio Fernando Mazuera	CBOSA	4.6066	-74.1920	Soil	1	Plane	ETNA
4	Universidad Corpas	CCORP	4.7617	-74.0940	Soil	4	Plane	ETNA
5	Universidad Agraria	CUAGR	4.7542	-74.0527	Soil/Rock	3	Plane	K-2
6	Academia de Policía	CPSUB	4.7379	-74.0726	Rock	2	Waved	ETNA
7	Colonia Escolar de Usaquén	CUSAQ	4.7064	-74.0332	Soil	2	Plane	ETNA (GPS)
8	Escuela de Caballería	CESCA	4.6822	-74.0332	Soil	1	Waved	ETNA
9	Banco de La República	CBANC	4.7085	-74.0791	Soil	3	Waved	ETNA
10	T.V. Cable	CTVCA	4.7181	-74.0848	Rock	1	Waved	ETNA (GPS)
11	Parque La Florida	CFLOD	4.7295	-74.1464	Soil	4	Plane	ETNA
12	Avianca	CAVIA	4.6858	-74.1190	Soil	4	Plane	ETNA
13	Fontibón	CFONT	4.6607	-74.1454	Soil	5A	Plane	ETNA
14	Centro de Estudios del Niño	CNIÑO	4.6962	-74.0932	Soil	4	Plane	ETNA
15	Jardín Botánico	CJABO	4.6665	-74.0993	Soil	3	Plane	ETNA
16	Colegio San Bartolomé	CBART	4.6205	-74.0620	Rock	1	Waved	ETNA
17	Universidad Manuela Beltrán	CUNMA	4.6415	-74.0563	Soil	1	Waved	ETNA
18	Hospital San Juan de Dios	CDIOS	4.5899	-74.0888	Soil	5	Plane	ETNA (GPS)
19	CITEC	CCITE	4.6395	-74.1131	Soil	3	Plane	ETNA (GPS)
20	Club El Tiempo	CTIEM	4.6943	-74.1558	Soil	4	Plane	ETNA
21	Parque Timiza	CTIMI	4.6084	-74.1511	Soil	5A	Plane	ETNA
22	Parque El Tunal	CTUNA	4.5753	-74.1313	Soil	5A	Plane	ETNA
23	Escuela de Artillería	CARTI	4.5468	-74.1234	Soil	2	Plane	ETNA
24	Bomberos La Marichuela	CMARI	4.5117	-74.1171	Soil	1	Plane	ETNA
25	Colegio Sierra Morena	CSMOR	4.5746	-74.1701	Rock	1	Waved	ETNA
26	Escuela de Tejedores	CTEJE	4.6149	-74.0951	Soil	5	Plane	ETNA (GPS)
27	Tanques de Vitelma	CVITE	4.5750	-74.0716	Soil	1	Waved	ETNA
28	Colegio Laureano Gómez	CLAGO	4.7180	-74.1003	Soil	4	Plane	ETNA (GPS)
29	Escuela General Santander	CGRAL	4.5881	-74.1301	Soil/Rock	5A	Plane	K-2
30	Radionet	CRADI	4.6465	-74.1694	Soil	5A	Plane	ETNA
National Network								
1	Bogotá, INGEOMINAS	CBOG1	4.6418	-74.0803	Soil/Rock	3	Plane	K-2 (GPS)
2	Gaviotas	CBOG2	4.6014	-74.0599	Coluvión	1	Waved	ETNA
3	Juan	CJUAN	4.7050	-74.1200	Soil	4	Plane	ETNA

* Geotechnical zone accroding to Seismic Microzoning in Bogota, 1997

Source: SIRE

Table 2.6.5 Recorded Earthquakes by Accelerograph Network of Bogotá

No.	Date	Time (GMT)	Earthquake	Magnitude (Ml)	Depth (km)	Lat. N	Lon. E	Hipocenter Distance (km)*	Epicentral Distance (km)*	No. of recorded stations
1	1999/1/25	18:19	Córdoba (Quindío)	6.2	0	4.44	-75.71	182.6	182.6	4
2	1999/1/25	22:04	Córdoba (Quindío)	5.4	0	4.41	-75.73	187.0	187.0	1
3	1999/4/14	7:26	Nido de Bucaramanga	6.13	170	6.82	-73.14	313.9	263.8	2
4	1999/5/15	10:20	Pulí (Cundinamarca)	4.82	18.74	4.67	-74.75	76.9	74.5	1
5	1999/6/1	21:42	Guayabetal (Cundinamarca)	5.21	0	4.29	-73.73	50.4	50.4	4
6	1999/6/10	3:22	Quetame (Cundinamarca)	4.67	2.04	4.31	-73.79	45.9	45.9	1
7	1999/7/17	12:23	Sativasur (Boyacá)	5.59	0	6.1	-72.74	206.2	206.2	7
8	1999/11/8	5:52	Betulia (Santander)	6.51	160	6.92	-73.18	302.2	256.4	21
9	2000/1/17	12:21	Fortul (Arauca)	5.87	1.06	6.64	-72.02	319.2	319.2	1
10	2000/2/5	21:53	Nido de Bucaramanga	6.02	160	6.77	-73.21	289.1	241.0	3
11	2000/5/24	1:05	Pulí (Cundinamarca)	4.43	0.64	4.76	-74.67	66.9	66.9	1
12	2000/9/12	10:55	Nido de Bucaramanga	5.92	160	6.76	-73.18	289.3	241.0	3
13	2000/11/8	7:01	Juradó (Chocó)	6.35	1.25	7.13	-77.94	499.2	499.2	3
14	2000/11/24	19:51	Nido de Bucaramanga	5.69	160	6.79	-73.02	297.9	251.3	2
15	2000/12/17	6:14	Nido de Bucaramanga	5.82	152.82	6.77	-72.97	294.1	251.2	9
16	2001/5/3	16:14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1
17	2001/5/18	15:04	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
	Total									66

* Minimum distance to stations

Source: SIRE

Source: "Period de vibracion fundamentales del suelo, en las estaciones de la Red de Accelerografos de Bogotá", 2001, Samuel Alexander et. al.., INGEOMINAS

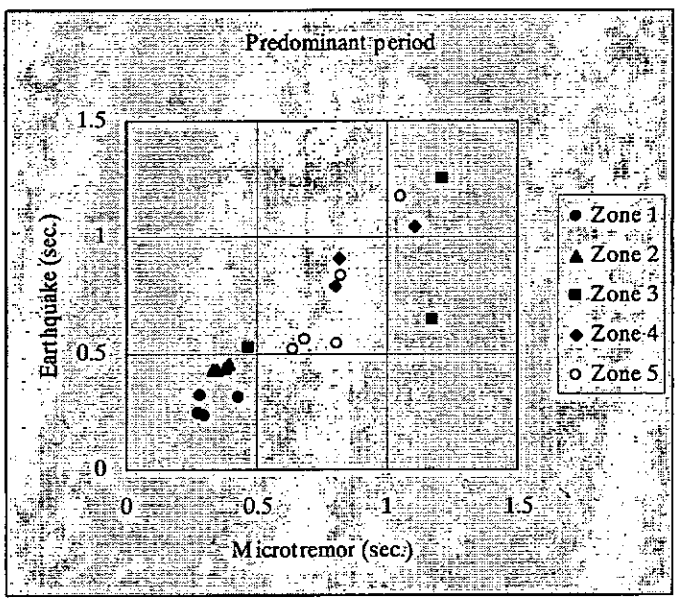
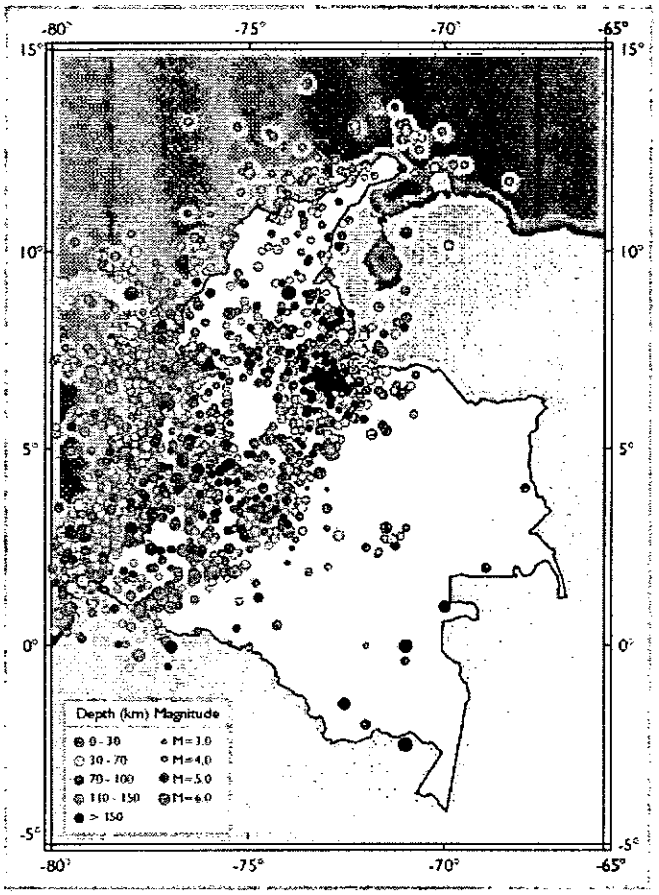


Figure 2.6.5 Comparison of Predominant Period of Microtremor and that of Earthquake

2) Seismicity in Colombia

Seism city in Colombia is high due to its tectonic environment. Figure 2.6.6 shows distribution of epicenters of the selected earthquakes that occurred between 1500-1994.



Source: Microzonificacion sismica de Bogotá City, INGEOMINAS, 1997

Figure 2.6.6 Distribution of Epicenters in Colombia from 1500-1994

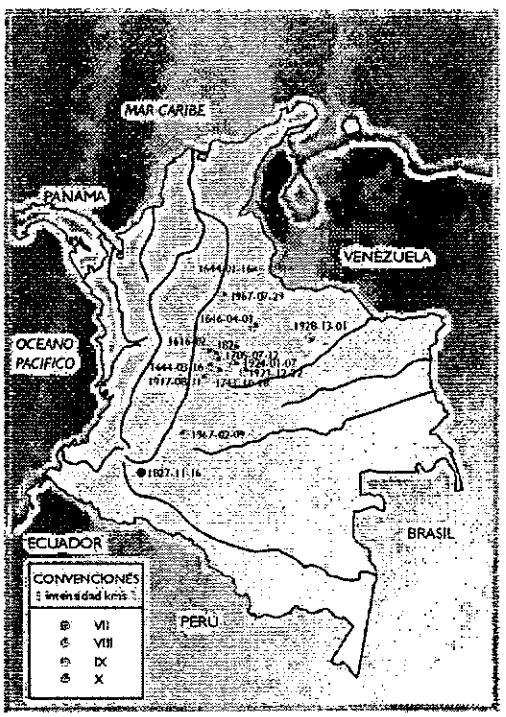
In Colombia, two types of earthquakes should be taken into account: One is the inter-plate earthquake generated from subduction movement between the Nazca plate and the South American plate. This type of earthquake is expected to have a Magnitude around 8, thus it would affect an extensive area of Colombia. The focal depth of these events deepens from west to east, reflecting the subduction of the Nazca plate beneath the South American plate.

The other type is an intra-plate earthquake, which is generated from faults within the plate. Active or potential faults exist elsewhere in Colombia as a result of tectonic settings. Due to intra-plate seismic activities for the active faults along the Cordillera Oriental, the seism city in the eastern part of Colombia is as high as the coastal area. Even if the magnitude of event for this type is relatively small, it can be damaging due to the short distance from the fault to major urban area.

3) Seismcity in the Study Area

Figure 2.6.7 and Table 2.6.6 shows a list of major seismic events that have affected Bogotá since its foundation in the sixteenth century.

Bogotá has experienced ground shaking of MSK intensity[2-6-1] VIII three times and VII four times. In this sense, the recurrence period for Bogotá of event having intensity VIII is from 42 years to 90 years, whereas for the event with intensity VII is from 44 years to 97 years.



Source: Microzonificación sísmica de Bogotá City, INGEOMINAS, 1997

Figure 2.6.7 Epicenters of Major Earthquakes that have Affected Bogotá

[2-6-1] MSK intensity VII: 50 gal - 100 gal; MSK intensity VIII: 100 gal - 200 gal

Table 2.6.6 List of Major Earthquakes that have Affected Bogotá

Year	Month	Date	Latitude	Longitude	Maximum Intensity	Intensity in Bogotá	Epicentre
1616	2	--	5.00	74.00	VII		Cajicá
1644	1	16	7.40	72.70	IX	VI	Pamplona
1644	3	16	4.50	74.00	IX		Chipaque
1646	4	3	5.70	73.00	VIII		Sogamoso
1743	10	18	4.40	73.90	VIII	VII	Páramo de Chingaza
1785	7	12	4.70	73.80	IX	VIII	Páramo de Chingaza
1826	6	17	4.80	73.90	VIII	VII	Sopó
1827	11	16	1.90	75.90	X	VIII	Timaná
1917	8	31	4.26	74.15	IX	VIII	Páramo de Sumapaz
1923	12	22	4.40	73.20	VIII	VII	Paratebueno
1924	1	7	4.70	73.50	VIII		Gachala
1928	11	1	5.50	71.50	VII		El Milagro
1967	2	9	2.93	74.00	IX	VII	Los Cauchos
1967	7	29	6.84	74.09	VIII	VI	Chucurí

Source: Microzonificación sísmica de Bogotá City, INGEOMINAS, 1997

4) Mitigation measures currently done

As described in the next chapter, Bogotá municipality completed the first seismic microzoning study conducted in Colombia in 1996 including rough risk analysis. The result of the study has been published in various media such as booklet, video and web page for the purpose of educating the public. However, due to the limitation of finance, its circulation is rather limited.

Further, University of Los Andes has extended risk study for infrastructures such as gas pipelines, roads and hospitals for the emergency preparations.

Besides, DPAE will have a network of 30 strong motion observation stations in Bogotá within the next five years. The network will, once completed, greatly contribute to the knowledge of seismic response within Bogotá, and provide information for emergency response activities in the event of a major earthquake in the future.

2.6.2 Landslide

1) General

Landslide is a form of slope disasters. Generally, there are three forms of slope disasters as follows:

Landslide: Rotational and translational movement of soil and rock mass.

Flow: Movement of soil or weathered rock in surface, including rapid movement such as debris flow.

Fall: Fall or collapse of rock mass from steep slope.

Although these forms of slope disasters are called landslide in this Study, they, however, are usually distinguished in a narrow sense.

Damages common to landslides are the collapse or serious deformation of buildings, structures or facilities due to the external force caused by the landslide. Sometimes buildings, structures or facilities are buried underneath tons of earth or loses much of their function.

On the other hand, rock falls, debris flows and slope collapses tend to connect with human loss or casualties. Therefore, there is a need to consider some different characteristics of damage of slope disasters by their forms.

In this Study, a survey on landslide hazard areas has been conducted for the eight municipalities in Cundinamarca prefecture based on the existing survey results of Bogotá City that was carried out by 1998. A supplemental survey of landslide disasters occurred after 1998 and an assessment of the landslide hazard areas were carried out for Bogotá City in order to prepare basic materials for the preparation of disaster prevention plan for the Bogotá Metropolitan Area.

2) Existing Situation

Landslides in Bogotá are generally distributed at steep slopes in the eastern part of the Bogotá, which are generated due to the Bogotá fault, according to the material of *Prevencion y Atencion de Emergencias en Bogotá*, D.C./1998-2000 (FOPAE) (see Appendix 2.6.1).

Such material as mentioned above was not accumulated for the eight municipalities in Cundinamarca. Outlines of the slope hazard areas which have been surveyed, are summarized below.

(1) Bogotá

There is evidence of landslide on the slopes of the eastern and southern areas. Many of the landslide events are located at the wasted quarries, but not many on the natural slopes. The slopes are covered by residential buildings, but the main portions of the slopes causing landslides are natural slopes.

(2) Chía

Evidence of landslides distributes at the slopes of Majuy mountain located in the suburbs of Chia. The slopes are formed by fault and relatively steep but gradual at the foot of the slopes due to detritus. No slope and evidence of landslides are found in the urban area.

(3) Cota

Cota is the city next to Chia. No slope and evidence of landslide are found in the urban area. But evidence of landslide distributes at the east side slope of Majuy mountain. There are quarries in operation and wasted quarries at the foot of the slopes.

(4) Facatativá

Earth flows of small scale exist at a small hill located in the east of the urban area. Same scale of earth flows is identified at El Aserradero Hill in the south but there is no protective facility due to the presence of pasture area.

(5) Funza

There is no slope in the city.

(6) La Calera

There is evidence of earth flows on both the slopes along the Teusaca River, which flows northward in the urban area.

Landslide areas are scattered at both the slopes along the Blanco River located at the eastern part of the city. There are some wasted quarries, from which houses are located far.

(7) Madrid

There is no slope in the urban area. There is no prominent evidence of landslide at Majuy mountain because it becomes low at the northern part of the city.

(8) Mosquera

There is no slope in the urban area and no prominent evidence of landslide at the slopes of Las Lajas and Terreros mountain. However, there are slope hazard areas, where residential buildings are located at the wasted quarries in the southern part of the city.

(9) Soacha

The slope collapse hazard areas are found at the wasted quarries at Lajas Hill in the vicinity of the southern urban area. In January 2000 a landslide occurred at the north west end of Terros Hill, located near at the boundary of Bogotá City, and houses are gathered in the upper area close to the landslide hazard area.

There are large scale quarries along the Soacha River and there some houses exist.

3) Historical Record of Landslides

A historical record of environmental disasters in Cundinamarca in the past (1923-1997) shows that the highest events in number are of inundation and followed by that of landslide, according to "*Catalogo de desastres ambientales de Cundinamarca Gobernacion de Cundinamarca*, INGEOMINAS, 1997" (refer to Table 2.6.7).

Table 2.6.7 Human Damage due to Ambient Disaster in Cundinamarca (1923-1997)

		Human damage		
Event type	No. of event	Dead	Injured	Affected
Earthquake	68	40	107	915
Innudation	248	16	18	514,931
Flood	57	82	28	5,933
Fire	46	8	1	1,550
Contamination	11	0	0	0
Landslide	121	783	33	9,719
Hurricane	20	4	13	2,001
Dries	16	0	0	0
Tempest	60	13	7	795
Total	647	946	207	535,844

Source: Catálogo de desastres ambientales de Cundinamarca Gobernación de Cundinamarca, INGEOMINAS, 1997

However, the events of landslides claimed 82 % of the total casualties. The victims of landslides in the past (1923-1997) were mainly caused by slope collapses and falls at the wasted quarries. But only one victim is recorded due to the landslide in the last five years. Therefore, present disaster prevention manner is considered advanced with the improved communication and the systematic measures, unlike in the past where there was a shortage of them.

Landslides due to earthquake has not been an issue in the past five years including the 1999 Quindío earthquake, but it is to be considered that a landslide occurs in an earthquake, depending on the distance from the epicenter or the scale of the earthquake.

Due to the slope disasters currently observed in Bogotá, most of them were caused by landslides, secondary rock fall and flows (refer to Table 2.6.8). However, risk of disaster potential by rock fall and flows is higher than the other forms of slope disaster.

Table 2.6.8 Investigation of Disaster Activity in Bogotá

	Landslide	Fall	Flow
Disaster of potential	16	27	3
Historical disaster	267	55	36
total	283	82	39

Source: Result of the Study

The relation between precipitation and landslides is anticipated, but a quantified relation is not yet established due to insufficient observation data of precipitation. Precipitation gauges have been installed to cover the southern part of Bogotá City since October 2000. As a result of the investigation during the Study, it is found that 282 landslide events were considered to be caused by precipitation and 238 landslide events caused by human factors (refer to Table 2.6.9). The

most prominent human factor is infiltration of sewerage, which is considered to be responsible for 175 landslide events. It means groundwater to be related with the landslide events.

Table 2.6.9 Trigger of Disaster in Bogotá (1996-2001)

Trigger			Historical disaster	Disaster of potential
Natural factor			281	33
	Earthquacke		0	0
	Rain		282	33
		Erosion	64	22
		Saturation of groundwater	38	3
		unknown	189	10
Human factor			238	21
		Deforestation	49	5
		Discharge of water	176	11
		Excavtion	121	9
		Overload	28	0

Source: Result of the Study

Table 2.6.10 shows that San Cristobal has been suffered from many landslides and earth flows and Rafael Uribe has been suffered from many rock falls. Table 2.6.11 shows heavy human damages and structural damages in terms of high numbers of injured people and collapsed houses. About 70% to 80 % of the slope disasters are due to landslide and those due to rock fall follow (refer to Table 2.6.12).

Table 2.6.10 Disaster Events of Each Locality in Bogotá

Disaster type	Locality								total
	Usaquen	Chapinero	Santa fe	San Cristobal	Usme	Suba	Rafael Uribe Uribe	Ciudad Bolivar	
Landslide	22	16	47	64	35	8	47	44	283
Fall	15	6	8	7	7	0	28	11	82
Flow	3	1	4	20	6	0	5	0	39
total	40	23	59	91	48	8	80	55	404

Source: Result of the Study

Table 2.6.11 Damage or Protection Object in Bogotá

		Historical Disaster	Disaster of Potential
Damage of Life		98	2
	Death	1	0
	Injuring	97	2
Damage of Structures		225	3
	House	200	2
	Road	37	0
	Aquaduct	5	0
	Sewer System	7	0
	Bridge	0	0
	Energy	9	0
	Other	0	1

Source: Result of the Study

Table 2.6.12 Recent Change of Disaster Type in Bogotá

Year	Landslide	Fall	Flow	Total
1996	18	1	1	20
1997	19	18	1	54
1998	53	23	12	80
1999	110	25	15	139
2000	53	12	9	71
2001	8	2	1	8
Toal	261	81	39	372

Source: Result of the Study

4) Mitigation Measures

(1) Present status of the countermeasures against landslide disaster

In San Martin, houses were relocated from near and around the scarp and the concrete spraying has been done at the scarp in order to secure stability and to use the area as a park. Also, the houses at the foot of steep slopes along the upstream valley have been relocated. Table 2.6.13 shows the number of affected families in Bogotá City from 1998 to 2000. As shown in the table, it is understood that the relocation is the main portion of the prevention work. The prevention cost per family is 4.9 million pesos and the cost related with relocation is 8.8 million pesos, which includes the costs for detailed investigation, demolition, construction and other expenses.

Table 2.6.13 Recent Change of Relocation of Families in Bogotá

Year	site number	Landslide	Fall	Flow
1996	0	0	0	0
1997	5	5	0	0
1998	19	10	5	4
1999	54	42	8	4
2000	27	20	3	4
2001	1	1	0	0
Total	103	74	16	13

Source: Result of the Study

As mentioned above, DPAE conducted an investigation and evaluation of the present stability of the slopes in highly hazard areas where many people have already lived. DPAE also exerted effort to judge whether relocation is necessary or not by the evaluation result. It was somewhat easy for DPAE to obtain information on landslide in the initial stage from the inhabitants and the early information facilitated taking appropriate measures in the early stage.

Table 2.6.12 and 2.6.13 show the recent numbers of disasters and hazard areas as well as number of families necessary to be relocated respectively, which are tabulated by the JICA survey.

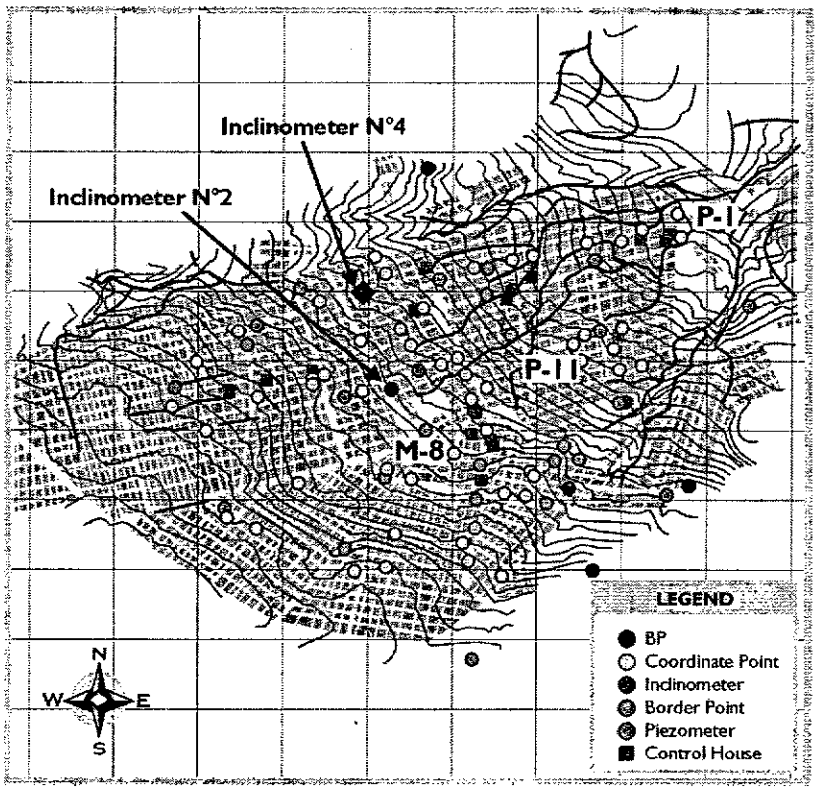
Also, it is considered that relocation of houses is more economical than implementing countermeasures at the hazardous sites. It is obtained by comparing Tables 2.6.12 and 2.6.13 that almost one-third of countermeasures pertain to relocation.

(2) Discussion of countermeasures for landslides

Although a monitoring system is not installed or operated, people near dangerous landslide areas could predict, to some extent, the occurrence of a landslide at an early stage. If the information were announced to the organization concerned, the proper countermeasures would be implemented. The recognition of hazard areas is the main activity taken in the present mitigation measures.

A landslide hazard map of Bogotá City prepared by DPAE shows three risk levels, shown in Appendix 2.6.1. During the Study landslide hazard area map has been prepared for the eight municipalities through the site survey, but a simple hazard map indicating the name or location instead of showing hazardous areas.

Measures and evacuation can be performed in Bogotá City before a landslide disaster, because the city has many experiences of landslide disasters and recognizing any unusual changes of slopes can be relatively done at an early stage due to the overlap of hazardous slopes and urban area (refer to Appendix 2.6.1 and Figure 2.6.8). But the main point is to raise the inhabitant's concern with landslide disasters, which prevails over installation of much monitoring equipment.



Fuente: Pagina inicial de DPAE

Figure 2.6.8 Landslide Monitoring Site Map (Ciudad Bolivar Carbonera)

(3) Present status of slope monitoring

In Bogotá City, monitoring equipment has already been installed at four landslide areas where accumulated movement was recognized and monitoring has been performed at around 15days interval. But the criteria for warning or evacuation are not yet made.

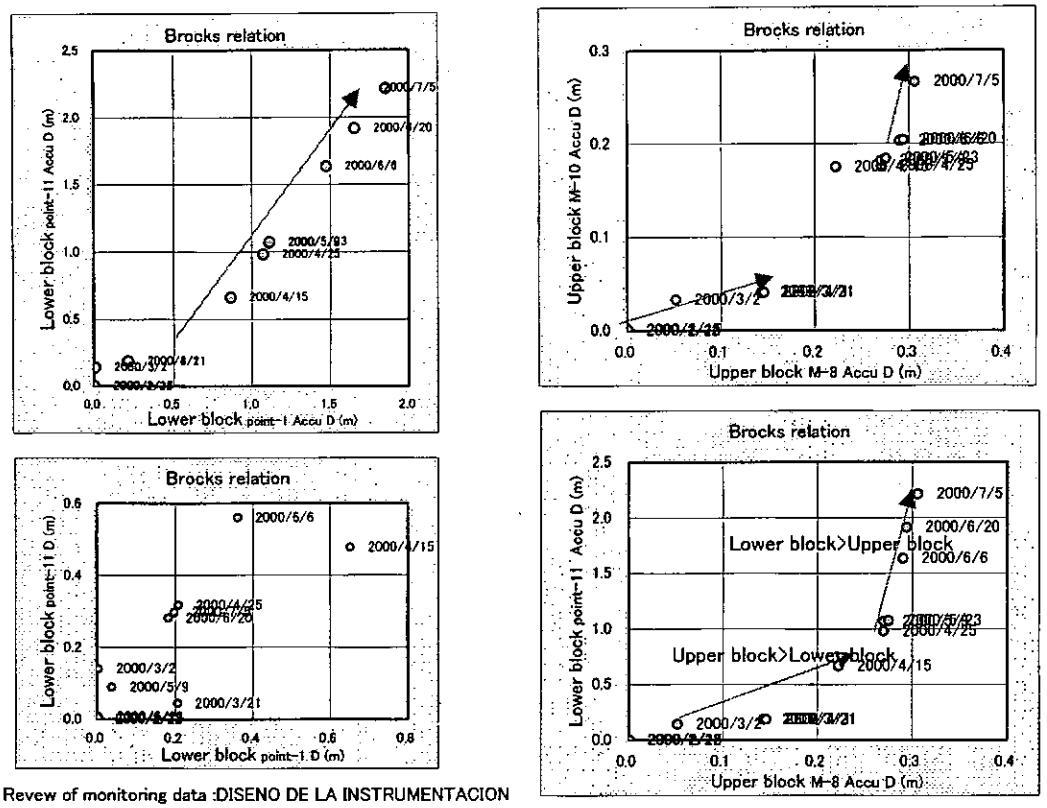
Movement of land began at Carbonera in Ciudad Bolivar in 1997 and houses were removed as the result of detailed investigation. Movement of 2m was confirmed at the monitoring in 2000. It is understood that movement of upper soil block stimulates that of lower soil block by analyzing the relative movement of both soil blocks in relation to time (refer to Figure 2.6.9 and Table 2.6.14) The behavior of landslide is evaluated well by proper analysis of monitoring data in such a manner as mentioned above.

Table 2.6.14 Review of Landslide Monitoring Data Analysis in Ciudad Bolivar Carbonera

	Lower block point-1 (m)			Lower block point-11 (m)			Upper block M-8 (m)			Upper block M-10 (m)		
Date	D	Accum D?	Accum D	D	Accum D?	Accum D	D	Accum D?	Accum D	D	Accum D?	Accum D
2000/1/22	0	0	0	0	0	0	0	0	0	0	0	0
2000/2/2	0	0	0	0	0	0	0	0	0	0	0	0
2000/2/15	0.003	0.002	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
2000/3/2	0.004	0.006	0.007	0.14	0.106	0.141	0.051	0.05	0.052	0.032	0.032	0.033
2000/3/21	0.206	0.141	0.213	0.044	0.138	0.185	0.091	0.053	0.143	0.008	0.024	0.041
2000/4/1	0.001	0.142	0.214	0	0.138	0.185	0.003	0.051	0.146	0	0.024	0.041
2000/4/15	0.651	0.384	0.865	0.478	0.433	0.663	0.076	0.028	0.222	0.134	0.154	0.175
2000/4/25	0.208	0.61	1.073	0.317	0.688	0.98	0.048	0.072	0.27	0.001	0.152	0.176
2000/5/9	0.037	0.642	1.11	0.088	0.776	1.068	0	0.072	0.27	0.006	0.148	0.182
2000/5/23	0.004	0.639	1.114	0.006	0.781	1.074	0.005	0.076	0.275	0.002	0.146	0.184
2000/6/6	0.361	1.074	1.475	0.56	1.235	1.634	0.015	0.063	0.29	0.019	0.152	0.203
2000/6/20	0.182	1.284	1.657	0.281	1.465	1.915	0.004	0.062	0.294	0.001	0.153	0.204
2000/7/5	0.197	1.521	1.854	0.298	1.714	2.213	0.012	0.059	0.306	0.062	0.107	0.266

D:differential deformation Accum D?:accumuration deformation? Accum D:accumuration deformation

Source: Revew of monitoring data : Diseño de la Instrumentación para el Monitoreo y Seguimiento del Deslizamiento en la Cuenca de la Quebrada la Carbonera ,UPES, Agosto, 2000.



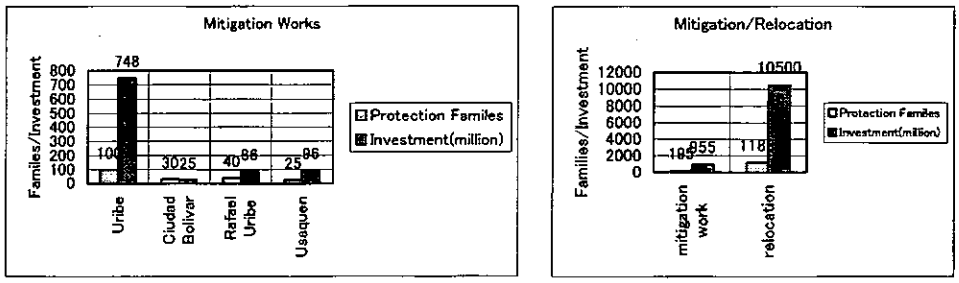
Revew of monitoring data :DISENO DE LA INSTRUMENTACION PARA EL MONITOREO Y SEGUIMENTO DEL DESLIZAMIENTO EN LA CUENCA DE LA QUEBRADA LA CARBONERA ,UPES,Agosto,:
Compiled by JICA study team

Figure 2.6.9 Upper and Lower Block Movement Traced from Landslide Monitoring Data in Ciudad Bolivar Carbonera

In other places, no criteria for alert and evacuation are established for slope monitoring. Monitoring places are very few in contrast to many dangerous places. Moreover monitoring system itself is considered to be at the testing stage and therefore is not introduced into proper disaster countermeasure system.

Table 2.6.15 Investment of Mitigation Works and Relocation in Bogotá (1998-2000)

	mitigation work(1998-2000)					relocation(1998-2000)
Locality	Urib	Ciudad Bolivar	Rafael Uribe	Usaquen	total	Bogota
Protection Familes	100	30	40	25	195	1188
Investment(million)	748	25	86	96	955	10500
I/F	7.5	0.8	2.2	3.8	4.9	8.8



Source: Prevencion & atencion de emergencias en Bogotá,D.C./1998-2000"Por la Bogotá que Queremos"

2.6.3 Flooding

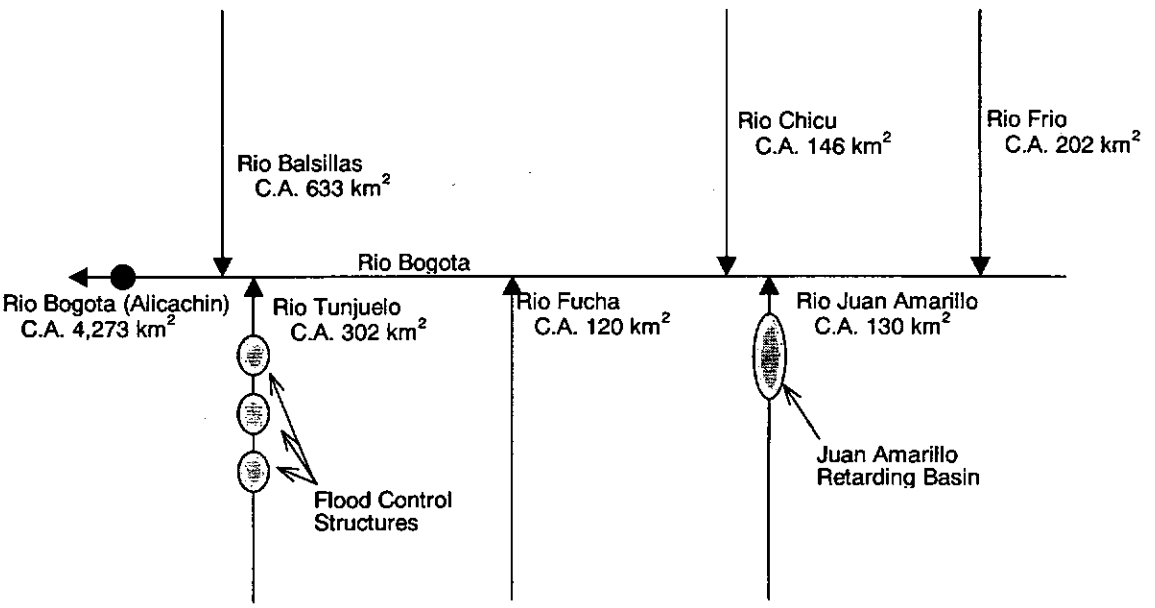
1) River Systems

The largest river in the Study Area is the Rio Bogotá and the area is mostly covered by this catchment. The catchment area of the river at the Alicachín Gate, which is at downstream of Soacha city, is approximately 4,273 km^2. The river flows with a mild slope of less than 1/5,000 near Bogotá City.

Three major tributaries, namely the Rio Juan Amarillo, the Rio Fucha and the Rio Tunjuelo, flow into the Rio Bogotá from the eastern side (Bogotá City area) of the Study Area. All the tributaries have a steep slope near the mountainous area of the city and it changes to a very mild of less than 1/1,000 near the junction of the Rio Bogotá.

Other major tributaries, such as the Rio Furio, the Rio Chicu and the Rio Balsillas are flows into the Rio Bogotá from the western side.

Figure 2.6.10 presents a schematic river system of the Rio Bogotá in the Study Area.



Source: Study Reports of DPAE and EAAB [2-6-2]

Figure 2.6.10 Schematic River System of Rio Bogotá in the Study Area

[2-6-2] Estudios Hidraulicos Geotecnicos y Topograficos para Definir el Nivel de Los Jarillones y Obras Requeridas para Mitigar el Riesgo de Inundacion del Rio Bogotá, en el Tramo Alicachin Humedal la Conejera, Hidroestudios, EAAB

Zonificacion de Riesgo por Inundacion del Rio Bogotá y Propuesta de Acciones para su Mitigacion en la Localidad de Bosa, Mayo 1999, Estudios y Asesorias

Estudio de Zonificacion de Amenaza por Inundacion del Rio Fucha en las Localidades de San Cristobal, Kennedy y Fontibon y Recomendaciones de Mididas de Mitigacion, Abril 2000, Hidroconsulta, FOPAE

Zonificacion de Riesgos por Inundacion del Rio Juan Amarillo, Marzo 1999, Hidrotec

For the management of the Rio Bogotá there are many entities related, but no entity managing it as a river basin. The left bank (East side or Bogotá city side) is under the management of the Bogotá city and EAAB, and the right bank (West side or Cundinamarca side) is under CAR, the municipalities related and Cundinamarca prefecture. It shall be important to arrange or establish an entity for managing water environment of the Rio Bogotá basin, considering the situation of water resources and water quality.

2) Present Flood Situation

The present flood situations of the cities to be studied are summarized in the following Table 2.6.16.

Table 2.6.16 Summary of Flood Situation

	Causes of Problem			Remarks
	by Rio Bogotá (or mainstream)	By tributaries	By poor drainage system	
Bogotá	Yes	Yes	Yes	No overflow from Rio Bogotá is reported since 1976.
Chía	Yes	No	Yes	Rio Frio had a problem before improvement.
Cota	No	No	-	
Facatativa	Yes (Rio Botello)	No	Yes	Less capacity of the river and building construction in low-lying area causes inundation problem.
Funza	No	No	Yes	Problem is a difficulty of drainage to Rio Bogotá.
La Calera	No	Yes (Qda. Toma)	No	The causes of the inundation by Qda. Toma is inappropriate treatment of stream course.
Madrid	No	No	-	
Mosquera	Yes	Yes	Yes	Illegal origin housing has been developed in low-lying area along Rio Bogotá.
Soacha	No	Yes	Yes	No overflow from Rio Bogotá is reported, however, dike of the river was damaged and inundated in 1998.

(1) Rio Bogotá

No severe flood damage along the Rio Bogotá has been reported since 1976. During the 1976 flood, the floodwater overflowed near the junction of the Rio Fucha.

Social and economic activities are mainly concentrated in the eastern side, Bogotá City side, and a small part of the western side (e.g. Porvenir) at present, while the land use is mainly pasture and/or agricultural land, so that the flood damage has a tendency to be concentrated to Bogotá City side.

(2) Tributaries flows through Bogotá City

A. Río Juan Amarillo

The downstream part of the river (Santa Cecilia) suffers from flood and inundation problems. The area suffered from floods from the overflowing of the Rio Juan Amarillo, however, even after construction of a dike, the drainage problems remained.

The water level at the downstream of the river is affected by the water level of the Rio Bogotá. Accordingly, dikes have been constructed along the river based on the floodwater level of Rio Bogotá. Some parts of the dikes have been damaged by illegal farming and informal settlements.

There is no flood problem in the upper reach from Cra.91, because the river has already been improved.

At the junction of the Rio Salitre and Rio Negro, where the riverbed slope changes from steep to gentle, periodic dredging is necessary to prevent the rising of riverbed by sedimentation, which might be a cause of inundation.

There are many tributaries, which flow into the urban area of Bogotá . Currently no record of flood or debris flows from those tributaries, but they should be studied because they have possibilities of flashfloods and debris from the geomorphologic conditions.

B. Rio Fucha

The upper reach from Ave. Boyacá of the Rio Fucha has been improved and has no flood problems.

In the downstream from Ave. Boyacá some areas suffer from floods from the river. The main cause is lack of the flow capacity at the bridge of Ave. Cali. The bridge is currently being improved, so that the problem would be solved in near future. The other cause of inundation is a lack of drainage capacity of the drainage system.

In the most downstream, near the junction to the Rio Bogotá, several development projects are on going. It is supposed that the area naturally retards the flow of water. With consideration of this situation, the EAAB instructed the developers to construct a drainage system as one of the conditions of permitting the development. Therefore, both wastewater and stormwater drainage system including the provision of pumping stations, discharging to the Rio Bogotá, have been constructed and the area has not been suffering from inundation so far.

Also in the this basin there are many tributaries, which flow into the urban area of Bogotá . They should be studied because they have possibilities of flashfloods and debris from the geomorphologic conditions.

C. Rio Tunjuelo

Among the three tributaries, the Rio Tunjuelo has the most severe flood problems. In 1996, the river overflowed at San Benito and flooding occurred widely. According to interviews with local residents at San Benito, the floodwater overtopped near the junction of the Rio Tunjuelo and the Rio Chiguaza, where the river had lower dikes. Average duration and depth of inundation were 8 days and more than 50 cm respectively.

(3) Other cities

According to the Government of Cundinamarca, the inundation problems have been reported in five cities, namely Facatativa, Mosquera, Chia, La Calera and Soacha at present.

Since the dike at the western side of the Rio Bogotá is mostly higher than that of the eastern side, Bogotá City side, and the areas are mostly used as farmland/pastures, there has been no severe flood damage.

A. Facatativá

The Rio Botello is mostly of natural stream and some reaches along the river have suffered from floods. Though there are no discharge data because no hydrological analysis has been carried out, the discharges of the river are not supposed to be a big amount at flood because of the following:

- The river is less than 10 m in width.
- A small bridge constructed in the 19th century still exists without any major damage.

According to interviews and field investigation, the main causes of the floods are the small conveyance capacity of the river channel and clogging at the small bridge by driftwood and garbage. The flood areas are limited at the area along the river, but flooding is of short duration.

B. Mosquera

Flood damages were reported at Porvenir, which is located along the Rio Bogotá. A dike was constructed along the Rio Bogotá, but the illegal farming and informal buildings on the bank have damaged and lowered the dike locally. The overtopping during floods occurred at the weak points of the dike, but there are no serious problems.

C. Chía

The Rio Frio flows through the city and usually caused flooding. However, flooding problem has not been reported since10 years ago when the river was improved.

There are some small flood areas reported in the low-lying areas along the Rio Bogotá, however, there are no serious problems because the area is not utilized much.

D. La Calera

The severe inundation problem has only been reported along the Qda. Toma. The area has been suffering from inundation almost every 5-years and the last one occurred in 1999.

Qda. Toma has no flow except when having heavy or continuous rainfall and has rather small flow area in the downstream. Many houses are located just beside the stream course and usually affected by flash flood during rainy season.

At the most downstream part, the stream goes into pipe culvert with the diameter of approximately 1 m, and discharged into Rio Teusacá.

The inundation problem usually occurred at the inlet of pipe culvert and at the bridge just upstream of the inlet. The bridge was improved after the 1999 flood and the pipe culvert also try to improve after the event of 1999. However, because of the uncontrolled housing development, the natural course of the downstream of Qda. Toma has been blocked and the stream could not be improved.

E. Soacha

The problems of the city are mainly due to the poor drainage system. However, the Rio Soacha, one of the small tributaries of the Rio Bogotá with smaller flood conveyance capacity, overflows usually during rainy season and causes inundation problem.

No overflowing from the Rio Bogotá is reported, however, the river water flowed into residential areas along the river from the weakened part of the dike in 1998.

3) Existing River Structures

(1) Flood mitigation structures

A. Río Bogotá

The Rio Bogotá has dikes on both sides in the major part of the Study Area. The dikes were constructed by CAR from 1980 to 1981 with a probable flood of once in 10-year to prevent floods from the river, as an urgent improvement project for the river after the 1976 flood.

After completion of the project, some parts of the dikes have been heightened by landowners along the river and also have been damaged locally by farming and informal settlements. That has caused the differences of dike crest elevation locally, which caused different safety levels along the river against floods.

B. Río Tunjuelo

The Rio Tunjuelo has dikes on both sides along most part of the channel. The river has three Flood Control Structures (FCS) with retarding basins to regulate the flood discharges at the

middle and lower reaches. The structure is like a small dam, having box culverts for ordinary discharges and a spillway for excess discharges. These structures are planned to regulate the maximum discharges. The outlines of the structures are shown in the following Table 2.6.17 and Figure 2.6.11.

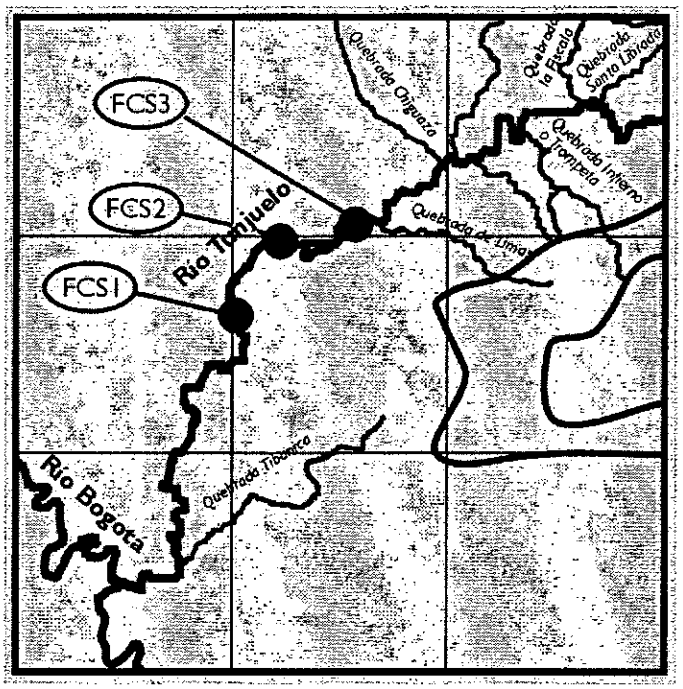


Figure 2.6.11 Location of Flood Control Structure

Table 2.6.17 Summary of Flood Control Structures in Rio Tunjuelo

	No. 1	No. 2	No. 3
Bottom Elevation (masl)	2,580.96	2,577.40	2,573.93
Crest Elevation (masl)	2,587.00*	2,583.00	2,582.00
Size and Nos. of Box Culvert	2.65 m x 2.65 m x 4 nos	2.80 m x 2.80 m x 4 nos	2.15 m x 2.15 m x 3 nos
Reservoir Capacity (m^3)	964,000	265,000	1,084,000

Source: DPAE study

* Estimated figure from the study report of DPAE

C. Río Fucha

The Rio Fucha has been improved with dikes and revetment along the mid-stream to upstream, however, in the lower part only poor earth dikes exist.

D. Río Juan Amarillo

Most part of the downstream of the river forms an earth channel with dikes, having a height of about 2 m, because the area is affected by floodwater of the Rio Bogotá.

The river has been improved in the upper part from Cra. 91. The channel downstream from the junction of the Rio Negro and the Rio Salitre has been improved as a compound cross section with dikes. Salitre box culvert system, which conveys the urban wastewater generated in the northern part of Bogotá City to Salitre Wastewater Treatment Plant, was also constructed under the riverbed, as shown in Figure 2.6.12.

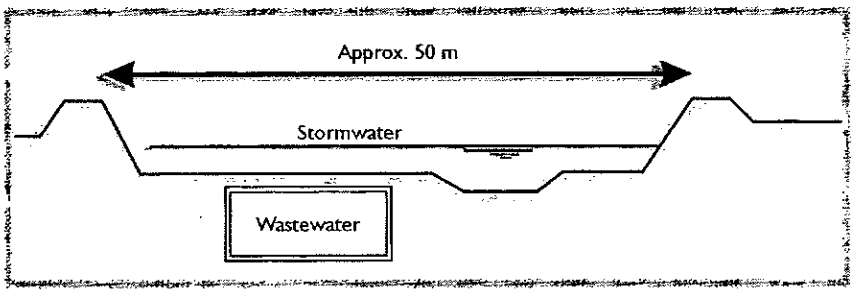


Figure 2.6.12 Cross Section of Rio Juan Amarillo/Salitre Box Culvert System

Embalse Salitre (Salitre Retarding Basin), which is located at the downstream of Cra.91 and planned to regulate the flood discharge to the Rio Bogotá, is now under construction. The retarding basin will regulate the probable flood discharge of once in 100-year.

(2) Other river structures

A. Alicachín hydropower intake

Two radial gates with a height of 10.88 m were installed in the mainstream of the Rio Bogotá at Alicachin hydropower intake, the downstream limit of the river for the Study, to take the river water for hydropower generation. In order to keep the pump efficiency (average pumping capacity: 43 m^3/s), the water level of the river is kept to an elevation of 2,539.24 m. The influence of these gates is estimated to reach approximately 15 km upstream of the river[2-6-3].

The gates are operated not to exceed the water level mentioned above to avoid drainage problems in the upper reach.

[2-6-3] Estudios Hidraulicos Geotecnicos y Topograficos para Definir el Nivel de Los Jarillones y Obras Requeridas para Mitigar el Riesgo de Inundacion del Rio Bogotá, en el Tramo Alicachin Hanedal La Conejera, Hidroestudios, EAAB

B. Salitre wastewater treatment plant

Salitre Wastewater Treatment Plant was constructed in 2000 at the junction of the Rio Juan Amarillo to the Rio Bogotá. The plant has a floodgate to avoid the floodwater of the Rio Bogotá into the Canal Salitre, which is constructed parallel to the Rio Juan Amarillo.

C. La Regadera dam

La Regadera Dam is located at the most upstream of the Rio Tunjuelo. The earth-fill dam was constructed in 1938 to supply water to Bogotá City and the reservoir capacity is 3,300,000 m^3. Since the dam was designed and constructed in the 1930s, it is said that an assessment of its seismic safety was recently conducted.

4) Existing Flood Mitigation Plans

(1) Bogotá City

A. Río Bogotá

EAAB carried out a study and has concluded that the most effective river improvement work for the Rio Bogotá is a combination of the widening (relocation of left dike from the existing position to 30 m behind the existing river bank, with excavation) and heightening of the dike by 3 m to have a conveyance capacity of the probable flood of a 100-year return period.

B. Tributaries

All major tributaries are planned to be improved to a scale of 100-year return period flood and some have already been improved.

(2) Eight municipalities

No active flood mitigation plans exist for the 8 municipalities.

2.6.4 Industrial Facilities

1) Existing Situation

Bogotá City and the eight municipalities in Cundinamarca have been investigated and reviewed as follows.

(1) Bogotá City

A. Potential technological threads

The survey and information gathering from companies that handle (producing, transforming, manipulating, storing and using) chemical substances, located in Bogotá City, was conducted by FOPAE-DPAE in 1999. Distribution of the potential technological thread in each locality of Bogotá City is shown in Table 2.6.18.

The selected systems were mainly found in the localities of Puente Aranda, Fontibón, Kennedy, Enqativá, Barrios Unidos and in lower rate in Usaquén, Los Mártires and Suba. These eight localities have 78% of the systems totally, since these localities count with identified industrial development zones.

Most of the selected systems are constituted by small companies (almost 80% are micro and small), according to the size classification criteria based on the gross assets reported by the Chamber of Commerce.

Table 2.6.18 Distribution of the Potential Technological Threat in Each Locality of Bogotá City

Locality	Total no. of entities		System with 4 types of hazard	System with 3 types of hazard			System with 2 types of hazard		System with 1 type of hazard		
	No	(%)	S,L,F,E	S,L,F	S,F,E	L,F,E	S,F	F,E	S	L	F
Usaquén	106	6.1	8	12	26		25	1		8	26
Chapinero	41	2.3	5	4	14		5			6	7
Santa Fe	20	1.1	5	4	9				1		1
San Cristobal	17	1.0	3	1	7		1				5
Usme	8	0.5			7						1
Tunjuelito	71	4.1	5	17	13		2	1	28	2	3
Bosa	37	2.1	8	7	11		3	1	1	4	2
Kennedy	161	9.2	15	14	42	1	29			15	45
Fontibón	205	11.7	46	15	51		31	4	1	14	43
Engativá	161	9.2	22	27	40		25			7	40
Suba	104	6.0	8	16	30		24			11	15
B. Unidos	132	7.6	13	21	34		28		1	16	19
Teusaquillo	79	4.5	14	15	23		20			3	4
Los Mártires	104	6.0	12	13	23		25			6	25
A. Nariño	58	3.3		5	14		16		2	1	20
Puente Aranda	390	22.3	39	41	78		71	6	1	34	120
La Candelaria	5	0.3			4		1				
R. Uribe	32	1.8	2	2	10		8			3	7
C. Bolívar	16	0.9	1		3		4		2		6
Total	1,747	100	206	203	439	1	318	13	35	130	389

Legend: S: Spill L: Leak F: Fire E: Explosion
Source: "Identificación, Evaluación y Análisis de Amenazas de Origen Tecnológico en el Distrito Capital" by FOPAE-DPAE

B. Accident investigation

The analysis was carried out about the accidents occurred in Bogotá City, related to spills, leaks, fires and explosions that had an impact on the community, the environment and properties. Distribution of the technological accidents from 1979 to 1998 in Bogotá is shown in Table 2.6.19.

- The activities or systems that registered a higher occurrence of events and magnitude were: the production and sale of gunpowder, transport, production of glues, restaurants, natural gas system, service stations, textile industry and a deposit of non identified chemical

residues. These activities are considered of high risk by the nature of the substance handled and the characteristics of the processes (Chemical industry).

- The most highlighted dangerous materials in the events by their frequency and impact were: gunpowder (including Christmas hot air balloons), propane, gasoline, ammonia, solvents, natural gas, chloride and hydrochloric acid.

  Firefighters, CISPROQUIM, industries and the police respectively are the entities that had greater participation in the response to these events.

Table 2.6.19 Distribution of the Technological Accidents from 1979 to 1998 in Bogotá City

Locality	Accident		Type of Accident						
	Number	(%)	L	S	F	E	F/E	F/S	L/S
Usaquén	14	7	1	0	9	3	1		
Chapinero	8	4	2	0	5	1			
Santa Fe	24	12	1	1	19	3			
San Cristobal	6	3	1	1	1	3			
Usme	0	0	0	0	0	0			
Tunjuelito	8	4	1	1	6	0			
Bosa	6	3	1	1	3	1			
Kennedy	22	11	1	2	13	2	2	1	1
Fontibón	11	5	0	2	6	1	2		
Engativá	9	4	2	1	6	0			
Suba	11	5	3	1	4	2	1		
Barrios Unidos	6	3	2	1	2	1			
Teusaquillo	9	4	2	1	5	1			
Los Mártires	8	4	2	1	5	0			
Antonio Nariño	3	1	0	0	1	2			
Puente Aranda	19	9	1	2	13	3			
La Candelaria	10	5	0	0	7	3			
Rafael Uribe	11	5	1	0	4	5	1		
Ciudad Bolivar	5	2	0	2	0	3			
Locality Not Identified	14	7							
Total	**204**	**100**	**21**	**17**	**109**	**34**	**7**	**1**	**1**

Legend: S: Spill L: Leak F: Fire E: Explosion
Source: "Identificación, Evaluación y Análisis de Amenazas de Origen Tecnológico en el Distrito Capital" by FOPAE-DPAE

(2) Eight municipalities

A. Potential technological threats

The information gathering from each company that handles chemical substances according to type of economic activity, chemical substances handled, processes and hazardous reactions involving heat, number of employees, prevention and emergency preparedness, seismic prevention measures, organization, training and generation of industrial residues, was carried out via the survey strategy using filled out forms. Distribution of the potential technological thread in each municipality is shown in Table 2.6.20. The characteristics of each municipality in terms of potential technological threat in summarized in Table 2.6.21.

Table 2.6.20 Distribution of the Potential Technological Threat in Eight Municipalities of Cundinamarca

Municipality	Total Number of Companies		System Type 4	System Type 3		System Type 2		System Type 1	
	No	(%)	S,L,F,E	S,F,E	L,F,E	S,F	F,E	S	F
Chia	46	12.7	3	1	0	37	0	4	1
Cota	28	7.7	2	0	1	18	0	7	0
Facatativa	29	8.0	3	1	5	15	0	3	2
Funza	70	19.3	9	3	9	28	0	11	10
La Calera	14	3.8	1	0	1	12	0	0	0
Madrid	44	12.1	9	3	2	26	1	2	1
Mosquera	15	4.1	5	4	1	4	0	1	0
Soacha	117	32.3	5	8	17	64	0	11	12
Total	**363**	**100**	**37**	**20**	**36**	**204**	**1**	**39**	**26**

Source: Study on the Prevention of Industrial Disasters in the Bogotá Metropolitan Area (2001) by JICA and CCS

Table 2.6.21 Potential Technological Threat in the 8 Municipalities

Municipality	Description
Chía	- The most representative systems in Chía, in terms of numbers, were construction materials (37%), service stations (24%), retail paint (13%) and agricultural chemicals (11%); the rest individually form 2% or less of the total, and most with only one establishment per system. - The Chía sample was mostly (over 90%) composed of micro-enterprises.
Cota	- The most representative systems of the Cota evaluated sample by number of establishments are the service stations (27.7%), the retail commerce of chemical products for farming use (20.7%), the manufacture of manure and inorganic compounds (10%), the flower-growing (percentage?) and the retail commerce of paints (7%); the remaining systems are dispersed and they do not even represent 4% of the sample on their own. Moreover, majority of them hardly has one establishment per system. - Small companies and micro-companies (86%) mainly constituted the evaluated sample in Cota.
Facatativa	- The systems with higher representation by the number of establishments in the evaluated sample correspond, in their order, to: flower cultivations (20%), wholesale commerce of propane gas (14%) and gasoline service stations (14%); the other systems (12) have one or two companies at most. - Small and micro-companies constituted most of the sample evaluated in Facatativá (more than 90%).
Funza	- The most representative systems by number of enterprises sampled were retail construction materials (13%), warehouses (8%), retail agricultural chemicals (6.7%) and manufacture of plastic products (6.7%). The rest individually did not account for more than 3% of the sample, and most only had one or two enterprises per system. - The Funza sample is mostly small and micro-enterprises (94%).
La Calera	- The most representative systems of the La Calera evaluated sample, due to the number of establishments, are the retail construction material businesses (50%) and retail agrochemical businesses (29%); the remaining systems are dispersed and most barely have 1 establishment per system. - The La Calera evaluated sample was totally made up by micro businesses.
Madrid	- Most representative systems for the number of stores of evaluated sample correspond to flower crops (15.6%), retail construction material businesses (11.2%), retail chemical products for farming and animal husbandry use businesses (11.2%), gasoline service station (9%) and retail paint businesses (6.8%); the remaining systems are dispersed and by themselves do not represent even 3% of the total sample. And most thereof barely have one establishment per system. - The Madrid evaluated sample was mainly constituted by small companies and micro-companies (78%).
Mosquera	- Most representative systems for the number of establishments of evaluated sample correspond to preparation of ready-to-eat food for animals (3 companies representing 20%) and wholesale business of raw material for the chemical industry (2 companies representing 13%); the remaining systems barely have one establishment. - The Mosquera evaluated sample was mainly constituted by small companies (40%) and micro-companies (33%). From samples evaluated from all municipalities, Mosquera had the greatest proportion of medium-sized and large-sized companies (27%), with the medium-sized (20%) having the greatest weight.
Soacha	- The most representative systems in terms of numbers within the sample were retail paints (21%), retail propane gas in bottles or cylinders for household distribution (10%), service stations (7.6%) and manufacture of plastics products (7%). The other 33 systems were represented by one or two enterprises only. - Over 90% of the Soacha sample is small or (particularly) micro-enterprises

B. Accident analysis

The analysis was carried out about the accidents related to spills, leaks, fires and explosions that have had an impact in the community, the environment and properties. Distribution of the technological accidents from 1989 to 2001 in the eight municipalities is shown in Table 2.6.22.

Table 2.6.22 Distribution of the Technological Accidents from 1989 to 2001 in Eight Municipalities of Cundinamarca

Municipality	Emergencies		Type Of Event					
	Quantity	%	L	S	F	E	S/F/E	E/F
Chía	2	8		1		1		
Cota	0	0						
Facatativá	2	8		2				
Funza	5	20	2	1		1	1	
La Calera	0	0						
Madrid	0	0						
Mosquera	2	8	1			1		
Soacha	11	44	8	1	1			1
Fontibón	2	8		2				
Sibate	1	4				1		
Total	**25**	**100**	**11**	**7**	**1**	**4**	**1**	**1**

Conventions: S: Spill L: Leak F: Fire E: Explosion
Source: Study on the Prevention of Industrial Disasters in the Bogotá Metropolitan Area (2001) by JICA and CCS

- There were not enough records available due to the poor recording system. So the preliminary diagnosis depending upon the statistics of accidents will be taken care of with a higher level of uncertainty.
- In the Bogotá Metropolitan Area, the most common emergency situation is the leak of chemical substances in the gaseous state, followed by spills of chemical substances mainly with inflammable characteristics. Nevertheless, the explosions and the fires are less frequent and have the same occurrence level.
- The municipality that has been affected in most occasions is Soacha, followed by Funza. Chía and Facatativá with the locality of Fontibón follow, sharing the same accident occurrence level.
- Soacha has suffered the highest number of high magnitude emergencies among all the eight municipalities. Funza has presented the highest number of medium-magnitude emergencies.
- The entities that have had the highest participation in the response to emergencies with chemical substances are, in order of participation: the fire brigade, CISPROQUIM®, the industries with their emergency brigades and the national police.

2.7 Distribution of Building and Infrastructure/Lifeline

2.7.1 Distribution of Buildings

1) Buildings

(1) Building distribution

The building data used for the Study is from the cadastral data of both Bogotá City and the eight municipalities in Cundinamarca. Every item of information is collected separately because it is managed by different organizations. Cadastral data is collected for the property tax collection purposes and it is the most reliable data for building classification.

In the Study the building data have been classified based on the structure and number of stories of the buildings. According to the cadastral classifications, the buildings can be classified into four categorizes: wood, prefabricated, masonry and RC frame structures. The data also provide the number of stories of buildings.

Table 2.7.1. shows the distribution of buildings in the Study Area.

Table 2.7.1 Number of Buildings in the Study Area

Locality/ Municipality	Wood, Prefabricated	Masonry			RC Frame Building		Total Building for Analysis	Unknown	Total
	All Estrato	Estrato 1, 2	Estrato 3, 4	Estrato 5, 6	Upto 3 Stories	More than 3 stories			
Usaquén	1,722	7,595	18,077	7,817	1,904	2,936	40,051	4,615	44,666
Chapinero	921	2,708	3,492	3,748	2,433	2,806	16,108	2,937	19,045
Santa Fe	1,671	9,953	2,027	0	1,598	601	15,850	2,648	18,498
San Cristobal	2,912	44,371	6,231	0	470	172	54,156	1,094	55,250
Usme	4,026	31,081	194	0	133	8	35,442	11,942	47,384
Tunjuelito	427	12,708	4,556	0	621	97	18,409	2,003	20,412
Bosa	2,449	43,850	2,794	0	699	62	49,854	7,038	56,892
Kennedy	3,310	40,154	43,024	0	4,342	1,220	92,050	6,188	98,238
Fontibón	893	3,824	19,904	0	1,633	489	26,743	2,122	28,865
Engativá	1,689	15,652	61,130	0	3,531	1,201	83,203	5,986	89,189
Suba	4,334	41,262	27,367	7,782	3,097	1,744	85,586	3,409	88,995
Barrios Unidos	553	81	24,063	476	3,194	710	29,077	1,683	30,760
Teusaquillo	186	128	12,972	364	1,699	1,746	17,095	2,628	19,723
Mártires	488	1,041	10,758	0	2,667	678	15,632	934	16,566
Antonio Nariño	257	768	11,100	0	1,194	358	13,677	600	14,277
Puente Aranda	539	607	32,497	13	3,880	546	38,082	3,538	41,620
La Candelaria	507	1,540	369	0	338	110	2,864	986	3,850
Rafael Uribe	2,012	26,600	21,928	0	939	200	51,679	1,632	53,311
Ciudad Bolívar	6,996	57,066	1,685	15	634	109	66,505	14,384	80,889
Subtotal	***35,892***	***340,989***	***304,168***	***20,215***	***35,006***	***15,793***	***752,063***	***76,367***	***828,430***
Chia	2,388	2,542	12,527	323	315	16	18,111	0	*18,111*
Cota	988	2,086	1,355	20	165	17	4,631	0	*4,631*
Facatativa	1,864	3,663	9,038	35	185	32	14,817	0	*14,817*
Funza	1,239	2,293	5,453	50	195	16	9,246	0	*9,246*
La Calera	530	546	3,056	613	47	8	4,800	0	*4,800*
Madrid	1,361	3,749	4,356	438	333	12	10,249	0	*10,249*
Mosquera	897	2,921	3,529	166	262	2	7,777	0	*7,777*
Soacha	3,929	18,682	33,946	588	483	302	57,930	0	*57,930*
Subtotal	***13,196***	***36,482***	***73,260***	***2,233***	***1,985***	***405***	***127,561***	0	***127,561***
Total	49,088	377,471	377,428	22,448	36,991	16,198	879,624	76,367	955,991

The total number of buildings in the Study Area is 955,991 based on the cadastral data. There are 828,400 buildings in Bogotá City and 127,600 buildings in Cundinamarca's eight municipalities. Masonry structure buildings share 81.3% of the total buildings, while that of RC frame buildings is only 5.6%. The Study Team found that the "unknown" structure buildings are distributed in the southern part of Bogotá City. However, it was impossible to identify their structure type even though a field survey was conducted. . The discussion with the cadastral office in Bogotá City concluded that "unknown" structure buildings cannot be classified by cadastral classification. "Unknown" structure includes weak structure buildings, such as temporary housing, illegal housing etc. Therefore, "unknown" structure buildings are not included in the damage analysis.

For the distribution of housing stock, huge housing accumulation is found in Estrato 1 to 4, which account for 79% of the buildings in the Study Area. The most building accumulation is found in Kennedy of more than 98 thousand, or 10.3%, of total buildings, followed by Engativa, Suba and Ciudad Bolivar. Of the eight municipalities in Cundinamarca, Soacha has more than 57,000 buildings followed by Chia of 18,111.

(2) Housing unit distribution

The cadastral and IGAC data provide housing unit data. Housing unit is defined as a household unit and used only for residential purposes. The number of housing units in the Study Area is more than 1.3 million. The number of housing units in Bogotá City is 1.2 million and 129,000 in the eight municipalities. The distribution of residential buildings shows that the three localities of Suba, Engativa and Kennedy account for more than 10% of housing units. Of the eight municipalities, Soacha has more than 5% of housing units.

The summary of the housing unit data is shown in Table 2.7.2.

Table 2.7.2 Summary of Housing Units

Locality/ Municipality	Number of Building	Total Housing Unit	Distribution (%)
Usaquen	44,666	118,697	8.9%
Chapinero	19,045	51,142	3.8%
Santa Fe	18,498	24,234	1.8%
San Cristobal	55,250	60,336	4.5%
Usme	47,384	43,997	3.3%
Tunjuelito	20,412	27,566	2.1%
Bosa	56,892	59,945	4.5%
Kennedy	98,238	143,784	10.8%
Fontibon	28,865	48,792	3.7%
Engativa	89,189	143,973	10.8%
Suba	88,995	165,348	12.4%
Barrios Unidos	30,760	36,565	2.8%
Teusaquillo	19,723	41,852	3.1%
Los Martires	16,566	15,999	1.2%
Antonio Aranda	14,277	16,567	1.2%
Puente Aranda	41,620	48,324	3.6%
Candelaria	3,850	5,615	0.4%
Rafael Uribe	53,311	59,993	4.5%
Ciudad Bolibar	80,889	87,279	6.6%
Sub-Toatal	***828,430***	***1,200,008***	90.3%
Chia	18,111	15,228	1.1%
Cota	4,631	3,145	0.2%
Facatativa	14,817	14,182	1.1%
Funza	9,246	8,027	0.6%
La Calera	4,800	4,984	0.4%
Madrid	10,249	7,259	0.5%
Mosquera	7,777	5,651	0.4%
Soacha	57,930	70,208	5.3%
Sub-Toatal	***127,561***	***128,684***	9.7%
Total	**955,991**	**1,328,692**	100.0%

Source: JICA Study Team, from Cadastral and IGAC data

2.7.2 Distribution of Infrastructure

1) Infrastructure Conditions

(1) General

This Study includes infrastructures and lifeline facilities as exist in the Study Area. The infrastructure is classified into roads, bridges, airports and railways. Electricity supply facility, water supply facility, gas supply facility and telecommunication facility are included in the lifeline facility.

(2) Road facility conditions

A. Existing road network in the study area

a) Administrative institution of roads and bridges

National roads outside of Bogotá City are under the jurisdiction of the Ministry of Transport. The Instituto Nacional de Vías (INVIAS) under the ministry is responsible for the construction and the maintenance of these national roads. Municipal roads are under the jurisdiction of Bogotá City or each municipality. Prefectural or departmental, roads are under the jurisdiction of Cundinamarca.

All the roads in Bogotá City area are under the jurisdiction of Bogotá City. The Urban Development Institute (IDU) under Bogotá City is responsible for the construction and the maintenance of these city roads. The eight municipalities have responsibility of roads inside of their cities. Cundinamarca Prefecture has responsibility for the roads connecting to national roads and municipality roads. Table 2.7.3 shows the summary of administrative institution of roads and bridges.

Table 2.7.3 Administrative institution of Road and Bridges

Road Classification	Administrative Institution		
	Bogotá	Eight municipalities	
		Urban area	Rural area
National Road	-	-	INVIAS
Municipal Road	IDU	Each City	-
Prefectural Road	-	-	Cundinamarca

b) Road network in Bogotá City

The trunk road network in Colombia is formed by two longitudinal trunk roads and three lateral trunk roads. Two national trunk roads, No. 25 and No. 45A, connect to the center of Colombia as the longitudinal trunk road network from south and north. Three national trunk roads, No.40, No.50 and No.60, are located at the center of Colombia as the lateral trunk road network from east and west.

Four trunk roads that connect with Bogotá City make up the radial road network of Bogotá City. The four national roads connecting Bogotá City and other municipalities are as follows:

- National Road No. 55 (Bogotá City to Tunja/Cucuta/Venezuela).
- National Road No. 45A (Bogotá City to Tunja/Cucuta/Venezuela).
- National Road No.50 (Bogotá City to Manizales/Medellin/Cali).
- National Road No.40 (Bogotá City to Villavicencio).

The urbanized area of Bogotá City is 17 km of east-west direction by 35 km of south-north direction. Six principal roads go through Bogotá City as the major gateways from other municipalities in the Study Area. They are major supply routes between the Study Area and other municipalities. Especially, the gateways from Medellin and Cali in Western Colombia are important for transporting food supplies. (see Figure 2.7.1).

- Gateway from Northern Colombia: Autopista Norte Rd.-Tunja/Cucuta/Venezuela.
  Avenida La Calera Rd.-Tunja/Cucuta.
- Gateway from Western Colombia: Autopista Medellin Rd.-Manizales/Madellin.
  Avenida Centenario Rd.-Manizales/Medellín.
  Autopista Sur Rd.-Armenia/Cali.
- Gateway from Southern Colombia: Avenida Villavicencio Rd.-Villavicencio.

The principal road network in Bogotá City is formed by three (3) ring roads and seven (7) radial roads as shown Figure 2.7.1. The seven roads radiate outwards from city center and serve as distributor roads to each Barrio, and the three ring roads act as connector roads to each radial road. The ring roads and radial roads are as follows:

- Ring Roads:
  a) Avenida Ciudad de Quito.
  b) Avenida del Congreso
  c) Avenida Boyacá.
- Radial Roads:
  a) Autopista del Norte.
  b) Autopista del Sur.
  c) Avenida Villavicencio.
  d) Avenida del Américas.
  e) Autopista El Dorado.
  f) Autopista Medellín.
  g) Avenida Suba.

The secondary roads have been developing in accordance with the progress of housing and industrial developments. The secondary road network in the urbanized area of Bogotá City is served by a grid pattern.

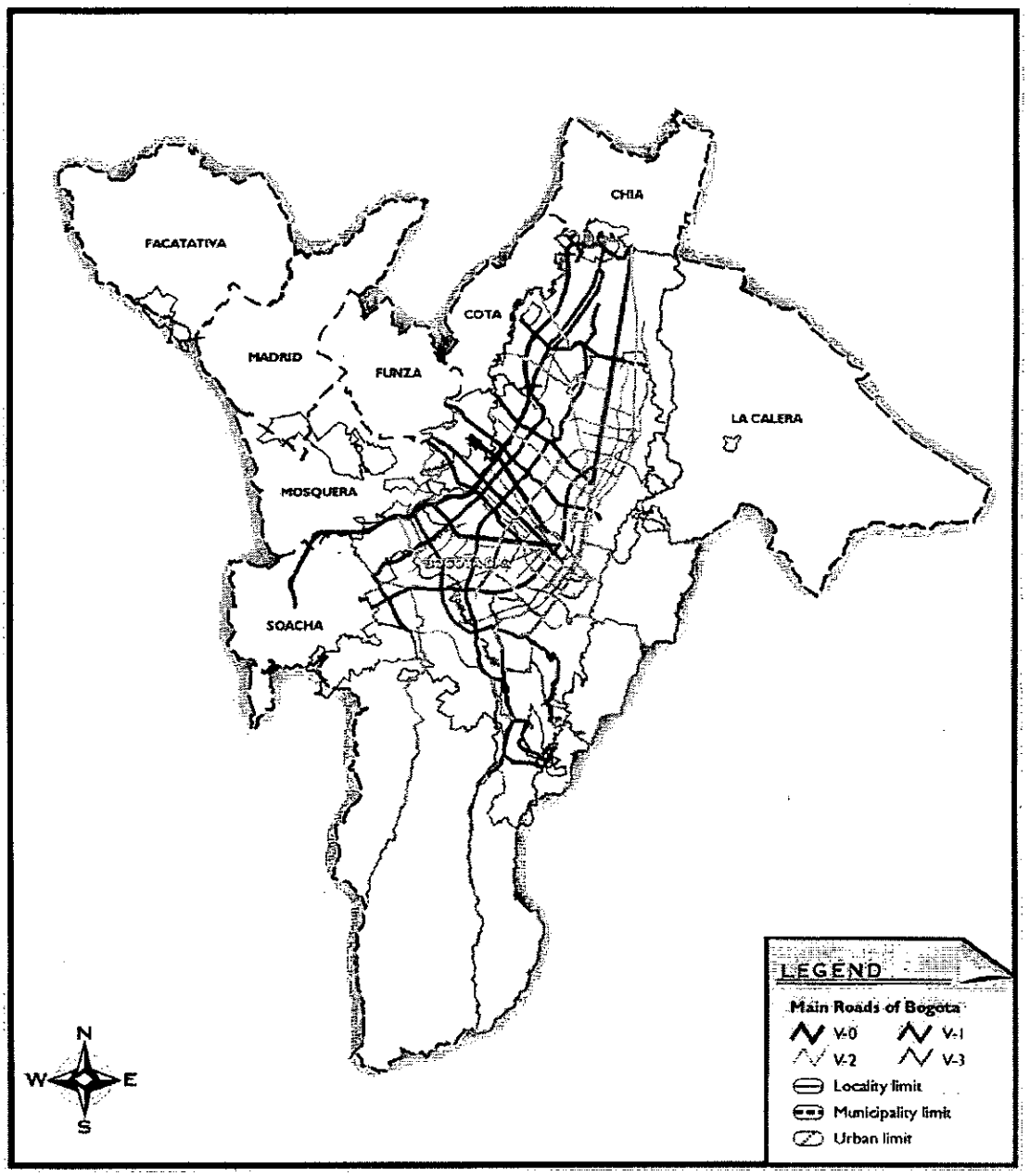


Figure 2.7.1 Principal Road Network in Bogotá City

c) Road network in eight municipalities

The conditions of the road network in the eight municipalities, which is shown in Figure 2.7.2, and described in Table 2.7.4.

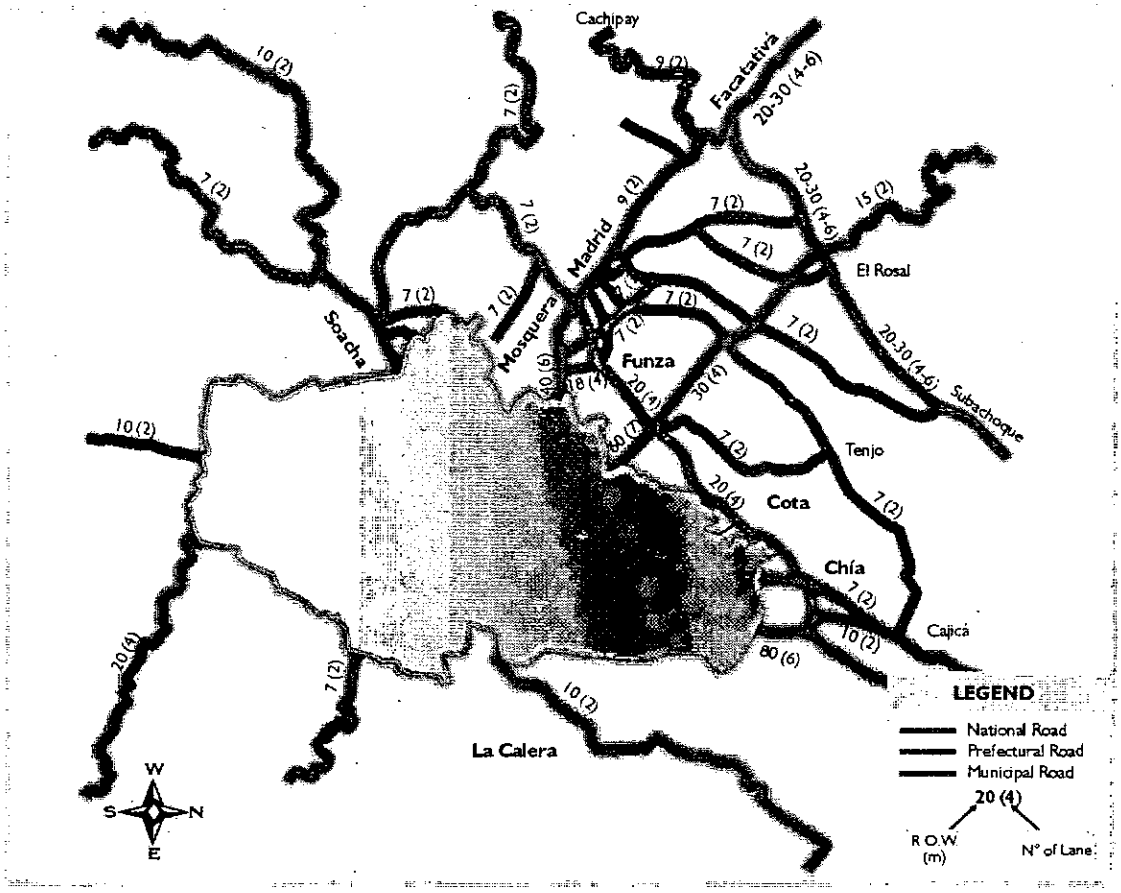


Figure 2.7.2 Inter-City Road Network of the Eight Municipalities Surrounding Bogotá City

Table 2.7.4 Principal Road Network Eight Municipalities

Municipality	Road Network
Chia	The road network in the municipality of Chia is formed by one ring road and four radial roads, which go outwards from the city center serving as main regional and principal roads. These roads are North-South Chia-Cajica Rd. and Chia-Suba Rd., East-West Chia-Cota Rd. and Mosquera Funza-Autopista Troncal Occidente Rd. They are main gateways of about 15-20 meters width entering into the city. Especially, the prefectural road of Mosquera Funza-Autopista Troncal Occidente Rd. is an important gateway connecting to Autopista Norte Rd. A ring road is formed by the complete links of about 20 meters width. Chia City is formed by adequate road network comparatively
Cota	Cota City is composed of the northern urban area and southern rural area. These areas of city are traversed from north to south by an arterial road of Mosquera Funza-Autopista Troncal Occidente Rd, which serves as main corridor for the city. This corridor is one of main gateway of about 20 meters width connecting to neighboring cities. Besides, another gateway, Cota –Suba Rd., goes through the central city from Bogotá City, and the southern rural area of the city is traversed by Autopista Medellin. Several principal roads of 20 meters width branch out from the main corridor. The role of road network in Cota City is not clear.
Facatativa	The corridor of Mosquera-Facatativa vía El Rosal Rd. (Avenida Centenario Rd.) traverses the Facatativa City from east to west as main gateway. Two radial roads form the road network of Facatativa City serve as other gateways. They are principal roads of about 20-25 meters wide connecting to a grid network pattern of local roads. The major radial road is a prefectural road between the cities of Facatativa and Subachoque. The road network in Facatativa City is orderly formed. The width of local roads is about 12-15 meters on average.
Funza	The road network in the municipality of Funza is formed by a ring road and two radial roads. The urban area of the city is bordered by the ring road and Fontibón-Mosquera-Facatativa Rd. (Avenida Centenario), and is served by a grid pattern of local roads. Two radial roads are major gateway of 27-28 meters width entering into the city. The average width of local roads ranges 17-20 meters wide. The road network in Funza is orderly formed
La Calera	The municipality of La Calera is traversed from north to south by an arterial road, which serves as main corridor for the city. The main corridor is the national road of Los Patios-La Calera-Briceño along the Rio Teusaca River. The La Calera road plays an important role of main gateway for the city. Four roads of about 6-7 meters width radiate outwards from the city center serving as main principal roads. The existing road network is poor; a few principal roads and many local roads form the road network of La Calera City..
Madrid	Facatativa-Madrid-Mosquera Rd. (Avenida Centenario Rd.) traverses the center of Madrid Municipality connecting to Facatativa from east to west. The road network in Madrid is formed by a ring road and four radial roads, three of which radiate from the main corridor of Avenida Centenario serving as main principal roads. The radial roads are North-South Madrid-Tenjo Rd. and Madrid-Subachoque Rd., East-West Madrid-Funza Rd. and Madrid-El Rosal Rd. These roads are main gateways of about 15-20 meters width entering into the city. The municipality of Madrid is formed by adequate road network comparatively
Mosquera	The central city of Mosquera is traversed from east to west by a corridor of Fontibon- Mosquera-Madrid Rd. (Avenida Centenario Rd.). Mosquera-Girardot Rd. and Mosquera Funza-Autopista Troncal Occidente Rd are gateways to the city center. Besides, branching out from this corridor to the city are seven principal roads, which are about 20-24 meters wide on the average. The road network in Mosquera is immature indicating unclear configuration.
Soacha	Autopista Sur traverses the municipality of Soacha from east to west. The road network in the municipality is formed by one ring road and three radial roads. Avenida Variente Longitudinal Rd. and Avenida Circunvalar Sur Rd., which form the ring road of the municipality, are principal roads of 45-60 meters width. The east side segments on the ring road have not been completed yet. Three radial roads of Avenida Terreros, Avenida Ciudad de Cali-Avenida Potrero Grande and Avenida Soacha-Avenida Indumil are linked to the Autopista Sur indiscriminately. These radial roads are about 45 meters wide. The road network in Soacha Municipality is very complex; it is necessary that road classification should be improved based on the role of each road, in order to become effective.

B. Functional road classification

a) Bogotá City

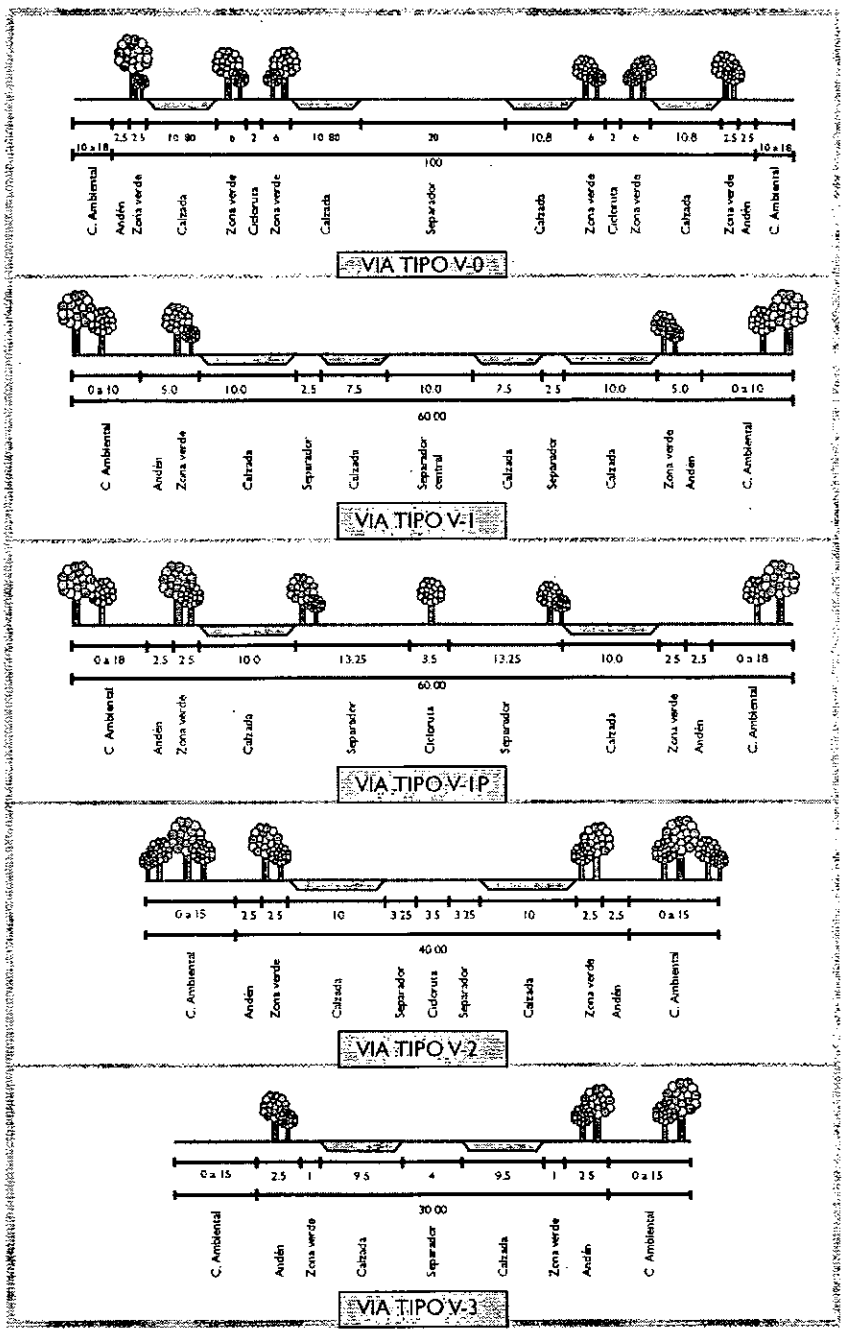
The functional road classification was stated in Acuerdo 2, 1980 of Bogotá City According to the Acuerdo, a road is classified into three types of roads as follows: principal roads, collector roads and local roads. The principal road is classified into four types of roads, the collector is classified into two types of roads, and the local road is classified into four types of roads. The width of the typical cross-section of each road type is shown in Table 2.7.5, and the typical cross-section of the arterial roads is illustrated in Figure 2.7.3.

The cross-section of V-0 and V-1 roads have the high-speed lane of 2 to 3 lanes and low-speed lanes of lanes, and V-2 and V-3 roads have 6 lanes dual carriage way with a 5- to 10-meter median divider.

Table 2.7.5 Functional Road Classification in Bogotá City.

Classification (Type of Road)		Right of Way (m)	Lane Width (m)	No. of Lanes (m)
Principal Road	V-0	100	3.50(H),3.50(L)	6(H)+6(L)=12
	V-1	60	3.75(H),3.33(L)	4(H)+6(L)=10
	V-1P	60	3.33(L)	6(L)=6
	V-2	40	3.33(L)	6(L)=6
	V-3	30	3.00(L)	6(L)=6
	V-3E	25	3.75(L)	4(L)=4
	V-3R	18	3.00(L)	4(L)=4
Collector	V-4	25	3.75(L)	4(L)=4
	V-4A	22	5.00(L)	2(L)=2
	V-5	18	5.00(L)	2(L)=2
Local Road	V-6	16	4.50(L)	2(L)=2
	V-7	13	3.50(L)	2(L)=2
	V-8	10	3.00(L)	2(L)=2
	V-9	8	3.00(L)	1(L)=1
	V-9E	6	2.00(L)	1(L)=1

Note, (H): High-speed lane, (L): Low-speed lane
Source: IDU, Bogota City.



Source: IDU, Bogotá City

Figure 2.7.3 Typical Road Cross-Section on Arterial Road in Bogotá City

b) Outside of Bogotá City.

National roads are classified into two types, namely, 4-lane road and 6-lane road, by the road design standards of INVIAS. The roads controlled by the Cundinamarca prefecture are almost similar to the Municipality's classification. With regard to the roads of the eight municipalities, the functional road classification is different by municipality. The road network of each

municipality generally comprises collector roads and local roads; the width by road type varies from V-0 to V-11.

C. Road bridge conditions

a) Number of bridges and their Locations

The existing road bridges are classified into three types: pedestrian bridges, vehicular flyover bridges and river bridges. Vehicular flyover bridges are constructed in various types such as diamond, semi-cloverleaf and full cloverleaf types as interchanges. Among them, the diamond-type interchange is the most popular.

During the Study a bridge site survey has been carried out in Bogotá City and in the eight municipalities for confirmation of IDU bridge inventory. The result showed that 13 of 134 pedestrian bridges and one of 103 vehicular flyover bridges in IDU inventory do not exist, but 26 pedestrian bridges 8 vehicular flyover bridges, and 68 vehicular bridges over rivers are newly found in the site survey in addition to IDU inventory. The number of bridges by type is shown in Table 2.7.6.

Table 2.7.6 Number of Bridges by Type

	Pedestrian Bridges	Vehicular Bridges			Total
		Flyover	River	Total	
Bogotá	146	108	69	177	323
Eight Municipalities	19	6	11	17	36
Total	165	114	80	194	359

Source: JICA Study Team

The location and structure of the bridge data collected from IDU have been clarified through the field investigation. It is found that the bridge inventory is accurate, except some bridge locations.

b) Bridge structure conditions

The existing conditions of the bridge structure classification such as type of girder, type of bearing, height of abutment/pier, material of abutment/pier and type of foundation, and seat width. Detailed conditions are described below:

Type of Girder

In the total pedestrian bridges, the share by girder type is as follows: simple of 2 or more spans at 56%, continuous of 2 or more spans at 26%, simple of 1 span at 14% and arch of one span at 4%. The girder type of simple/2 or more spans has a high share. The girder type with the highest share is single of 1 span at 51% followed by continuous of 2 or more span at 28% and simple of 2 or more span at 21%.

Type of Bearing

In the total pedestrian bridges, the share by different bearing types are as follows: normal type at 75% and fixed type at 25%. While in the vehicular bridges, normal type are approximately 96% and fixed type are only 4%. Therefore, most of the bearings of bridges are of the normal type.

Maximum Height of Abutment/Pier

In the total pedestrian bridges, the share by maximum height of abutment/pier is as follows: height of 5 to 10m at 82% and height of less than 5m at 18%. While in the total vehicular bridges, the shares of 5m to 10m, under 5m, and over 10m in height are 81%, 17%, and 2% respectively. Therefore, most of abutments/piers of bridges have a maximum height ranging from 5m to 10m.

Material of Abutment/Pier

In the total pedestrian bridges, the share by material type of abutment/pier are as follows: reinforced concrete at 84%, steel at 15% and masonry at 1%. While in the total vehicular bridges, the share of reinforced concrete is 74%, steel at 24% and masonry at 2%. Therefore, most of abutments/piers of bridges are made of reinforced concrete.

Type of Foundation

In the total pedestrian bridges, the share by foundation type is as follows: pile type at 57% and spread type at 43%. While in the vehicular bridges, the share of pile type is at 90%, and spread type is at 10%.

Seat Width

The seat width of the pedestrian bridges is in the range of 0.14 m to 0.65 m. On the other hand, in the vehicular bridges, the approximate seat width is between 0.25m to 2.0m. The seat width of existing bridges is small.

D. Railway conditions

a) Administrative institution of railway

The National Railway of Colombia (FNC) was dissolved and privatized by Law No. 21 of 1988. FNC was transformed to a new public entity in smaller size named *Empresa Colombiana de Vias Ferreos* (FERROVIAS) which manages infrastructure and facilities of the railway. Regarding private capital, two companies were newly established for the railway operation: *Sociedad Colombiana de Transporte Ferroviario* (STF) and *Sociedad Colombiana de Transporte Ferroviario de Occidente* (STFO). They have contracts annually with FERROVIAS to operate the assigned railway. Both of them are regarded as private companies. Another new entity, *Fundo Pasivo Social de Ferrocarriles* (FPSF), was founded to succeed to the FNC and manage its assets. This agency is also dealing with pensions and insurance of retired employees of FNC.

Railway system in Bogotá city is managed by the Central Regional Office, one of five Regional Offices of FERROVIAS and is operated by STF.

b) Present railway line in Bogotá City.

Location of the railway lines is shown in Figure 2.7.4. There are three railway lines: the west line starts from the central station called *Estacion de la Sabana* and runs westward while the north and south lines branch from the west line. The west and the north lines are operated for cargo, but the south lines are unused. Although maintenance of rail tracks is contracted to private companies, they are maintained in very bad conditions due to the shortage of budget. Because of poor maintenance, a train is forced to run at the speed of less than 15 km/hour. Presently, the operation of each line is very poor as follows:

- The west line operates one train a day each direction between Bogotá City and Santa Marta, transporting coal, salt, grain and steel to Bogotá City., but few cargos from Bogotá City.
- The north line operates one train in each direction everyday between Bogotá City and Belencito, transporting cement, iron ore, beverages, etc. In the weekend, a tourist train is operated from the Sabana station to Nemocon (60 km), with a steam locomotive by Tourist Train Company.
- The south line has already been discontinued, partly due to the reduction policy since 1980, and partly due to squatting.

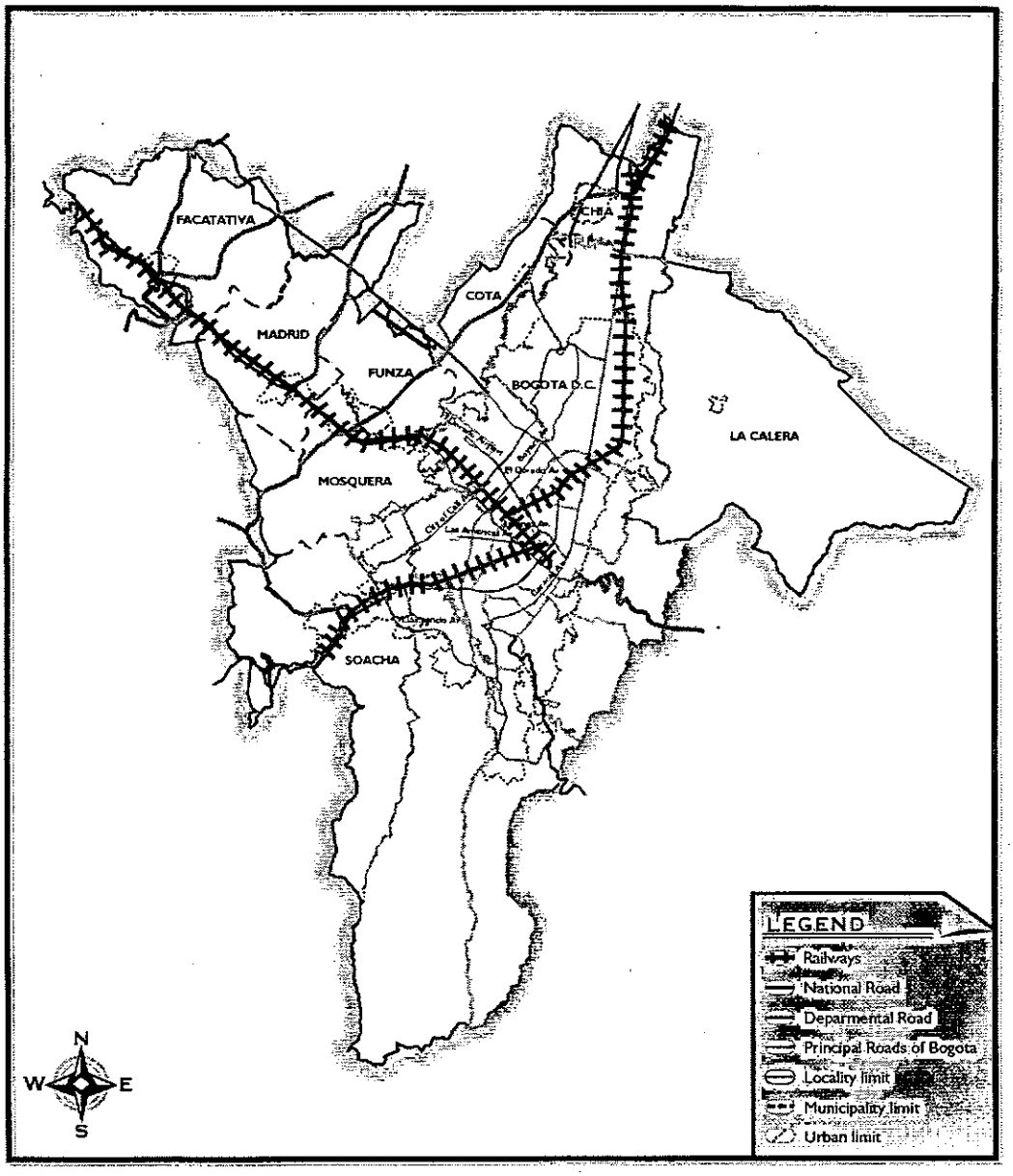


Figure 2.7.4 Location of Railway Lines in Bogotá City

(3) Lifeline conditions

A. Water supply and sewage system

a) Administrative institution of water supply and sewage system

EAAB-ESP, *Empresa de Acueducto y Alcantarillado de Bogotá*, is responsible for water supply, sewage and drainage services to Bogotá city, and for water supply to neighboring municipalities. ESP of EAAB-ESP is the Spanish acronym meaning Public Service Rendering Company, which keeps control over the resources and operation of its supply systems. EAAB is an Industrial and Commercial Company of the Capital District, rendering domiciliary public services, equipped

with legal identity, administrative autonomy and independent patrimony, according to Agreement 6 of 1993.

With regard to the eight municipalities, a public company in each municipality services water supply from wells and rivers, and manages their resources and supply facilities. However, EAAB supplies water to them to cover the shortage of water supply in each municipality. The amount supplied by EAAB to each municipality ranges widely between 10% and 100% of their water demand.

Table 2.7.7 Institution of Water Supply System

Plan	Facility in Charge	
	Bogotá	Eight municipalities
EAAB	Complete water supply system such as water reservoir, intake, purification plant, transport & supply pipeline, storage tank, pump station.	Service water supply for the shortage of consumption in each municipality
Public company in Eight Municipalities	-	Water supply system such as water reservoir, intake, purification plant, transport & supply pipeline, storage tank and pump station. But storage tank and pump station in some municipalities are insufficient in number.

b) Facility conditions of water supply and sewage system

Bogotá D.C.

1) Water Supply System

The distribution system is divided into matrix networks of tunnels, (as in the Chingaza system described below), or of big iron pipelines with diameter between 60 and 78 inches, which conducts the water from the sources to the purifying plants, and then to the main distribution networks with diameters between 12 and 36 inches. Detailed distribution network is composed of pipelines less than 12" in diameter. According to the brief description provided by EAAB, water for distribution is supplied through a 6,500-km long pipeline utilizing 65 operation stations composed of 31 pumping stations, 25 storage tanks and 9 control stations.

In order to supply water to high areas of Bogotá city, especially at the South part of Bogotá City., the company has pumping chains that is pumping stations located consecutively to guarantee the service to altitudes higher than 3,000 meters. The system is also composed of compensation and storage tanks, which are intended to decrease the pressure of the water that goes through the matrix network, thus making it easier to manage water for distribution. These storage/compensation tanks are located in the mountainous areas of Bogotá city (East and South), and there are two tanks in Suba hills with a total storage capacity of 6,000 m^3.

A special pumping station that receives water from Chingaza and Tibito systems is the one called *Planta de Rebombeo de Usaquen*. The plant water is pumped and distributed to approximately 70% of the city, and to the municipalities, Funza, Madrid and Mosquera, located on the west of Bogotá city. Table 2.7.8 shows how Bogotá City is divided water resources according to the main purifying plant or source that supply the respective areas. These zoning consists of 11 zones. Table 2.7.9 and Table 2.7.10 describes purifying plants (with the exception of Tibitóc system) and water sources managed by EAAB respectively.

Table 2.7.8 Zone System by Main Purifying Plant/Water

Zone	Laguna	Vitelma	Control Santafé	San Diego Sur	San Diego Norte	Paraiso	Chico	Zona Interme-dia	Zona baja sur	Zona Baja Norte	Soacha
Main Source	Laguna Purifying plant	Vitelma or San Diego Purifying plant	Usaquen pumping station	San Diego Purifying plant	San Diego Purifying plant	Wiesner Purifying plant	Wiesner Purifying plant	Usaquen pumping station	Usaquen pumping station	Usaquen pumping station	Usaquen pumping station
Area Aprox. of Bogotá (%)	8.3	10	4	3	1.5	2	3	1.5	15	45	7

Source: JICA Study Team, 2001.

Table 2.7.9 Purifying Plants Managed by EAAB

Plant	Capacity	Location	Structure Type	Use
Wiesner Purifying Plant	14 m^3 / sec.	Km 12 Via La Calera	CONCRETE	Drinkable water treatment
Vitelma Purifying Plant	1.5 m^3 /sec.	Circunvalar Road through 9th south street	CONCRETE	Drinkable Water treatment
La Laguna Purifying Plant	0.45 m^3 /sec.	East Side of the Usme Municipality	CONCRETE	Drinkable Water treatment
El Dorado Purifying Plant	1.6 m^3 /sec.	South Side of the new road to Villavicencio, next to the first tunnel	CONCRETE	Drinkable Water treatment
San Diego Purifying Plant	0.1 m^3 /sec.	Circunvalar Road No.2–03	CONCRETE	Drinkable Water treatment
Tibitoc Purofying plant	10.5 m^3 /sec.		CONCRETE	Drinkable Water treatment

Note) Tibitoc purifying plant is a concession one but supplies water to Bogotá City like EAAB plants.
Source: JICA Study Team, 2001

Table 2.7.10 Water Sources Managed by EAAB

Structure	Capacity	Location	Structure Type	Alert And Monitoring System0
Regadera Dam	Storage Volume 3,300,000 m^3	South of Usme, in the El Destino vereda	Dirty gravel clay nucleus	A monitoring by levels is carried out. Readings at 6 am, 12 am and 6 pm, in case of strong rains, the readings are done every half an hour and it's reported to the Office of Prevention and Attention of Emergencies. Instrumentation Monitoring: is carried
Chisaca Dam	7,700,000 m^3	South of the Usme Municipality El Hato vereda	Dirty gravel clay nucleus	A monitoring by levels is carried out. Readings at 6 am, 12 am and 6 pm, in case of strong rains, the readings are done every half an hour and it's reported to the Office of Prevention and Attention of Emergencies. Instrumentation Monitoring: a topograp
El Tambor Dam			A Dam of 59.50 m of maximum height located on the Teusaca River's valley constituted by homogeneous material, with a chimney's filter. The approximate volume of refilling is 2,75 hm^3.	Instrumentation Monitoring: (Piezometer reading, topographic control, and filtration measuring.
Chuza Dam	257,000,000 m^3	East of Bogotá City	Dirty gravel clay nucleus	A Monitoring by levels is carried out through readings every 24 hours. Instrumentation Monitoring: (Piezometer reading, topographic control, and filtration measuring.
San Rafael Dam	75,000,000 m^3	East of Bogotá City Within La Calera rural area	-	Instrumentation Monitoring: (Piezometer reading, topographic control, and filtration measuring.
Sisga Dam	102,000,000 m^3	North of Bogotá City	-	-
Tomine Dam	690,000,000 m^3	North of Bogotá City	-	-
Neusa Dam	102,000,000 m^3	North-West of Bogotá City	-	-

Source: JICA Study Team, 2001

EAAB has four sources or systems of water supply, which are shown in Table 2.7.11.

Table 2.7.11 EAAB Systems of Water Supply

System	Dam Composition	Storage Capacity Million m^3	Max. Supply Capacity m^3/seg	Tunnel Conduction (Km)	Pipeline Conduction (Km) / Diameter	Delivers water to
Chingaza	Chuza San Rafael	332	34	32	4.5 Km (60")	Wiesner Purifying Plant
Vitelma	La Regadera Chisaca Los Tunjos	11	1.35	No	(34") to Vitelma (20") to La Laguna	La Laguna or Vitelma Purifying plant
Tibitoc	Sisga Tominé Neusa Aposentos	894	10.5	No	(60")	Tibitoc Purifying plant and then to Usaquen pumping station
San Diego	San Francisco River	0.03	0.14	No	(14")	San Diego Purifying plant

Source: JICA Study Team, EAAB, 2001.

2) Sewage Service System

Bogotá City's sewage system consists of two kinds of networks as follows: one for storm water with a pipeline length of 1,654 km in total and 32,064 manholes, and another for wastewater that has a total length of 5,008 km and 85,110 manholes. Both networks are independent from each other for the most part but before the discharge points to the rivers the waters are mixed. Another problem is that even though the city networks are almost divided, the pipelines running in each house are not divided, so rainfall and wastewater coming from houses are combined and then discharged to the city wastewater network.

Eight Municipalities

The characteristics of water supply and sewage system in the eight municipalities are summarized in Appendix 2.7.1.

1) Water Supply System

The water supply system in each municipality has individual solutions; there are different systems such as the utilization of supply source, the function of supply facility and the service conditions. The method of water supply from source is generally classified into three types as follows:

- 100% coverage by well and river of each municipality.
- 100% coverage by EAAB supply.
- Mixed type by EAAB supply and each municipality's well/river.

About 75% of the eight municipalities combined are supplied with the mixed type of potable water by EAAB and wells/rivers of the municipalities. It is observed that the municipalities of Madrid, Mosquera and Soacha receive the highest share of EAAB supply in the range of 50% to 90%. Other municipalities of mixed type water supply have the following distribution: EAAB at

28% and river at 72% in La Calera, EAAB at 10% and well water at 90% in Funza. The municipalities of Cota and Facatativa are self-supporting with 100% of water supplied through their wells/rivers. While Chia is directly supplied 100% of water from EAAB by the purification plant of Tibitoc.

The supply facilities maintained for each municipality are mostly purification plants, supply pipelines, storage tanks and pumping stations. Number of purification plants in each municipality is about 1-3. The diameter of main pipelines network in each municipality varies between 6 and 40 inches, and the local network is composed of pipelines of less than 4" in diameter.

For the service conditions for each municipality, the service covers above 80% of the demand, however, storage volume capacity is not enough in the municipalities of La Calera, Chia, Madrid and Mosquera. The municipalities of Cota, Funza and Facatativa have enough in storage volume system.

2) Sewage Service System

At present, the sewage service system in each municipality consists of three kinds of sewer network as follows:

- Mixed type of rainfall/wastewater.
- Separated type.
- Mixed and/or separated type.

The municipalities of Chia, Facatativa and Soacha have the mixed type of rainfall and wastewater; La Calera, Cota and Funza, the separated type, and the municipalities of Madrid and Mosquera have the mixed and/or separated type. Especially, the system of La Calera is immature and complex. Regarding wastewater system in urban area, in Veredas Sector, individual solutions are made by a small group of people that do not have any control of the final disposition. In Los Molinos Sector, 80% of the population counts on a sewage system supplying four principal collectors; these supply the brooks that drain to the Los Molinos brook. Of the remaining 20%, 12% has a septic tank, and waste is discharged into the brook. The 8% has a secondary supply, superficial sewage systems that discharge to the Puente Piedra brook and the brook in the yard zone. A common problem among the system of other municipalities is sporadic flooding during rainfall seasons. All treatment plants with complementary facilities were constructed and managed by CAR (*Corporacion Autonoma Regional*). The capacity of treatment plants in each municipality varies widely at 60-160 LPS except the municipality of Cota.

(1) Electric system

A. Administrative institution of electricity system

The electricity supply in the study area is provided by several electricity supply companies such as EMGESA, EEB, CODENSA, AMBAS and ISA. EMGESA is in charge of the generation, EEB and ISA are in charge of the transmission at a districts and national level, respectively. CODENSA is in charge of distribution at a domiciliary level. Almost 100% of inhabitants are covered by electric supply. The generation and transmission network is not an isolated one, but is connected to the national electrical system through the National Transmission System. This means that Bogotá City and the other municipalities can be supplied from generation plants in other regions in Colombia or even from Venezuela or Ecuador. Interconexión Eléctrica S.A. Company or ISA are in charge of the most part of the national transmission network.

Before 1997 EEB (*Empresa de Energía de Bogotá*) was in complete control of the generation, transmission and distribution business around Bogotá Metropolitan Area, but in 1997 EEB sold approximately half of the stocks in the generation and distribution business to EMGESA and CODENSA companies respectively.

Figure 2.7.5 illustrates the stock participation in generation and distribution business before and after 1997, and Table 2.7.12 shows the institutions of electricity.

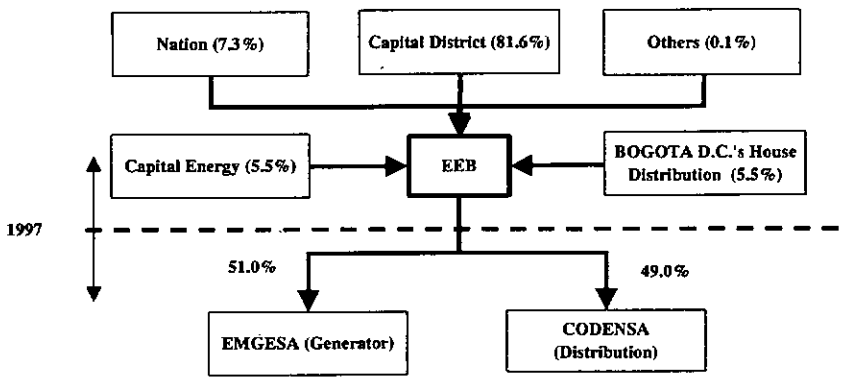


Figure 2.7.5 Stock Participation in Generation and Distribution Business Before and After 1997

Table 2.7.12 Institutions of Electricity

Company	Private or Public	Responsibility	Service Area	General Information
CODENSA	Mixed 51% Public (belongs to EEB) 49% Private	a. Expansion, maintenance and reparation of the distribution network (under 115 kV) and the facilities related with distribution (Sub-stations, posts, electrical transformers, etc). This work is performed by construction companies hired by CODENSA. b. Maintenance and reparation of the high voltage transmission lines (230 and 115 kV) within Bogotá. c. CODENSA personal is basically for administrative matters and there are around 600 people working at the company.	a. Bogotá, 8 municipalities in study (In Facatativa only one minor sector) and many other municipalities in Cundinamarca (a total of 96 municipalities)	a. EEB participation is only a monetary one. EEB Doesn't have administrative participation. b. Codensa S.A.-E.S.P. in its private part is the result of the capitalization of the Energy Company of Bogotá, carried out with contributions from three International Companies: Endesa (Spain) 55%, Enersis (Chile) 25.71% and Chilectra (Chile) 19.29%.
EEB	Public	a. Maintenance and reparation of a electrical circuit of high tension lines – 230 kV- (Transmission from the generation plants to Bogotá city)	a. Around Bogotá City	a. The personnel of EEB is minimum at the present time. Around 50 people.
EMGESA	Mixed 49% Public (belongs to EEB) 51% Private	a. Management, maintenance and reparation of electrical power plants (thermo-generation plants, Hydro-generation plants). b. Generation of energy for the national interconnected system (EMGESA produces energy not only for Bogotá but for the national system. This means, the national system gives energy to Bogotá too). c. EMGESA manages seven Hydro-electrical generation plants: Canoas, El Salto, Laguneta, Colegio, El Guavio, La Guaca y el Paraíso; Furthermore the company controls the thermo-electrical plant called Termozipa. A brief description of each one of the plants is included in this report.	a. Cundinamarca/Country (EMGESA participates in the electrical interconnected national system)	a. EEB participation is only a monetary one. EEB Doesn't have administrative participation. b. Emgesa S.A. E.S.P. is the largest and most important Generator Company of Electric Energy in Colombia. This company is the result of the capitalization of the Energy Company of Bogotá, carried out with contributions from two International Companies, leaders in the matter: Endesa Chile and Endesa Spain. In 1999 Emgesa generated 11.013 GWh, which approximately corresponds to the 20% of the total energy demanded in Colombia. b. Endesa is one of the largest private electrical. c. Groups in the world, with a total installed capacity of 36,994 MW, 153,264 GWh distributed capacity and more than 2 million customers in 12 countries.
AMBAS		a. Expansion, maintenance and reparation of the Distribution network. b. Distribution of under 115 KV voltage	a. Facatativa	
ISA	Mixed ISA is a mixed-economy public utilities company ascribed to the Ministry of Mines and Energy	a. ISA owns and operates the largest high-voltage transmission network in Colombia: 1,449 km of 500-kV lines, 6,456 km of 230-kV lines, 7,372 MVA of transformation, 2,789 Mvar of reactive power compensation, six 500-kV substations and thirty-four 230-kV substations, all of which corresponds to 70% of the total National Transmission System. b. ISA has a 44% share in the connection business nationwide, which is served with 3,272 MVA of transformation capacity and 84 transformer bays	a. Colombia	a. Interconexión Eléctrica S.A. –(ISA)- is a Colombian corporate group with two power sector affiliate companies – Transelca and Interconexión Eléctrica from PERÚ, and Internexa from Colombia. b. The National Transmission System (NTS) provides a viable means of transaction between generators and traders. The transmission service is a natural monopoly that is regulated by the Energy and Gas Regulating Commission – CREG-. c. In Colombia there are eleven companies presently in charge of transmission activity, ISA being the largest with a partial ownership of more than 70% of the NTS network.

Facility Conditions of Electric System

- Distribution of Electricity

1) Service Area and Cable length in Bogotá City.

The distribution of electricity for houses in Bogotá city and the eight municipalities of Cundinamarca is maintained by CODENSA. Facatativa is served by CODENSA and AMBAS. CODENSA is generally in charge of expansion, maintenance and repair of the distribution network less than 115 kV, and the facilities related with distribution such as sub-stations, posts, electrical transformers, etc.

The service area of CODENSA is divided into three zones in Bogotá City as shown in Figure 2.7.6. The UN is the northern zone from Autopista El Dorado, UC is that between Autopista El Dorado and Avenida 1st de Mayo and US is the southern zone from Avenida 1st de Mayo. The total zonal cable length less than 50 kV is shown in Table 2.7.13. The total cable length in the City is 5,205 km, and the longest total length (of 1,994 km) is seen in US zone of southern city; the other zones have a cable length almost equivalent to about 1,600 km. The ratio of overhead cable and underground cable is significantly different according to the estrato. The areas of

estrato ranked from 1 to 3; high-income society, is equipped with overhead cable with a ratio in the range of 80%-100%. Meanwhile, areas ranked from 4 to 6, low-income society, show the ratio of 5%-20%.

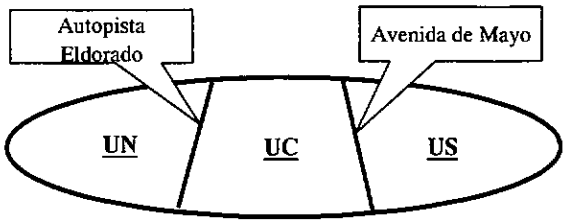


Figure 2.7.6 Definition of Zone for Electricity in Bogotá City

Table 2.7.13 Cable Length of Less Than 50 kV

Zone	Cable length (km)		
	Overhead	Underground	Total
UN	869	760	1,629
UC	681	901	1,582
US	1,574	420	1,994
Total	**3,124**	**2,081**	**5,205**

Source: CODENSA material; Circuitos de Media Tensión

The total length of 115 kV network is approximately 617.4km, while, the total length of 57.5 kV is approximately 80.4km.

2) Circuits Conditions Around Bogotá City.

The distribution of electric lines in and around Bogotá City is composed of 230 kV EEB, 115 kV CODENSA and 57.5 kV CODENSA. The high voltage lines of 230 kV are located outside Bogotá City bordered by Toroca, Noroeste, La Mesa, El Paraíso, Muña, Fusagasugá, Usme, Circo and Embalse San Rafael. At each boundary, there are eight main substations for transforming 230 kV into 115 kV, with a total of eight as it is shown below:

- Northern area outside Bogotá City.:
  1. A Chivor.
  2. Torca.
  3. Noroeste.
- Western area outside Bogotá City.:
  4. Balsillas.
- Southern area outside Bogotá City.:
  5. La Guaca.
  6. Tunal.
- Eastern area outside Bogotá City.:
  7. La Reforma.
  8. Circo.

The voltage lines of 57.5 kV are located at the central Bogotá. D.C. bordered by Concordia, San Facon, Salitre, Puente Bosa, Soacha, Veraguas and Calle 1a. There are three major substations for transforming 115 kV into 57.5 kV, namely, Salitre, Veraguas and Concordia.

Generation of Electricity

Power generation for Cundinamarca and the rest of the country is maintained by EMGESA. EMGESA is generally in charge of management, maintenance and repair of electric power plants. There are nine generation plants, which consist of a thermo-electric plant and eight hydro-electric plants.

- Thermo-electric Plant: 1. Termozipa.
- Hydro-electric Plant: 2. El Paraiso 6. Dario.
  3. Laguneta 7. Canoas.
  4. El Salto 8. Guavio.
  5. La Guaca 9. Muña.

These power plants generate 45MW -1,150 MW of electric power. The plants were constructed before 1992, and the oldest is the hydro-electric plant at Laguneta, which was constructed in 1957.

Transmission of Electricity

Power transmission for Cundinamarca and the rest of the country is maintained by EEB and ISA respectively.

1) EEB (Empresa de Energía de Bogotá)

EEB is generally in charge of maintenance and repair of an electrical circuit of high-tension lines – 230 kV (transmission from the generation plants to Bogotá City). Table 2.7.14 breaks down the total length of 230 kV transmission lines belonging to EEB.

Two of these generation plants located to the Southwest of Bogotá -La Guaca and Paraíso plants- are connected by a double transmission line of 7.5 km each, while La Guaca plant has connection only to the national system through 230 kV lines. Paraíso plant is connected to San Mateo and El Circo substations, which are located in South and East areas within Bogotá City respectively. It is necessary to clarify that the connection between La Guaca Plant and Bogotá City. City is made by lines lower than 230 kV. On the other hand, Guavio generation plant has a direct connection to the national network, and furthermore it is connected to the Bogotá City substations of El Circo and Tunal by two 230 kV lines.

Other three sub stations that receive 230 kV lines, but this time from ISA network, are Torca located at the North part of Bogotá, and Noroeste and Balsillas sub stations located at the

Northwest and West areas of Bogotá. These three sub stations are interconnected, with the Noroeste station functioning as a bridge between Balsillas and Torca.

Table 2.7.14 230 kV Transmission Lines of EEB

Origin	Destination	Owner of the Destiny facility	Total length (Km)
El Paraiso generation plant	San Mateo Substation	Codensa	33.9
	El Circo Sub Station	Codensa	50.0
	La Guaca generation plant	Emgesa	7.5
	La Guaca generation plant	Emgesa	7.5
La Guaca generation plant	La Mesa Substation	ISA	5.0
	La Mesa Substation	ISA	5.0
Guavio generation plant	El Circo Sub Station	Codensa	109.8
	El Circo Sub Station	Codensa	109.6
	Tunal Sub Station	Codensa	155.1
	La Reforma Substation	ISA	80.4
Tunal Sub Station	La Reforma Substation	ISA	74.7
	El Circo Sub Station	Codensa	29.8
	San Mateo Substation	Codensa	14.8
Total			683.1

Source: JICA Study Team, 2001.

2) ISA

ISA owns and operates the largest high-voltage transmission network in Colombia as follows: 1,449 km of 500 kV lines, 6,456 km of 230 kV lines, 7,372 MVA of transformation, 2,789 MVA of reactive power compensation, six 500 kV substations and thirty-four 230 kV substations, all of which corresponds to 70% of the total National Transmission System.

There is a unique interconnected network system in Colombia that links generation plants with electricity charge centres in the Andean region of the country, the Atlantic and Pacific seaboards and the Eastern plains. The national network managed by ISA is divided into five administrative centres or CTE (Spanish abbreviation of Energy Transport Centre) as shown in Table 2.7.15. ISA owns some of the 230 kV lines around Bogotá. A summary of them is shown in Table 2.7.16.

Table 2.7.15 National Network Managed By ISA

Name or CTN area	Network System
1. CTE North	a. This administration center is located in the town of Sabanalarga (Atlantico) and is the disembarkation point of a 500 thousand watt transmission system which links the electricity system in the Center of the country with the electricity system in the Northern region and passes through the departments (prefectures) of Antioquia, Cordoba, Sucre, Bolivar and Atlantico. b. From this center, 3 substations, located in Cerromatoso, Chinu and Sabanalarga, are served by a 500 thousand volt transmission system and 949 kilometers of lines. There is an associated transformation capacity of 1,950 MVA in these substations, represented by four transformer units of 150 MVA of a relation 500/150 kV located in Cerromatoso and Chinu and three banks of transformers in Sabanalarga with a relation 500/230 kV, each of 450 MVA.
2. CTE East	This administration center is located in the city of Bucaramanga and serves 9 substations and 1,126 kilometers of 230 thousand volts of network circuit. These installations include the circuits which allow the interconnection of the Eastern region of the country - the Santanderes, Boyaca and Arauca prefectures - with the central network of the
3. CTE North west	a. This administration center is located in the substation of Ancon Sur in the jurisdiction of La Estrella. This center serves 8 substations and 1206 kilometers of 500 thousand and 230 thousand volts of network circuit, making possible the integration of the large hydroelectric resources of the region (Antioquia) with the remainder of the country. b. This CTE is in charge of the most important substation in the Colombian electricity system, which is associated with the San Carlos hydroelectric center, and is the site where transmission systems of 500 thousand and 230 thousand volts join by means of three banks of transformers that total 900 MVA of capacity.
4. CTE Center	a. From this administration center, 8 substations and 1553 kilometers of 230 thousand volts of network circuit are served, allowing connection of important centers for the national electricity system such as Guavio and Chivor, with the largest consumer in the country, which is the capital of the republic - Santa Fe de Bogota. b. The total transformation capacity served is 834 MVA with transformer units in the substations of Torca and Balsillas, which allow the transformation of approximately one fourth of the energy required by Santa Fe de Bogota.
5. CTE Southwest	a. From there it attends 10 substations at 138, 230 and 500 kV, as well as 246.72 km of 500-kV transmission lines with 488 transmission towers; 1,125.63 km of 230-kV lines with 2,254 towers; 9.86 km of 138-kV lines with 30 towers which constitute the interconnection with Ecuador; and 77.15 km of 115-kV lines with 134 towers. b. Its influence area includes facilities in the prefecture of Caldas up to the region bordering Ecuador, where Panamericana Substation was inaugurated in 1998 becoming the starting point of the 138-kV interconnection with Ecuador power system.

Table 2.7.16 Network of 230 kV Around Bogotá City Belong to ISA

Origin	Destination	Owner of the Destiny facility	Total length (Km)
La Mesa Substation	Balsillas Sub Station	Codensa	27.0
	Noroeste Sub Station	Codensa	-
Noroeste Sub Station	Torca Substation	ISA	20.0
	Torca Substation	ISA	20.0
Torca Substation	Guavio generation plant	Emgesa	82.9
	Guavio generation plant	Emgesa	82.9
Total			232.8

Source: JICA Study Team, 2001.

C. Telecommunication system

a) Administrative institution of telecommunication system

The telecommunication supply in the Bogotá Metropolitan Area is provided by several telecommunication companies. In Bogotá City, there are three companies that render the service of local communication through fixed telephones. These are: *Empresa de Teléfonos de Bogotá* – ETB-, CAPITEL and *Empresas Públicas de Medellín en Bogotá* –EPM-Bogotá-. Except CAPITEL, the other companies render the long distance communication service too, using not

self-networks but one that belongs to TELECOM, which offers the long distance service for Bogotá and the local communication service in the eight municipalities. Local communication is performed by wire system while long distance is carried out by waves. Table 2.7.17 shows the institutions of telecommunication.

Table 2.7.17 Institution of Telecommunication

Company	Public or Private	Responsibility	Service Area	Remarks
ETB	Public a. The company is a society of stocks. The 99.93% of the stocks belong to the Capital District of Bogotá. The other shareholders are public entities of Bogotá D.C.	a. Management, construction, maintenance and reparation of Bogotá telephone network (this company has the biggest coverage in service) and the facilities related with it like Sub-stations, cabinets, poles, etc. Its main function was for local communication, but now has the long distance communication service. b. At the present time, ETB manage 1,900.00 telephone lines. c. There are around 4,500 employees at ETB. d. In 1999 ETB won $153.155 million pesos (66.5 million dollars).	a. Local network in Bogotá D.C.. b. Long distance communications	a. ETB controls the 26% of COMCEL Cellular company stocks.
CAPITEL	Public a. This is an industrial and commercial company of the state	a. Management, construction, maintenance and reparation of Bogota telephone network that belongs to Capital. Its main and unique function is for local communication.	a. Local network in Bogotá D.C.. b. Long distance communications	a. This company is a vice-presidency of Telecom
EPM-Bogotá	Public a. This is an industrial and commercial company of the state. Belongs to the Medellin governorship.	a. Management, construction, maintenance and reparation of telephone network that belongs to EPM-Bogotá. Its main and only function is for local communication, but it has the long distance service too. b. The company offers Internet service.	a. Local network in BogotáD.C.. b. Long distance communications.	a. In Bogotá D.C. EPM only has telephonic service. In Medellín city they manage all public services.
TELECOM	Public	a. Management, construction, maintenance and reparation of municipality telephone network. Its main national function was for long distance communication service (at national level) and local communication for small towns. b. Long distance communications, through micro waves transmission towers located at the top of some mountains. Telecom repairs, maintains and operates these towers, which are frequently damaged by terrorist attacks. c. The company offers Internet service. d. Gives the communication service to 800 municipalities in Colombia (total number of municipalities in Colombia is around 1100). e. TELECOM attend the service demand of 400 important companies in Colombia (Cash Machines, communication within banks, etc)	a. Local network in Eight Municipalities. b. Long distance communication in Bogotá	-

Source: JICA Study Team, 2001.

b) Facility conditions of telecommunication system

Distribution of Telecommunication

Until 1990 some public companies are in charge of the telephone service. TELECOM was one of them and it was in charge and had the monopoly of the national and international long distance communication, as well as the local service in some regions within the country. The other companies belonged to some municipalities or to some prefectures, and were in charge of local communication. Having those companies allowed them to have a monopoly of the communication business in their own areas; one company like this , and the biggest, is ETB.

For more than 110 years ETB had the monopoly of the telephone service in Bogotá City, but since 1995 this situation has changed. After Law 142 of 1994, the markets of local communication service were opened and some companies entered to compete with ETB for the market in Bogotá City. Therefore, at the beginning of 1996, TELECOM started to consolidate a project for local communications called CAPITEL, a company that made contracts with international companies

in order to install their network within Bogotá. Furthermore, at the beginning of 1997 another public company called *Empresas Públicas de Medellín* signed a contract with the multinational company Itochu to install around 95,000 lines. Table 2.7.18 shows the approximate number of lines projected and installed by each company in Bogotá City.

Table 2.7.18 Number of Projected and Present Telephone Lines in Bogotá D.C.

Company	Projected lines	Present lines
CAPITEL (TELECOM)	550,000	200,000
EPM	95,000	16,000
ETB	No available	1,900,000
Total	**645,000**	**2,116,000**

Source: ETB, 2001.

On the other hand, ETB owns 26% of the shares of COMCEL Company, the main operator in cellular telephone services in the country. Last year, COMCEL acquired 68.04% of the property shares and control over OCCEL Company, one of the two cellular operators in the western zone in the country.

In respect to long distance communication, in 1998 ETB received the license to compete in this field with TELECOM, as well as with Orbitel, which is a company put up basically by EPM and other shareholders.

ETB (Empresa de Teléfonos de Bogotá)

ETB has 37 local control centers and 4,500 cabinets in Bogotá City. The information is provided by GIS data. Furthermore, the information on cable length of main cables, cable length of local cables, percentage of overhead cable and number of pole were provided through interviews. The average length of main cables per cabinet is approximately 42,000m, and the average length of local cables per one cabinet is about 2,410m. The shares of overhead cable by type are as follows: main cables, 1%, local cables, 49%. Total number of poles is about 120,000. Table 2.7.19 shows average length of cables and percentage of overhead cable by type.

Table 2.7.19 Average Length of Cables and Percentage of Overhead Cables by Type

1. Average length of primary cables per cabinet	42,000 m
2. Average length of secondary cables per one cabinet	2,410m
3. Percentage of overhead cable of primary network	1%
4. Percentage of overhead cable of secondary network	49%
5. Total number of poles	120,000 Nos.

Source: ETB by interview survey of JICA Study Team. 2001

ETB has its main transmission network 100% digitized into optic fiber using the SDH technology; 83% of the commutation is digital. There are projects under the reposition execution of analog lines to achieve a digitalization of 100% in commutation in the year 2001.

CAPITEL

CAPITEL has a cable telephone network and mobile telephone network. The information of both networks is provided by well-organized GIS database, which contains mobile radio station, overhead cable network, underground cable network and telephone poles. The share of overhead cable is 58% and that of under ground cable is 42%. The total number of poles is 54,970and the number of radio stations is 98. Table 2.7.20 summarizes CAPITEL telecommunication network.

Table 2.7.20 Summary of CAPITEL Telecommunication Network

1. Total length of over head cables	1,618km
2. Total length of under ground cables	1,160km
3. Total number of poles	54,970 Poles
3. Total number of radio bases	98 Stations

Source: CAPITEL, 2001.

Table 2.7.21 shows location of local control centers and client attention centers owned by CAPITEL; the first part of the list is for local control centres and the last one for client attention. Unfortunately, the information given by the company does not include details like constructed area of each building.

Table 2.7.21 Location of Local Control Centers and Client Attention Centers

	Building	Address	No. of Story
Local Control Center	CENTRAL AUTOPISTA	Av.13 No. 135-20	2
	CENTRAL TOBERIN	Cra. 38 No. 167-06	1
	LA CABRERA	Cl.86A No. 13-33	5 + 1 cellar
	MORATO	TRANSV. 9 No. 105-84	1
	VILLA MARIA	Cr.107 No. 136B-16	2
	CENTRAL SALITRE	Cr.69 No. 43B-44	3 + 2 cellar
	PROGRESO	Cr.22 No. 3-2/286	2
	ASTURIAS	DIAG.42Bis.Sur x TRANSV.62A	1
	MARRUECOS	Cl.50A Sur No. 7-53/61	3
	SOACHA	Cr.4 No. 22-30	1+ 1 cellar
C.A.C. (Client Attention Center)	CENTRO SUBA	Cl.140 No.91-19 Loc.5-117/8/9	1
	CIENTO NUEVE	Diag. 109 No. 17-15	-
	COLGAS	Cl.36 No. 8-64	1
	CENTRO INTERNACIONAL	Kr.13 No. 26-49	1
	ALAMOS	Transv. 93 No. 62-92	1
	FONTIBON	Diag. 43 No. 95-89	1
	UNISUR (soacha)	Autop. Sur No. 29A-02	1
	SIBATE	Kr.8 No. 10-44	1

Source: TELECOM

D. TELECOM

TELECOM maintains and operates the local communication network in the eight municipalities. TELECOM also maintains the long distance communications through microwave transmission towers located at the summit of the hills. The tower height is in range between 8 and 40 meters; all towers are of the self-supported square section type.

E. Gas supply system

a) Administrative institution of gas supply system

The natural gas resource that comes to Bogotá is mainly extracted from Ballena offshore well (70% of the total amount of gas consumed in Colombia) which is managed by Texaco company and is located on the Atlantic Ocean, in the Guajira prefecture. The second source of natural gas comes from Apiay wells (25 % of the national consumption) located in the east part of Colombia and their manage is performed by ECOPETROL. After being extracted, natural gas is transported by conduction lines that are managed by a company called ECOGAS, which is a national public company. The maximum transport capacity of the North line is 30 million ft^3/day, while the maximum one of the East line is 17 million ft^3/day. The present demand in Bogotá city is around 25 million ft^3/day.

Around Bogotá there are two city gates: The first one is near a municipality called Cogua that is located North-west of the city and receives the coming gas from Ballena wells, while the second one is located in Usme (South of Bogotá) and receives the gas from Apiay area. A city gate is an installation where the gas that comes from a line is received and its pressure is regulated in order to reduce it to distribution values (from 1200 PSI to 250 PSI).

The principal pipelines from the city gates as well as the distribution networks are not controlled by ECOGAS but by Gas Natural Company. Table 2.7.22 shows institution of gas supply system.

Table 2.7.22 Institution of Gas Supply System

Company	Public or Private	Responsibility	Cover Area	Remarks
Gas Natural	Private a. The company is a group dedicated to the distribution of natural gas in Spain and Latin-American. 59% of the capital is international and the other one is national.	a. Management, maintenance and reparation of natural gas pipelines distribution network. b. Management, maintenance and reparation of natural gas pipelines distribution network.	Bogotá D.C., Soacha and Chia	a. This company recently won a bid to distribute natural gas to the municipalities studied in this project. In the future de control of these networks will belong to gas Natural company. There are around 500 employees
Ecogas	Public a. This company was created in August 20th of 1997. Before Ecogas was founded, Ecopetrol controlled the transportation of natural gas.	a. Management, construction, operation, planning and commercial exploitation of the natural gas transportation systems. This work is performed by other companies that are hired by Ecogas. This is the reason why there are not many workers. b. The company is in charge (through other companies like Texaco, BP, ECP) of the gas production areas located in the north and in the plain land of Colombia; some areas of the main transmission network (pipelines) are in concession as well. This means this company is not so important for this study, because the main transmission line for Bogotá and the other municipalities is managed by Gas natural	Transmission lines in Colombia.	In total there are 50 employees

Source: Gas Natural, JICA Study Team, 2001

b) Facility conditions of gas supply system

Distribution of Gas Supply

- ECOGAS

As described before, the natural gas transmission network from Ballenas and Apiay to the cities is managed by ECOGAS. The distribution of the network and the main pipe length by pipe diameter is shown in Figure 2.7.7.

This national network is composed by iron pipes and there is a shut down valve every 25 Km on the lines; the design of the lines were done based on international codes as API and ANSI. The North coastal system was constructed around 15 years ago, while the rest of the net was put in service since 1996. The calculated reserves of natural gas in Colombia are enough for 15-20 years. The average consumption per family is calculated in 30 ft^3/day. The construction of the line Monterrey-La Belleza has two main reasons: The first one is because Cusiana wells have a big reserve of natural gas, even though the exploitation of this resource is relegated to a second plane by now, because the principal resource of this area is oil. The second one is that the transport line from Apiay to Bogotá has already fulfilled its maximum transmission capacity (17 millions of ft^3/day) and further availability is required for the future.

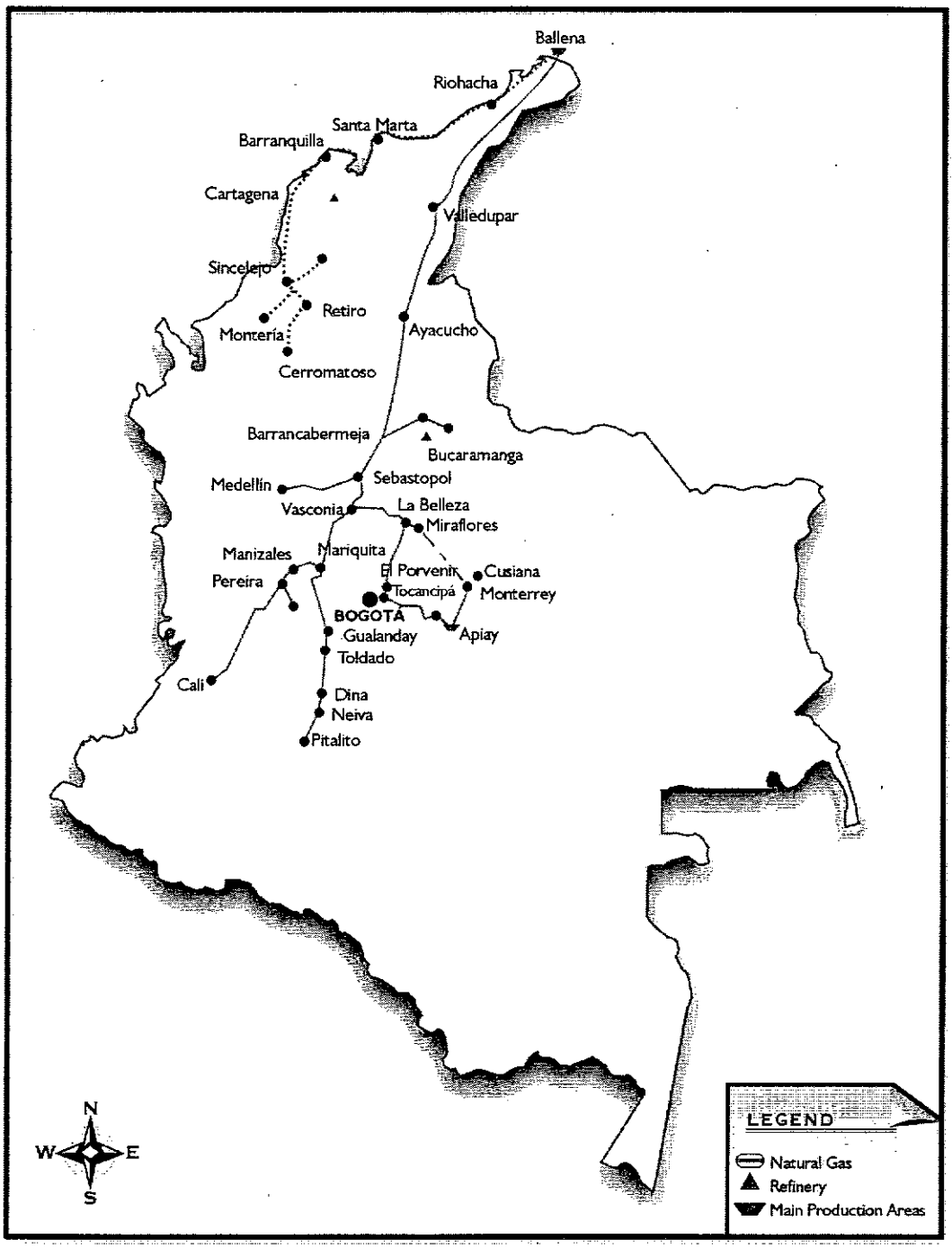


Figure 2.7.7 Distribution of Network and Main Pipe Length by Diameter

c) Gas natural company

The current extension of the primary and distribution network covers about 90 % of the urban area in Bogotá City. For the capital city, the network attends 751,734 users (houses or apartments) and is in capacity to attend a total of 1,140,080 users; the same numbers for Soacha are 91,122 and 306,556, and for Chia are 4,160 and 21,042 respectively. Even though the service is rendered at the present time only to the mentioned municipalities, Gas Natural Company recently won a

public bid to distribute the resource to all municipalities studied in this project. In the future control of these networks will belong to Gas Natural Company.

The principal or high pressure network consists of some kind of distribution rings within the city, in such way that if a track of pipe is broken or damaged, the gas service to the affected area can be supplied from other different branch. This redundant system is not for all Bogotá City and the presence or not of it depends on the city area where the damage might occur.

A transmission line or a pipeline for gas is installed from a supply source or sources towards one or more distribution centers. They are different from the main distribution lines, which operate with higher pressures. The total length of gas supply pipes is shown in Table 2.7.23, while the Figure 2.7.8 shows the distribution iron network within Bogotá City.

Table 2.7.23 Total Length of Gas Supply Pipes In Bogotá City

Area	Length (km)
Bogotá	8,023.0
Soacha	584.0
Total	8,607.0

Source: Gas Natural Company, 2001.

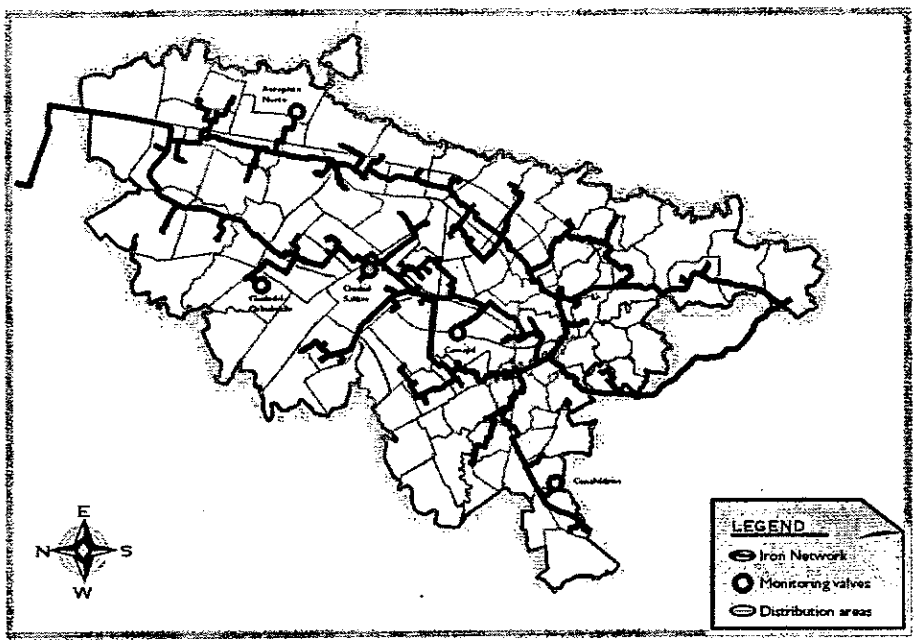


Figure 2.7.8 Network of Main Gas Line in Bogotá City

d) Valve stations for control and attention of emergencies

In order to receive information of problems or emergencies in the gas natural network, the company has two different systems: the first one is through the dispatch center where the main

network is monitoring in real time at some valves by the measurement of gas volume, temperature, pressure, smell and calorific value. This valve stations are constructed underground, and there are instruments that monitoring the well functioning of the measurement gauges. The communication from this points to the central building is done or transmitted by CDP, which is a communication system similar to the one used by cellular phones.

There is one monitoring gauge in each city gate and five additional ones located on the iron network within the city. According to the recommendations suggested by Los Andes University study of Seismic Vulnerability, Gas Natural Company is installing other 15 points of valves; this processes have been finished by the end of October in 2001.

The second information system is the Urgency Center where phone calls from the users are received in aspects related to distribution and gas usage. All phone calls are introduced to a computerized system to follow the progress of the emergency, and to categorize the level of problem: Leakage and gas smelling reports have priority over lack of gas.

2.7.3 Public Facilities

The Study Team collected a wide range of public facilities data within the Study Area. These data can be used for identification of the command center, emergency response center, evacuation site, storage places and others. The information is also useful to identify where to set up emergency response centers and disaster management centers and prioritize the seismic reinforcement required. The data include the following items:

- Name of facility and main functions.
- Size of land and building coverage.
- Structure type, age of building and number of stories.
- Capability of the facility (staff and equipment).

The public facilities data items collected in this study are as follows:

- Fire fighting station.
- Civil defense.
- Red cross.
- Police station.
- Military station.
- Public and private hospital.
- Government facilities.
- Educational facilities (kindergarten, primary school, intermediate school).
- Parks and open space.
- Emergency goods storage center.
- Food Storage center.

- Transportation Facilities (Airport and Bus Terminal).

The information is collected from each organization responsible for the facilities in Bogotá City. In eight municipalities, the local governments do not compile this kind of information, so that the Study Team had a field survey undertaken by a team of local consultants.

The list of the public facilities in the Study Area is shown as follows:

Table 2.7.24 List of Public Facilities

Locality	Government		Disaster Organization						Transportation		Storage Places		Evacuation Facilities		
	Locality Offices	Ministries	Police	Civil Defense	Fire Fighting	Red Cross	Hospitals & Clinics	Army	Airport	Bus Terminal	Goods Storage	Food Storage	Public Schools (Primary/Secondary)	Kindergartens	Parks & Open Spaces
WITHIN BOGOTA CITY :															
1 - Usaquén	1		1		1		9	2					32	7	246
2 - Chapinero	1		2	1	1		9						11	3	133
3 - Santa Fé	1	5	4	1			2						18		71
4 - San Cristóbal	1		1	1	1		7	1					64	3	194
5 - Usme	1		1		1								64	11	154
6 - Tunjuelito	1		1		1		2	1					24	5	58
7 - Bosa	1		1		1		1						34	12	187
8 - Kennedy	1		1		1		3					1	70	8	494
9 - Fontibón	1	1	2	1	1		1		1	1			19	1	132
10 - Engativá	1		2	6	2	2	3						61	3	508
11 - Suba	1		1	1	2		1						42	10	319
12 - Barrios Unidos	1		1										26	4	109
13 - Teusaquillo	1	4	3	3			9	1			1		4		119
14 - Los Mártires	1		1	2	1		4						15	1	47
15 - Antonio Nariño	1	3	1		1		1						12		54
16 - Puente Aranda	1		2	2	1	1		2					33	3	284
17 - La Candelaria	2	7	1	1	1								7		15
18 - Rafael Uribe	1		1	1			2						53	5	212
19 - Ciudad Bolívar	1*		1				1						69	10	263
SUBTOTALS	*20*	*20*	*28*	*20*	*16*	*3*	*55*	*7*	*1*	*1*	*1*	*1*	*658*	*86*	*3,599*
WITHIN EIGHT MUNICIPALITIES :															
Chía	1		1		1	2	7						29		17
Cota	1		1				1						9		
La Calera	1		1	1			1						9		
Facatativá	1		1	1	1	2	7						17		18
Funza	2		1	1	1		3						15		20
Madrid	1		2				4	1					25		29
Mosquera	1		1		1		3						19		26
Soacha	2		6	1	1	1	13						32		12
SUBTOTALS	*10*		*14*	*4*	*5*	*5*	*39*	*1*					*155*		*122*
TOTALS STUDY AREA	*30*	*20*	*42*	*24*	*21*	*8*	*94*	*8*	*1*	*1*	*1*	*1*	*813*	*86*	*3,721*

Source: JICA Study Team

The details of each facility is summarized below:

1) Fire Fighting Station

The Fire Fighting department is under the national government specifically the Ministry of Interior, yet it is under the Command of the Bogotá City Government. The fire fighting office in Bogotá City prepared the data for the office, but for eight municipalities in Cundinamarca, data were collected by the consultant team on field survey. There are 21 fire fighting stations with a collective staff of 330 and 57 volunteers, including those of eight municipalities. The vehicles for the fire fighting activities are 42 in total.

2) Civil Defense

There are 24 Civil Defense buildings in the Study Area. The Civil Defense office, Bogotá Direction, provides the data about capability of the institution and building information of each branch. The Civil Defense in the Study Area has a staff of 224 and 491 volunteers in total. The headquarters of Civil Defense in Bogotá City is in Teusaquillo locality, while the one in Cundinamarca prefecture is located in Puente Aranda locality.

3) Red Cross

In the Study Area, there are eight rescue force centers of the Red Cross with a personnel complement of 538 and 690 volunteers. Apart from those facilities, the Red Cross has health and emergency medical care centers in Engativá locality in Bogotá City and in Chia, Facatativa and Soacha municipalities. Information for Bogotá headquarters was provided by the National Red Cross. For eight municipalities in Cundinamarca, the information was collected by the field survey carried out by the consultant team.

4) Police Station

The police stations are identified in each locality and municipality in the Study Area. The information was collected through the Constructions and Maintenance Group from the National Police Institution that provides the Study Team with the data about staffing, capability and structure of the buildings. For Cundinamarca, information on police stations was collected during the field survey by the consultant team. Nine specialized police stations are distributed in Bogotá City as follows:

Table 2.7.25 Distribution of Police Stations

Locality	Functions
Santa Fé	Perseverance station with 30 policemen for policewomen station La Estanzuela station with 700 policemen to support other stations in any case Carabineros National Park stations with 70 policemen.
Chapinero	Chicó station with 200 policemen for Embassies' security
Fontibon	Modelia station with 50 policemen, same as La Estanzuela station
Engativá	Airport station with 70 policemen for narcotics and related issues
Teusaquillo	Bus terminal station with 12 policemen Judicial station with 200 policemen
Puente Aranda	Traffic police station with 600 policemen

Source: JICA Study Team

It is found that 27 police stations, or 64%, of the total police stations were constructed before 1984, which could be categorized as weak seismic resistant structures; 16 masonry structure stations were also found to have weak seismic resistant structures.

5) Military Station

Seven major military bases and Commanding Center are strategically located in the north, west, south and center of Bogotá City. The General Secretary of the Ministry of Defense provided the information on the military buildings. Regarding the eight municipalities, in Madrid there are some facilities for the Air Force, mainly for maintenance and training.

The number of military personnel is around 20,000 in the Study Area. Almost all buildings were constructed before '84, yet the data cannot be verified due to security reasons.

6) Public and Private Hospital

The Secretary of Health in Bogotá City and each municipality in the Cundinamarca government prepare the data of the public and private hospitals. However, the Cundinamarca data are not so reliable. The consultant team went on field to visit each facility and also checked 55 of the hospitals in Bogotá.

Ninety-four (94) hospitals are identified in the Study Area, of which 54 hospitals are public and 40 are private.

7) Government Facilities

The information was collected from each one of the offices in Bogotá, including information from ministries, but those of eight municipalities were collected during the field survey by the consultant team as well. The information on government facilities is important to determine the location of command center for the national, regional and local level.

8) Educational Facilities

The educational buildings such as primary and secondary schools are distributed in the whole Study Area. The Study Team collected the data for public schools in Bogotá and for public and part of private schools within eight municipalities in the whole Study Area. The source of the information is the Secretary of Education in Bogotá City and a field survey carried out by the consultant team in Cundinamarca prefecture. Reliability of the information is very good for Bogotá as well as for Cundinamarca municipalities.

Educational facilities are important after the earthquake for community level evacuation places. Bogotá City carried out the seismic resistance investigation for the public school facilities in the last 3 years due to the expedition of the Seismic Resistance Code NSR-98. As the results of the investigation, all public schools have undergone a diagnostic study but less than 1% has improved its structure because of the lack of resources.

In addition, information of kindergartens and community centers was provided by the Administrative Department of Social Welfare (DABS) that includes information about the buildings and staff.

9) Parks and Open Space

The information on open space is collected from the District Institution of Sports and Recreation (IDRD). IDRD has responsibility for the maintenance and rehabilitation of the parks. The parks in the Study Area have six stratification based on the size of the park: metropolitan, urban, regional, barrio parks, pocket parks and zonal parks. Based on the information provided by IDRD, the Study Team visited some of the parks and open space to verify the area and facilities. The parks and open space is used for the evacuation places, after the disaster has happened.

10) Emergency Goods Storage Center

For materials and goods storage place, the exhibition center "Corferias" was selected for this purpose due to its size, location and storage capability. The information was obtained from the administrative department regarding structural data and areas in general.

11) Food Storage Center

For emergency food supply, it was necessary to identify a storage place for food.. The biggest food storage place in Bogotá is "Corabastos," which provides to the Study Team the information about its facilities.

12) Transportation Facilities

Aerocivil was provided the information regarding passenger and cargo terminals within the International Airport "El Dorado" in Bogotá. Besides, bus terminal information was collected from the Transportation Terminal of Bogotá that includes the structural data only.

2.8 Emergency Health and Medical Service System

Laws and regulations, administrative systems, on-going plans, health facilities and personnel as medical resources available in case of a disaster are reviewed here.

2.8.1 Laws and Regulations

Medical response in case of a disaster is not prescribed especially in laws and regulations, which are often in the form of government decrees and resolutions. Among them the following regulations are important for planning of mitigation measures and medical response:

- Decree 1283 in 1996, Resolution 4252 in 1997.
- *Normas Colombianas de Diseño y Construcción sismo Resistente NSR-98.*
- Decree 93 in 1998 (*Plan Nacional para la Prevención y Atención de Desastres*).
- Decree 03019 in 1998 (*Sistema Departamental para Prevención y Atención de Emergencias y Desastres de Cundinamarca*).
- Decree 723 in 1999 (*Sistema Distrital de Prevención y Atención de Emergencias*).
- Many government decrees have been issued especially after the Quindío Earthquake occurred in 1999. Refer to the chapter on "Law and Organization" for further details.

2.8.2 Organizational System

The agencies, which plan and carry out disaster medical response, and their roles and responsibilities, are given below.

1) National Level

Fundamental frame: Sistema Nacional para la Prevención y Atención de Desastres.

Core agency for activity: Subdirección de Urgencias, Emergencias y Desastres, Dirección General para el Desarrollo de Servicios de Salud, Ministerio de Salud

Responsibility: Formulation of policy, Coordination of roles among agencies concerned, Supervision of emergency services by municipalities and prefectures, Command and coordination of agencies in a disaster

Staff: 8 in total, including Medico-2, Bacteriologist-1, Dentist-1

2) Regional (Cundinamarca) Level

Fundamental frame: Sistema Departamental de Prevención y Atención de Emergencias y Desastres (DPAE)

Core agency for activity: Centro Regulador de Urgencias, Cundinamarca (CRUC), Dirección General para el Desarrollo de Servicios de Salud, Secretaria de Salud.

Responsibility: Formulation of policy on emergency service, Operation of emergency information system. Coordination of roles among agencies concerned, Supervision of emergency services, Command and coordination of agencies in a disaster,

Staff: 19 in total, including Medico-4, Nurse-1, Radio operator-12, Emergency technician-1

3) District (Bogotá D.C) Level

Fundamental frame: Sistema Distrital de Prevención y Atención de Emergencias.

Core agency for activity: Area de Emergencias y Desastres, Dirección de Desarrollo de Servicios de Salud, Secretaria de Salud

Responsibility: Formulation of plan for preparedness, Coordination of roles among agencies concerned before and after a disaster, Stockpile of medicines, etc.

Centro Regulador de Urgencias (CRU) will play a role in Formulation of plan, Provision of common emergency service, and Operation of emergency information system, etc.; it will also actively participate in relief effort, in close cooperation with Area de Emergencias y Desastres, when a big disaster occurs.

Staff: 3 (originally 5) in total, including Medico-2.

4) Local Level

In Cundinamarca, some *municipios* which have a population of less than 100,000 form an association to plan and implement measures against disasters. However, information about the system and activities of the associations has not been obtained yet.

2.8.3 Health and Medical Response Plans

The progress and outline of the medical response plan, which has been already prepared at each level, are as follows.

1) National Level

There does not seem to be any plan on the emergency disaster medical response or any guideline to prepare it at the national level.

2) Regional (Cundinamarca) Level

It is the responsibility of municipalities to settle on a plan of measures against disasters. Except for Soacha, the present population of each municipality in Cundinamarca is small with less than 100,000. And the kind of disasters anticipated varies according to the location of each municipality. Therefore, the government of Cundinamarca leads municipalities that have a small population, to form an association for the purpose of devising an emergency plan. The association membership of eight municipalities in the metropolitan area is given below:

- La Calera belongs to an association consisting of several municipalities adjoining the metropolitan area.
- Chia and Cota are just two of 11 municipalities comprising 'Sabana Centro' association.
- The municipalities of Funza, Madrid, Facatativa and Mosquera have formed their own group.
- Soacha has its own association.
- Sabana Centro association, which includes Chia and Cota has already completed its plan preparation, and others are reported to be still in preparation. But even the plan of Sabana Centro does not show the emergency plan concretely though the health sector program is said to be partial in every comprehensive prevention plan.

3) District (Bogotá D.C.) Level

Bogotá City is the only city in Colombia where the plan for the medical response in case of a disaster has already been settled. *Area de Emergencias y Desastres* in charge has officially announced 15 plans in total since 1999 (see Table 2.8.1). The plan divides the causes of disasters into two categories: natural threats and man-made threats (see Table 2.8.2).

Table 2.8.1 Disaster Threats in Bogotá

Type of Threats	Threats
Natural Threats	Earthquake, Landslide, Flood, Gale
Man-made Threats	Technological, Epidemiological, Organizational and Chemical

Table 2.8.2 List and Outline of Emergency Plan by the Health Department in Bogotá

	Title	Outline
1	Frame of health sector plan	Medical response system at a disaster in Bogotá and a communication network by telephone are explained. CRU is placed as the center of command and is given parts such as coordination of related agencies, arrangement for free beds and preparation of blood transfusion.
2	Threats in Bogotá	Potential threat in Bogotá is explained.
3	Methodological guide for elaboration of Hospital Plan of Emergency	It is a kind of a guideline for a hospital to make an emergency plan (PHE). It contains 14 kinds of forms, in which condition of facilities, personnel alarm system, etc are to be filled out.
4	Link of telephones	This is the attached document to 1 above, to show a link by phone network within the Health Secretariat in an emergency. A communication network is to be decided at the following two Phases. Phase- 1: Impact Phase- 2: Interinstitutional total activation
5	Rationing of water	It shows the way for a hospital to secure the necessary amount daily, because public hospitals usually have poor capacity of water storage. It suggests the necessity to reduce the number of patient admissions in the worst-case scenario. Among all 40 hospitals, 23 hospitals fall below the necessary capacity of water storage that is calculated from the number of beds.
6	Rationing of energy/electricity	There are 3 steps given to save on electric consumption, because hospitals have low electric capacity as well as low water capacity. It shows that service has already been restricted in several hospitals.
7	Evacuation Plan	Omit
8	Management of shelters	Items of infrastructure, environment and items of minimum sanitary condition are shown for health personnel in charge to evaluate a refuge.
9	Massive poisoning	The way to cope with a break out of massive poisoning is shown by three steps.
10	Floods-Landslides	Investigation forms to assess the inhabitants in the danger area from the health side, before and during a disaster, is shown. An activity process before and during a disaster is proposed briefly

Among the 15 volumes in total, general countermeasures are described in the 1st volume to the 8th, and the medical response plan against specific disasters is explained in the 9th volume to the 15th.

The plan takes up the disasters, which are expected to occur more frequently, for example, riots or social unrest as threats by human activity and the 'El Nino' phenomenon or flooding as natural threats (see Table 2.8.2). Therefore, a response plan against a potential massive earthquake is not contained there. It is possible, however, to develop the target plan from the existing plans. This can be pointed out as a clear difference with Cundinamarca, who has yet to prepare its own response plan..

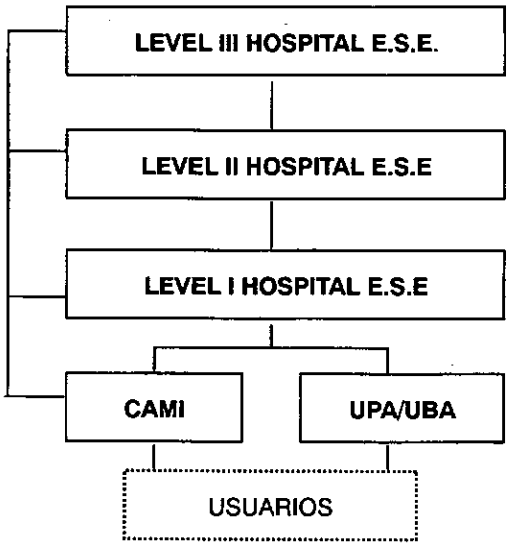
Since the target plan is still underway, *Area de Emergencias y Desastres* is soliciting opinions from concerned persons in order to improve the plan.

2.8.4 Medical and Health Service System

1) Health Delivery System in Bogotá Metropolitan Area

(1) Public health service system

Public health institutions are categorized into the following three levels (Figure 2.8.1). Patients can freely choose a hospital regardless of its level without being penalized.



- **LEVEL III:** furnish several subspecialties and an Intensive Care Unit (ICU), other than Internal Medicine, Surgery, Ob/Gyn, and Pediatrics.
- **LEVEL II:** furnish inpatient wards for Internal Medicine, Surgery, Ob/Gyn, and Pediatrics.
- **LEVEL I:** Small hospitals and affiliated health centers, CAMI, with basic treatment, dental care, disease prevention activity and observation beds.

E.S.E.: Empresa Social del Estado
CAMI: Centro de Atención Medica Inmediata
UPA: Unidad Primaria de Atención
UBA: Unidad Básica de Atención

Figure 2.8.1 Health Service System

(2) Net of services

The Health Department divides a city area into four health service zones, and arranges one level III hospital in each zone. And in each *localidad* one level I hospital is allocated, at least. (Figure 2.8.2).

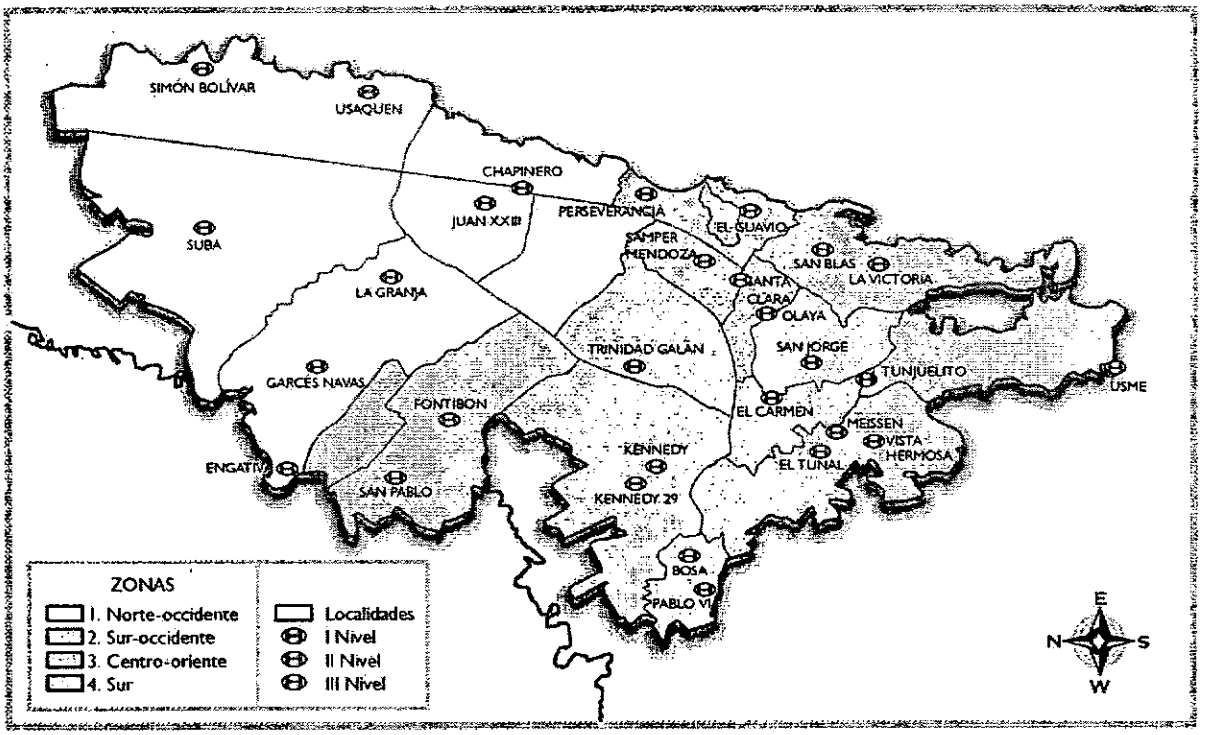


Figure 2.8.2 Four Zones and Hospital Allocations in the Health System

Such a network of zones has just been adopted from 2001 by the change of health administration system. This system corresponds to the idea of the service zone of the 2nd level. It becomes possible that a balance of medical demand and supply is examined by service zone.

(3) Public hospitals by level

The number of public hospitals E.S.E in the Bogotá Metropolitan Area is 39, and the number of beds is 2,189 excluding emergency beds (see Table 2.8.3). There are 13 hospitals of level IIand level II furnished with 921beds in total. These 13 hospitals are expected to become the bases to provide in-hospital care in times of disaster. The hospitals of level III in Bogotá are functioning as Top Referral Hospitals not only for Bogotá City but also for Cundinamarca. The usage of beds in public hospitals is very high at 80-85% BOR, compared with 60% of private clinics.

And "Fusion" of the hospital name shows that it is a complex of a hospital and CAMI and/or UPA/UBA affiliated to it. This is also a newly established system by the reform in 2001.

Table 2.8.3 Number of Public Hospitals E.S.E and their Beds by Level and Area (Year: 2001)

Area		Level III		Level II		Level I*	
		No.	Beds	No.	Beds	No.	Beds
Bogotá	North	1	328	3	160	6	116
	South-West	1	245	3	141	5	82
	Center-East	2	339	3	323	4	13
	South	1	165	3	157	7	120
Bogotá Total (a)		5	1,077	12	781	22	331
8 municipalities in Cundinamarca (b)				1	140	7	190
Bogotá Metoropolitan Area (a) + (b)		5	1,077	13	921	29	521
Cundinamarca Total (d)		1	258	9	1,530	67	1,271

Name of Public Hospitals E.S.E

Area		Level III	Level II
Bogotá	North	Simon Bolivar: 328 (ICU: 24 beds)	Engativa: 17 Granja: 51 Fusión Engativá: 92
	South-West	Kennedy III: 245 (ICU: 23 beds)	Fontibon: 36 Fusión Fontibón: 46 Bosa: 59
	Center-East	La Victoria: 161 Santa Clara: 178 (ICU: 15 beds)	Guavio: 52 Fusión Centro Oriente: 59 San Blás: 212
	South	Tunal: 165 (ICU: 18 beds)	Carmen: 20 Fusión Tunjuelito: 44 Meissen: 93

Note: *mark shows that Health Centers are included in both numbers.

(4) Private clinics and other public hospitals

All private clinics in Bogotá are classified as Level II and/or Level III; they number 37 and have 6,521 beds in total (Table 2.8.4). This capacity is equivalent to 2 times in number of facilities and 3.5 times in beds in comparison with those of public hospitals at the same levels. Moreover, there are many comparatively bigger hospitals in terms of admission capacity. In addition to clinics, number of private practitioners comes up to 12,565.

It is clear from these figures that the role of the private sector in health and medical activities in case of a disaster is not to be ignored.

Table 2.8.4 Number of Private Clinics, Other Public Hospitals and their Beds by Level

Area	Level III		Level II	
	No.	Beds	No.	Beds
Bogotá	31	6,153	6	368
Eight municipalities in Cundinamarca (b)	-	-	3	364
Bogotá Metropolitan Area (a) + (b)	31	6,153	9	732

Note: * Not including beds for emergency purpose .Year 2000)

(5) Health personnel

In 1997, the number of medical doctors amounted to 4,253 (including 756 engaged in emergency service), which was double the number of nurses that same year (Table 2.8.5). In addition to this, there were over 10,000 private practitioners. Therefore, it could be said that the number of doctors reached an almost excessive level. It could also be pointed out that there were far fewer nurses compared to the number of doctors contrarily.

Table 2.8.5 Health Personnel by Level and Area in Bogotá (Year:1997)

	Level			Total
	I	II	III	
Medical Doctor	413	1,628	2,212	4,253
Nurse	153	489	1,251	1,893
Auxiliary	377	1,750	4,223	6,350

Note: * Includes personnel for emergency services.

Private sector occupies the most part of health facilities. Therefore, as for the number of doctors, private sector accounts for 89% of specialists and 80% of general practitioners.

2) Emergency Medical Service Network

(1) Facility services

Hospitals of level II and III, regardless of whether they are public or private, provide 24-hour emergency medical service. Even in the number of observation beds for emergency patients, the private sector has a capacity over three times, compared with that of the public sector (Table 2.8.6). Moreover, *Servicio de Atención Medical de Urgencia* (SAMU) of the Red Cross has 3 observation beds and 10 ambulances. Thus, SAMU plays a big part in emergency service in the metropolitan area.

Table 2.8.6 Hospitals with Emergency Services by Level in Bogotá (Year:2000)

Sector	Level	Service Hours		Hospitals	
		24h	12h	Nos.	Nos. of beds
Public	III	all		5	114
	II	all		12	67
	I	CAMI only	all	23	9
	Total			40	181
Private	III	all		31	581
	II	all		6	27
	Total			37	608

Note: Hospitals in Cundinamarca are not included.

(2) Information and communication network system

The information and communication center for emergency medical service is CRU in Bogotá and CRU Cundinamarca (CRUC). With regard to their information centers, both are located in the

center of Bogotá independently, with a staff of 23 for CRU and 12 for CRUC working 24 hours by 3-shift system.

Moreover, there are medical doctors who are stationed to give medical directions and consultations on the telephone. The radio-communication system, which covers the whole city area through two relay points with huge tower antennas, is almost completed in Bogotá City. Furthermore, the latest facilities of CRU will function as a control tower at the time of a massive disaster; therefore, it is furnished with a room where the responsible persons in charge can gather at this crucial time. There are no such facilities in CRUC.

It should be noted that there is no direct radio contact between CRU and CRUC. But rather the radio system of SAMU is connected with all the organizations directly. It means that SAMU occupies the important position (Figure 2.8.3) in terms of covering the metropolitan area as a whole.

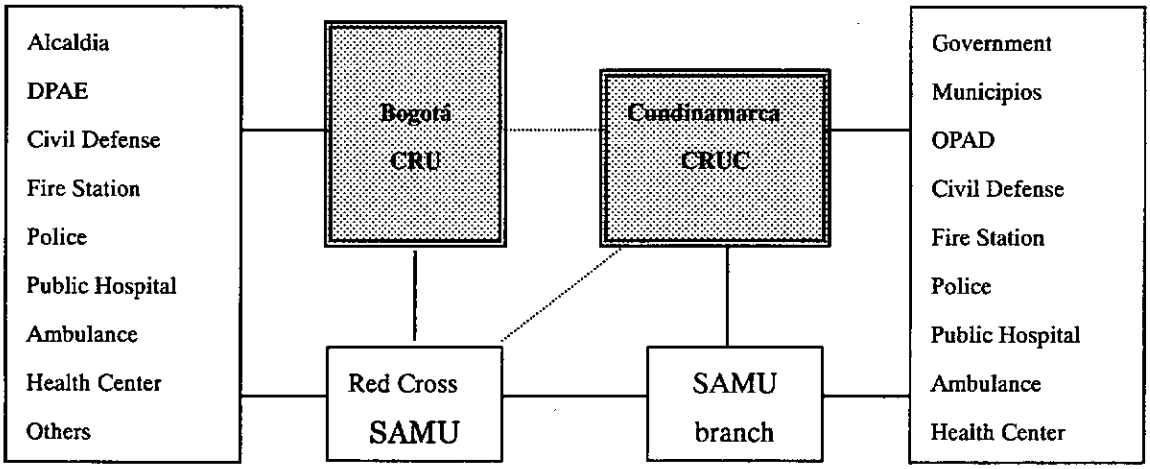


Figure 2.8.3 Radio Communication Network in Bogotá Metropolitan Area

(3) Ambulance arrangement system

There are 28 units of ambulances, which CRU can use at any time. On the other hand, CRUC can only use several units even if units contracted with a private company are included. (Table 2.8.7) CRU arranges, by contract, a team consisting of a doctor, an assistant nurse and a driver to every 15 TAMs out of 28 units for 24 hours.

However, it is uncertain how many ambulances under control of public hospitals and municipalities CRUC could actually use, although a government decree prescribes that the health authority can use any ambulance regardless of its ownership in times of urgency.

Table 2.8.7 Allocation and Arrangement of Ambulances

Bogotá	Public hospitals – **60** cars CRU – allows **28** cars by contract among 60 to arrange at Strategic Points like fire stations. Private ambulance – 180 cars (including 10 of Red Cross')
Cundinamarca	Public hospitals and municipalities – **260** cars. 8 municipalities have **18** cars among them. CRUC –owns **2** cars only, then contracts with a private company. Other public agencies like Police have 7 cars. No information about private ambulances.

2.8.5 Preparedness

1) Progress situation of preparing a plan for disasters

Government Decree 619 in 2000 places main municipalities under an obligation to settle on a medical response plan against disasters. Though the essential plan already mentioned is prepared, Bogotá does not have a plan for a big earthquake completed yet. Furthermore, the eight municipalities in Cundinamarca have not set a time frame for preparing even a fundamental one.

2) Education on disaster medicine

A. Ministry of Health

A study is made of 35 medical doctors in charge of emergency services on Disaster Administration in 8 courses (2 years) in Valle University and Antioquia University respectively. Another 2 courses will be added in 2001.

B. Bogotá City

- *Centro de Estudios sobre Desastres y Riesgos Naturales* (CEDERI) of Los Andes University was entrusted to study the risk analysis of disasters of natural and man-made origins in 1999.
- The textbook titled "*Capacitación en Manejo y Administración de Emergencias y Desastres*" was made in cooperation with Bosque University in 1999. It is used for educational purpose for people involved in the measures against disasters, including health personnel.

Apart from the academic and comprehensive education mentioned above, several health entities like *Secretaria de Salud* in Bogotá are providing health personnel with educational courses. Targets of these educational courses and the executing agencies, shown in Table 2.8.8, are characterized as follows:

- There is no subject on disaster medicine in the undergraduate and postgraduate courses.
- Training courses by health authorities are carried out actively, but they are very low-key in Cundinamarca.

Table 2.8.8 Agencies In-Charge of Training and Enlightenment Activity on Disaster Health Care

Executing Agencies \ Education Targets	1.Undergraduate: Medical Students	2.Postgraduate Education	3.Professional Health Personnel	4.Community Health Volunteers	5.Community People	6.School Students
1. Ministerio de Salud			○			
2. Secretaria de Salud, Bogotá			○	○	○	○
3. Alcaldia Localidades, Bogotá			○	○	○	○
4. Secretaria de Salud, Cundinamarca			○	○		
5. Alcaldia Municipios, Cundinamarca						
6. Cruz Roja			○	○	○	○
7. University or other agencies	○	○	○			

Frequency of holding training courses is about once a year. Consequently, the number of participants is quite large (Table 2.8.9).

Table 2.8.9 Frequency and Cost to Carry Out Disaster Health Training/Education by Secretaría de Salud in Bogotá

Target	Frequency and cost
Professional Health Personnel	Target: Doctors of public and private hospitals, Frequency: 2-day course for 250 participants, once a year Budget: $68,000 a person, Bogotá hired a consulting firm to design the curricula and recruited lecturers.
Community Health Volunteers	Frequency: 2-day course for 600 participants, once a year Budget: $70,000 a person Bogotá conducted the course in 1998, 1999, & 2000, but Bogotá hired a consultant to do it.
Relief Personnel (Civil Defense, etc.)	These relief agencies provide training by themselves
Community People	Frequency: 15 to 20 times a year, 6-hour course for 40 participants Budget: $ 15,000-20,000 a person, Target: 1,000 participants a year CRU staff themselves become lecturers
School Students	Included in community people

3) Building Reinforcement of Public Hospitals against Earthquake

There is a law prescribing completion of reinforcement work on buildings within six years from the date of the law's effectiveness. However, it is only Kennedy Hospital (Level Ⅲ) which has started reinforcement work, and it is still ongoing. Budget for the reinforcement works is shown in Table 2.8.10.

Table 2.8.10 Budget to Reinforce Buildings of Public Hospitals E.S.E

	Level III		Level II	
	No. of facilities	Budget	No. of facilities	Budget
Bogotá City	5	US$20,000,000	8	US$25,000,000
Cundinamarca	0		27*	1,400 million pesos

*Note: Consists of 18 level-I and 9 level-2 hospitals.

4) Stockpile of Medical Necessities

- Ministry of Health: Medical supplies and materials for 10,000 patients are stored in Bogotá.
- *Area Emergencias y Desastres*: 21 packs (1 pack can meet the needs of 150 patients) of medicines and materials for the hospital are stockpiled in the Central Storage.
- CRU: It has a plan to stockpile the blankets, materials and medicines for medical teams on site in the storage located at the underground of the centers.
- Cundinamarca: Medical supplies and materials for 200 patients are stored in CRUC. There is a plan to set up a warehouse in four strategic places in the Department.

2.8.6 Some Major Problems Recognized to be Solved

As for the emergency medical system and its response plan against a disaster, even Alcaldía Mayor Bogotá, the lead agency for such preparation, has not made a plan for a massive earthquake yet. The Study Team, the Health Department of Cundinamarca, and the Health Department of Bogotá, have discussed on-going plans and came to an understanding that the following seven problems were indispensable for phase 2 of the Study.

The Study Team and *Area De Emergencias y Desastres* of Bogotá made the remarks written under each problem.

1) Cundinamarca is far behind with preparing the plan, compared with Bogotá.

- Cundinamarca covers so wide an area for emergency service that it is more difficult to provide the corresponding resources to urgent requirements.
- There is a big gap in the budget scale, the number of staff and so on between both governments, and this has an enormous influence on planning too.

2) The role of private sector is hardly being taken into consideration in the plan.

- Bogotá considers that the private sector is involved in the disaster medical services to a certain extent, because it participates in the disaster training.
- Private clinics are not actually being taken into consideration when the capacity of beds for the injured is examined.
- A dialog with owners of private clinics has started on the diagnosis of building resistance against an earthquake, which is to take place in a year's time.

3) Necessity of formulating a coordination system, which unifies all agencies of Central-Cundinamarca-Bogotá and the Private Sector, is not being considered.

- Ministry of Health does not have much scope to elaborate such system, because the Ministry has to take care of many departments and municipalities all over the country.

4) A quantitative countermeasure based on the damage prediction is not planned. The resource, which can be inputted at the time of a big disaster, is not grasped quantitatively.

- Bed occupancy rate of public hospitals in Bogotá is 80%-85 %, and it would not be able to admit serious patients, even in the case of the lightest damages estimated by INGEOMINAS.
- Human damage estimated in the microzoning system: Number of beds which can be available need to be calculated corresponding to the medical needs in order to check the balance of supply and demand.

5) The radio communication system of CRU and CRUC does not synchronize. Therefore, neither one can communicate directly any more once their telephone lines are interrupted.

6) Stockpile of medical supplies for disasters is not sufficient.

7) It is necessary to test if the emergency response plan, which each hospital has, is actually effective.

2.9 Existing Communication and Information System

2.9.1 DPAE System

1) General

The communication system of DPAE is the vertebral column type, which has been chosen for its functionality. It connects all the personnel in DPAE as well as 15 different entities subscribed in the *Red Distrital de Emergencia* (District Emergency Network).

The communication system of DPAE actually falls under the "Operation Coordination". It consists of basically two systems: the old analog system, in operation at present, and the new digital system in implementation for future.

2) Objective of the Unit

The objectives of the information system in DPAE are:

- To coordinate and administrate the communication network installed in DPAE and other places; and
- To serve as PBX of DPAE outside the office hours of DPAE.

3) Technical Specifications

The communication system can be divided into two broad categories, namely, analog system and digital system, based on the installation type. The present analog system is at the moment in operation but will be shortly replaced by new digital system. The digital system should be the information system in DPAE. The following section explains the digital system, which will be for future use.

The new digital system consists of "Smart Trunk" of Motorola. In total there are six repeaters, three of which are inside the installation of DPAE and three more repeaters are located in the southern part of Bogotá. The "Smart Trunk" technology lets the base unit continuously communicate with the repeaters in the southern part of Bogotá. Also all the verbal communications generated can be saved through one CPU in digital format.

4) Frequency and Channel

The communication is carried in VHF (Very High Frequency) and presently has two channels in operation.

- Channel 1 or Administrative Channel.
- Channel 2 or Emergency Channel.

Channel 1 is for only the personnel of DPAE (CLE, EQT etc.) and for the communication among the personnel of DPAE. There are about 120 users for this channel.

Channel 2 is for all the 15 institutions subscribed to the District Emergency Network. The institutes subscribed to this network are the following: Secretary of Health (District), Secretary of Traffic, Water Supply and Sewage, Energy, Natural Gas, Telephone Service, CISPROQUIM, Fire Fighting Office, Red Cross, Civil Defense, Police, 13th Army Brigade, DNPAD (National Directorate of Emergency Attention), *Transmilenio* (Public Transport System) and DPAE. All these entities have one base unit in their installations and use channel 2 to communicate with each other.

Another channel, Channel 3, is also being tested for the communication between point to point or mobile unit to mobile unit directly. This might optimize the traffic to the base unit.

Also, there is a plan to connect the present network in such a way that it can communicate with other communication systems such as normal telephone, cellular etc.

5) Coverage

The location of antenna and repeaters in DPAE and the southern part of Bogotá City allows the DPAE to communicate with almost all localities of Bogotá. Part of the localities of Santa Fe and USME is not covered. Also the Region of Sumapaz is not covered.

6) Functionality

The communication unit in DPAE operates 24 hours a day, all year around. It has four operators. Three operators rotate on eight-hour shifts: 6:00 – 14:00, 14:00- 22:00 and 22:00- 6:00. The fourth one is the backup when someone takes a leave.

(1) Normal emergency management

When no major disaster event happens, it is defined as normal emergency management. Under normal emergency management, the operator listens to the communication of different institutes and makes a note of the events in the database system developed in Excel. This database system covers type of event, victims, locality, barrio, address, responsible institution and action taken. The database has been registered since 1998 and is saved as Excel files. Actually, this database is used in DPAE for future planning of actions.

(2) Disaster management

Under emergency situation (landslide, flood, forest fire etc.), the operator takes a pro-active role. The operators are not only listening to the communication but facilitating the people in charge of emergency to locate materials, other people etc. The operator, in emergency situation, may use conventional communication system such as telephone and cellular to contact the institute or person not connected with this network.

7) Installation

Three antennas and three repeaters are installed in the building of DPAE (located in Diag. 47 # 77b 09). Another three antennas and three repeaters are located in Sierra Morena in the southern part of Bogotá City.

2.9.2 The Information System for Risk Management and Attention of Emergency (SIRE)

1) Mission

Sistema de Informacion para la gestion de Riesgos y Atencion de Emergencia de Bogotá: (SIRE) was created by the Inter administrative agreement 006 of 1998 between FOPAE and INGEOMINAS. The mission of the organization is to facilitate the risk management by capturing, organizing, processing, and supplying available information rapidly.

2) Vision

The vision of SIRE is to be an integrated system that can be converted into the pillar of risk management at the national level

3) Objective

The objectives of SIRE are summarized as follows:

- Store, integrate, and maintain adequately the information related with the risk management;
- Facilitate the access or the query of existing and future information in the most rapid way;
- To help the promotion of the disaster prevention culture; and
- To guarantee the security, integrity, recuperation and privacy of the information for all types of events.

SIRE contain basically two types of information system, namely, generated information or product information, and locally structured information.

- Product Information: The product information is information generated by third party (studies, maps, reports and others) that cannot be modified by the users in any of the risk management stage. This type of data will be entered in the system with meta-data and geographic coverage.
- Locally structured Information: This information is generated during the risk management stages and organized with relational tables.

4) Component of the System

This system is composed to work under two environments; public environment under internet service having domain under www.sire.gov.co, and restricted environment under intranet and internet with user name and password.

Under the public environment, users are permitted to access to the product information by using the data warehouse (library) or to the maps by using a geographical information system for internet (GIS-Web). The users are asked to download a free plug-in for these data visualization.

Under the restricted environment, it is depended on the several modules, each of which has the user profiles. The main modules of the system are: administration, security, metadata entry, data warehouse, requests, reports, projects, boring survey, directories, inventories, emergencies, and geographic information systems.

The fundamental characteristics of the main modules are described as follows:

- Data warehouse: This is permitted to all the users and allows to search by using the data warehouse. Users are allowed to search a document by key words, such as title, author, or by the type of product. Once the document is found, a small summary of the content (metadata) is displayed, and permits to access to the digital document on-line based on the user request.
- Requests: This is not permitted to the public. This module allows to organize and allocate the appropriate personnel to answer for the requested questionnaires by citizen or the public employee of the other entity. All the questions are controlled digitally for information.
- Reports: Controls the elaboration in a standard manner and approval of reports which respond to the different requests. This is captured and stored digitally for the purpose of anytime consulting.
- Boring Survey: Allows access to the boring survey profile and tests realized in the study as well as access to the meta-data of the study. Detailed maps of the surveyed area are available based on the request. The data entrance module is not for public, though the questions and the reports are fully accessible for the public.
- Directories: Entry and consulting of structured information in the form of directories (Ex. Directory of Entities on risk management, Directory of Academic Programs related with risk management, Directory of Education Centers etc.) with geological reference. With new need, new directories can be created.
- Inventories: Inventories are structured similar to directories. The difference lies in the fact that the inventories store information related with the accumulated quantity of the elements (Ex. Inventory of Human Resources, Inventory of Resource Materials). This module has

interface with SUMA program (System of Human Inventory Preparation) that is used often for the preparation emergency control.

- Emergencies: One of the most complete and complex module of the system. This module helps the functions related with the attention of Emergency, with which information on emergency procedures is generated as well as the necessities, and the mobilized resources. This module is complemented with directories, inventories, data warehouse, and geographic module.
- Geographical Module: This is based on the geographical information system for WEB, and transversal to the system and can be utilized by different modules simultaneously. The information is stored in a Geographic Information System, possesses a geographic location with coordinates, and can display maps, geographic queries and geographic codification. This is also related to the land database which is officially provided by DACC. The data has more than 40 layers of different information and the users are available to access to different geo-statistical information. Any geographic element could be questioned through the direct navigation or address, because this system has official information of Census Bureau.

  In addition, users are not required to download the plug-in files, because it had developed in Java.

5) Technical Infrastructure

SIRE is a system based on Intranet. It develops the major part of the processing in a central server and through the communication infrastructure supply information to clients.

The hardware necessary for implementing SIRE is composed of:

- Server with local domain.
- Proxy Server or the Internet.
- Application server.
- Database server.
- Clients.
- Accessories.

The software necessary for operation of the system is Oracle8i, MapXtreme Java, communication and productivity software.

6) Advantages of the System

SIRE, as an information provider, offers the following advantages:

- Easy access to information in all the stages of risk management thus speeding up the decisions making.
- Generates standard documentation.

- Covers the major part of the culture of disaster prevention by supplying the public the general information related to risk management.
- Improves the coordination of the activities to concentrate and integrate different sources of information.
- Allows the consolidation of the information related to emergency and disaster; and
- Facilitates the planning and control of public investment, optimization of human, physical, and logical resources, although this is not the principal objective of SIRE.

7) General Restrictions

- The goal of SIRE is to provide the information, and thus SIRE in itself does not do the risk management and it is just a tool to facilitate the risk management, stated as the provider.
- SIRE is not the best system for simulation modeling for risk management, because it was not designed for this kind of purpose. It is rather strong for the data distribution.
- It is not robust enough to connect with the Internet in case of emergency.

8) Projection of the System

DPAE and INGEOMINAS are the institutions that can update the new version of SIRE. These institutions can perform thematic and functional amplification as well as summon other institutes for the system's improvement and use.

SIRE can be implemented in other geographic places. The system allows the application of new technology and utilization. Moreover, SIRE makes possible the adoption of changes in risk management models.

2.9.3 Cundinamarca Government

1) General

Since 1995, all the agencies of Cundinamarca in charge of emergency attention and relief-provision are concentrated in Cra. 58 with calle 10 in Puente Aranda.

2) Communication Unit of Government of Cundinamarca

The communication system of Cundinamarca government serves to establish a link with all the 116 municipalities of prefecture. It connects all the municipalities through the network of 16 repeaters.

This communication system actually falls under the "Secretary of Government." It consists of one independent analog system. Adjacent to this communication unit there is a smaller unit handled by one person from the national army.

3) Objective of the Unit

The objective of the unit is to coordinate and administrate the communication network installed in base unit and other 116 municipalities

4) Technical Specifications

The communication system consists of an analog system based on the Motorola technology, which serves basically three types of users.

- Officials of Government of Cundinamarca.
- 116 Municipalities of Cundinamarca and their officials.
- Provincial units (CAPS) of Cundinamarca.

In total, there are sixteen repeaters located in different parts in Cundinamarca.

5) Frequency and Channel

The communication is carried in the following frequencies: VHF (Very high Frequency) high, VHF low and UHF.

The majority of the municipalities does not have a communication base installed and work point to point basis. Following is the status of the communication system installed in the municipalities. Further check on the status should done in each municipality.

Table 2.9.1 Communication System in Eight Municipalities

Municipality	Communication base installed
Chía	Yes
Cota	No
Facatativá	Yes
Funza	No
La Calera	Yes
Madrid	No
Mosquera	No
Soacha	No

Source: JICA Study Team

All the municipalities that do not have communication base installation communicate point-to-point basis. Also, there is an emergency 9800 number that any person can use to report an emergency and there are operators to handle such calls.

6) Coverage

The location of 16 antennas and repeaters all over Cundinamarca gives an almost complete coverage of the Prefecture of Cundinamarca. Although actual number of users is not known it is estimated that users of this system may exceed 1,000.

7) Functionality

The communication unit of Cundinamarca functions 24 hours per day. Like the units of other institutions, it operates under two modalities:

- A normal situation is when there is no major disaster events, like forest fire, landslide, flood etc. Under normal situation, the operator listens to the communication of different municipalities and takes note of the events in the register book.
- Under emergency situation such as landslide, flood, forest fire etc., the operator takes a pro-active role. The operator is not only listening to the communication but facilitating the people in charge of emergency to locate materials, other people etc. The operator, in emergency situation, may use conventional communication system such as telephone and cellular to contact the institute or person not connected with this network.

The Cundinamarca government also has two mobile repeaters, which can be installed on the emergency spot when needed.

8) Installation

Sixteen antennas and sixteen repeaters are installed all around Cundinamarca.

9) Workshop of Communication Unit

The workshop is the unit for the maintenance of the equipment and the network. It has three people working in it. The people in this unit offer services to base unit in Cundinamarca and all the other municipalities. Often they provide the services to adjacent agencies like Civil Defense.

The personnel in the workshop have deep knowledge of the installation and equipment, especially of the Motorola Technology. According to the person interviewed, 90 percent of the communication system consists of Motorola Technology.

2.10 Education and Training

2.10.1 Existing Situation

1) Background

In case of disaster, it is inevitable that concerned governmental organizations are required to implement the systematic and integrated rescue works with private sector. In addition to this, communities should be able to carry out disaster relief effort by themselves in cooperation with related agencies. More important are preventive measures to mitigate the damages in case of disaster. Therefore, in normal condition, people should be aware of disaster prevention and attention and prepare to act effectively in case of emergency. In order to make the prepared condition among government agencies, private sector and communities, necessary information should be distributed; coordination among relevant entities and capacity building are indispensable through education and training on disaster prevention and emergency responses.

2) Present Conditions

(1) Organizations in charge of education and training for prevention and attention of disaster

Major organizations that plan and implement education and training on prevention and attention of disaster are summarized below with their responsibilities. Organizations are categorized by level and type as shown in Table 2.10.1.

Table 2.10.1 Organizations Related to Education and Training for Prevention and Attention of Disaster

Level	Educational Organization	Special Organization for Disaster Management	Coordinator	Cooperating Institution	Private Sector
National	Ministry of Education	- National Committee -National Advisory Commissions - SNPAD	DNPAD	- Ministry of Health - National System of Fire Fighters - National Police - Colombian Civil Defense	Red Cross Colombia
Regional (Cundina-marca)	-Secretariat of Education -Board of Education	- CREPAD - CLOPAD	OPAD	- Secretary of Health -Corps of Fire Services - Metropolitan Police - CAR - Civil Defense	Red Cross
District (Bogotá City)	Secretariat of Education	- SDPAE - District Committee	DPAE	- Secretary of Health - Fire Men Official Body - Metropolitan Police - Civil Defense	Red Cross

A. Educational organization

a) Ministry of Education

At national level, Ministry of Education is included as a member of National Advisory Commissions (*Comisiones Nacionales Asesoras*) and an integral party of the National System for the Prevention and Attention of Disasters (SNPAD). Decree 9129 (1989) articulates the Ministry's function as preparing the community on issues related to prevention, attention and rehabilitation of disasters.

b) Secretary of Education

At regional and district levels, there are Secretaries of Education. Since there is no specific staff in charge of prevention and attention of disaster and budget for the topic, Secretaries of Education have cooperated and coordinated mainly with OPAD and DPAE, and have also established some relation with Firemen Official Body, Police and Red Cross. At locality level, there are CADELs in Bogotá (Coordinator of the Local Education Administrative Center) that can touch base with communities but any specific activities related to prevention and attention of disasters have not been done yet.

B. Special organization on preparedness and attention of disaster

a) Education Commission in CREPAD

Under CREPAD, Education Commission was established based on the Decree No. 3019 in 1998 in parallel with Technical and Operation Commissions in Cundinamarca. Education Commission is coordinated by Secretary of Education. Significant areas covered by the Commission are a) Training of community and institutions, b) School plan and c) Public information and its dissemination.

b) Education Commission in CLOPAD

CLOPAD also has an Education Commission, whose objectives are:

- To coordinate training activities and training directed to CLOPAD.
- To define training programs for communities with high risk.
- To implement School Emergency Plan with the conformation of Brigades in schools, and
- To elaborate instructions, bulletins, and official statements for popularization of preventive measures for emergencies.

c) District System of Prevention and Attention of Emergencies in Bogotá (SDPAE)

SDPAE is organized in order to generate and establish discussion, arrangement and sectoral and institutional commitment spaces and process, in such a way as to strengthen the coordination, management and execution capacity of district entities on the issues of prevention and attention of emergencies, as well as on rehabilitation and reconstruction.

d) District Education Committee in Bogotá

Under the District Committee of Prevention and Attention of Emergencies of Bogotá, three committees (Operation, Technical and Education Committees) were organized in 1999. The objectives of Education Committee are to involve and integrate the theme of prevention and attention of disaster/emergency into the culture of local community through planning and implementing of policy, strategy, projects, and methodology in cooperation with concerned organizations. Secretary of Education coordinates this committee and the role of the members. Activities and roles of each committee member are not defined clearly. They are not coordinated regularly and do not function as preventive organizations.

e) Local Committee on Prevention and Attention of Emergencies 19 Localities of Bogotá (CLE)

Each locality of Bogotá establishes CLE as an inter-organizational coordinating body in order to cope with disaster in each locality through formulating emergency plan, planning and promoting projects of emergency prevention and attention issues by way of incorporating the projects into the local investment plan and budget. The number of committee members is basically 19 but the

additional members such as community organizations and leaders are available in order to deal with specific theme in the locality. The members and condition of each CLE are various as shown in Appendices 2.10.1 and 2.10.2. DPAE supports CLE in the way of close cooperation of consultants and staff with community. Inside CLE, there is also an internal education commission for the performance of its duties and the development of the topic.

C. Coordinator

a) OPAD

In OPAD, there are 3 sections:

- Coordination of Technique and Planning.
- Coordination of Education and Public Information.
- Coordination of Operation and Emergency.

Each section has one professional staff and the total number of staff is 7, which is very limited. The Section of Coordination of Education and Public Information is responsible for the following: a) Training for community and institution and b) School plan and curriculum. Its target groups are CLOPAD, municipal operation organizations such as Firemen Official Body, Police, Army, Red Cross, Civil Defense, Community Brigades, etc., schools, and vulnerable communities living in zones of high risk as well. OPAD concluded an agreement with the Red Cross for financial support to build the Prevention and Attention Training Center in Cundinamarca, which is already in operation.

b) DPAE

The number of staff of DPAE in each section including assistants and secretaries is shown in Table 2.10.2

Table 2.10.2 Staff of DPAE

	Section	No. of Staff
1	General Direction	3
2	Planning	1
3	Administrative and Financing	20
4	Juridical Area	6
5	Dissemination and Press	1
6	Inter-institutional Coordination	
	- Technical Coordination	2
	- Operation Coordination	17
	- Education Coordination	1
7	Risk Analysis	17
8	Local Management	12
9	SIRE	4
	Total	**84**

Source: DPAE

There is one coordinator each in charge of education and information in Dissemination and Press and Education Coordination who plans and implements all activities related to education, training, workshop, publication, and other public relations activities. It is clear that the number of staff is not enough and the staff allocation to cover all necessary work is not appropriate. The length of their existing services in DPAE is rather short and experienced administrators are not included. Most of them are employed on contract basis, which means essentially that they hold unstable positions. There is no motivation to become devoted to their work because of the absence of a long-term prospect. Many aspects of the work required have been subcontracted with local consultants and private companies. These include planning, implementation and even evaluation of workshop, seminar, training, and materials to be used for staff activities. The staff sometimes have not monitored and supervised and evaluated sub-contracted works carefully due to lack of time. It is likely that information and the activities at local level have not been systematically compiled and understood. Without feed back from past work, the expertise is often lost partly in the offices because of frequent personnel relocation, thus future work is not improved. It is a pressing need that the existing staff should be provided with stable positions and trained continuously. Also, additional permanent or long-term experts who are experienced administrators with capacity of planning, monitoring and evaluation of the plan should be hired.

DPAE spent 653 million pesos from FOPAE for training/empowerment in 1998-2000, which targeted mainly on educational staff (365,171 million pesos mainly to the educational personnel), community in general (181,383 million pesos) and local institutions (106,830 million pesos). As for the dissemination activities, guidebooks, videos, pamphlets, posters, other publication, etc. were produced with 462 million pesos from FOPAE. DPAE also organized several seminars, workshops, talks, forums, etc. As Enforcement of District System of Presentation and Attention of Emergency, more than 1,200 government officials in different institutions were trained. They are from Firemen Official Body, Secretary of Health, Metropolitan Police, Civil Defense, Red Cross, and NGOs.

D. Cooperating Institution

a) CAR

CAR attends to activities relating to forest fire, that is, forest fire prevention through training and rehabilitation of the affected areas. The officers in regional area are in charge of promoting the establishment and advancement of CLOPAD, as well as the accompanying plans and programs, planning and advise addressed to the prevention and control of forest fires, being part of PMU (*Puesto de Mando Unificado*: Unified Command Post) and of the operation protocol. CAR is part of the Forest Fire Commission of Cundinamarca (*Comision de Incendios Forestables de Cundinamarca*), as well as CREPAD, which follows the guidelines of the Office for the

Advancement of Forest Fire Prevention and Control (*Oficina de Gestion para la Prevencion y Control de Incendios Forestables*) of the Ministry of Environment.

b) Firemen official body

There are six fire stations among eight municipalities in Cundinamarca. Since the two municipalities of La Calera and Madrid have no fire stations, a supporting system from neighboring municipalities has been established. Besides professional staff, there are some volunteers working for the stations.

An academy of the Firemen Official Body of Bogotá has a mission of the internal training of firemen and emergency brigades at national and local levels. Also, the Academy has trained external institutes and communities. Furthermore, 16 fire stations in Bogotá play an important role of touching base with general citizens through education and training of schools and communities.

c) Civil Defense

Civil Defense is structured with two components, Administrative and Control by national budget under the Ministry of Defense, and Volunteers by private system. In Cundinamarca, 5 public employees and 2,000 volunteers work for Civil Defense. In Bogotá, there are 6 public employees and 3,579 volunteers. Volunteers consist of 2 groups: a) *Civil Defense Board* (the general citizens) and b) Supporting groups (experts). Therefore, activities of Civil Defense rely heavily on the volunteers. A Training School opened in 2001 in Funza (Cundinamarca). The courses and programs are formulated with technical support of National University.

E. Private sector

a) Red Cross

Red Cross covering both of Cundinamarca and Bogotá has Sections of Education/Training and Volunteer as related section to prevention and attention of disaster. Volunteers are consisted of 3 groups as shown in Appendix 2.10.3. Training Center for Prevention and Attention of Disasters is constructed in financial cooperation with Cundinamarca and land is supplied by Tabio City. The expenditure to education and training had a 13% share of the total expenditure in year 2000. The Training Center opened in June 2001 and already started to offer its services, whose costs vary according to the town requesting the services.

F. Community level

In communities of Cundinamarca and Bogotá, there are community-based organizations of JAC (*Juntas de Action Communal*: Community Action Board) and administrative organization of JAL (*Juntas de Administracion Local*: Local Administrative Board). JAC is a beneficiary group, organized at neighborhood (*barrio*) level and its operation is related to management level of

neighborhood processes. JAL is a local administrative body; it decides priority assignment of budget and approval of local agreements and decrees in local mayoralty. Although JAL represents the community in local government, it is not directly a community organization. In municipalities of Cundinamarca, there has been 533 JAC organized in 2001; Bogotá had 1,500 JAC in 1999. The representatives of JAC organize Association of Juntas. The President of the Association can exchange information with CLE. JAL is consisted of 7 councilors (*edils*). Some members of JAL can participate in CLE. In addition to these, there are many traditional informal community organizations and NGOs such as women, mothers, youth, the elderly, environment, and community self-guard groups. They are engaged in activities for development and improvement of areas and members with their group's respective topics of interest. Prevention and attention of disasters are not covered directly in their topics, but some groups may touch on them indirectly.

(2) Regulation and plan of education on prevention and attention of disaster

A. National level

Law of General Education 115 (1994) includes instructions and flexibility for elaboration and inclusion of topics pertaining to prevention and attention of disaster in school curriculum. The National Plan for Prevention and Attention of Disasters addresses education, training and community participation. The plan points out that the private sector should play an important role in disaster management and calls for the involvement of non-governmental organizations to participate in the implementation of the plan. In the plan, there is a strategy on "Socialization of Disaster Prevention and Mitigation". The programs are listed as follows:

- Public information for adequate prevention and response by the community in case of disaster.
- Incorporation of concepts of disaster prevention and environmental protection in formal education.
- Development of national system of training of government staff and community leaders.
- Development of activities with organizations of civil society responsibility.

Also, directive No. 13 (1992) of Ministry of Education gives the following guidelines.

- Incorporation of disaster prevention subjects in education and create an environmental conscience
  - a) Analyze the curricular contents.
  - b) Formation of professional group to present disasters
  - c) Teachers' training.
- School Program of Disaster Prevention.
  - a) Disaster prevention plans in educational establishments.

- Make the necessary changes in educational facilities under the General Direction School construction of Ministry of Education and physical plant of the Secretarial of Education
- Emergency Plans in Sporting Events.
- Inter-institutional Coordination.

Resolution 7550 (1994) regulates the performances of the National Education System as to the Prevention of Emergency and Disasters. The resolution requests educational establishments to create and develop a project on the prevention and attention of emergencies and disasters, in accordance with the guidelines issued by Ministry of Education, which will be an integral part of the Institutional Educational Project. This project shall cover at least the following aspects:

- Creation of a school committee for the prevention and attention of emergencies and disasters, as well as school brigades,
- School risk analysis,
- Action plan, and
- School simulation for potential threats.

B. Regional level

Department Decree 2653 (1995) establishes actions within the Education System for prevention and attention of emergency and disaster in the Prefecture of Cundinamarca. The public and private establishments should be responsible for preparing a detailed balance of the potential risks that may exist in each educational institution, on the basis of studies and investigations they may perform together with different institutions such as the Red Cross, and related to the participation of directors, teachers and students. Cundinamarca Decree No. 3019 (1998) directs that prevention and attention of disaster should be incorporated into the school curriculum.

C. District level

Resolution No. 3459 (1994) of the District Secretarial of Education regulates the responsibilities of the Educational System in Bogotá for the prevention of disaster. All the educational establishments in Bogotá should adopt an Emergency and Disaster Prevention Plan that as a minimum will include the following aspects.

- Creation of school brigades.
- Risk school analysis.
- School vulnerability.
- Evacuation plan.
- School simulation.

General Plan for Prevention and Attention of Disaster in Bogotá covers: a) Risk analysis and construction of risk scenario, b) Reduction of threat, c) Reduction of vulnerability, d) Preparation for emergency, and e) Rehabilitation. As for the vulnerability, the Plan has many objections:

institutional, educational community reinforcement and community involvement. In the new Development Plan of the City (2001-2004), as non-structural preparation, education of local people at every level is emphasized.

D. Locality level

CLE of each locality in Bogotá should make a Contingency Plan based on the new POT. Five localities have already prepared the plan, 5 others have prepared the plan for countermeasures and the rest (9 localities) have not done anything yet. In this plan, policy and target of education and training will be included.

(3) Activities of organizations related to prevention and attention of disaster

A. Education system

a) School education

National Education System

The system covers 9 areas in the primary, medium and higher levels, which are:

- Natural science and environment.
- Social science (history, geography, political system, democracy, etc).
- Artistic education.
- Ethnic, and human values.
- Physical education and recreation/sports.
- Religion.
- Humanity and languages.
- Mathematics.
- Technology and information theory.

Educational institutes are obliged to achieve 70% of the formal curriculum and the remaining 30% corresponds to programs whose contents are dependent on each school. In this case, the school can come up with an institutional educational project that includes the topic of prevention and attention of disaster. The system applies for Bogotá.

b) Curriculum

There are 7,610 teachers and 180,711 students in Cundinamarca as of 2001. In Bogotá, there were 73,868 teachers (22,891 for public and 56,977 for private schools) and 1,307,636 students (570,574 for public and 737,062 for private) in 1999. In the Secretary of Education in Bogotá, there is no specific budget allocated for education on prevention and attention of disaster. However, this topic is being socialized in locality. The Secretary of Education with Cooperation of CADELES and CLE, the amount of 24 billion pesos is allocated for reinforcement of physical structure against seismic vulnerability.

As for curriculum of the school, regardless of the existing regulations, there is no mechanism for implementation. The Secretary of Education has not any information of the present condition whether the school curriculum includes prevention and attention of disaster or not because its implementation ways vary depending on the school level of interest and budget. It is likely that only big schools can afford to have contracts with specific organizations such as Civil Defense, Red Cross and DPAE to do training of prevention and attention of disaster. With the exception of official Firefighters and DPAE, other organizations require high fee for their assistance.

DPAE designed a special program for teachers, which is being promoted at the universities, with the objective of producing experts to design programs and projects for disaster prevention. Also, its official implementation (enactment of regulation at national level) is suggested. Actually, DPAE is promoting the university Francisco Jose de Caldas and the Gran Colombia University. The course covers all the subjects relates to the context of the city development, legislative aspects and the territorial ordering, disaster prevention, a pedagogical focus for the disaster prevention, among others.

B. Seminar and workshop

a) DPAE

DPAE organized many seminars, workshops, talks, forum, etc. mainly about seismic threat and preparation for emergencies, among which about 900 persons participated in 3 seminars during 1998 to 2000. All localities in Bogotá participated at these workshops organized by DPAE in 2000, and total participants reached nearly 23,000 as shown in Appendix 2.10.4. Also, DPAE staff visited universities to provide talks regarding the topic. "The 1st Encounter of District CLE in October 2000" was organized to discuss how to integrate and re-feed organizations and people in districts and local aspects for Prevention and Attention of emergencies. Other seminars conducted were as follows: Seismic Zoning and its Effects in the Infrastructure and Urban Planning in March 2000, Experiences of Seismic Vulnerability Evaluation and Reinforcement in September 2000, Reduction of Structural Vulnerability in Clinics, Private and National Hospitals in November 2000, and Reduction of Structural Vulnerabilities in Private Schools in January 2001.

"Reduction of Seismic Vulnerability on Essential Buildings" was organized using FONADE with support of DPAE in April 2001. This is the 3rd seminar on earthquake in series following the 1st and 2nd ones on seismic risks for university engineering students. Thirty (30) participants, who are directors and heads of related organizations such as hospitals, health service, universities and other government institutions, discussed seismic hazard and risks on Bogotá and Colombia, different mechanisms to reduce seismic vulnerability and energy mechanism. In the following months in 2001, other seminars were held for experts such as members of engineering society.

b) CAR

Fifteen (15) officers have been trained and they work both at central and regional levels; they are in charge of the management of the forest fires program. In addition, there have been 7 workshops, covering 65 municipalities in Cundinamarca with participation of about 350 people. These seminars are given at a central level, by those who compose the fires prevention team, supported by audiovisual aids, publications and other material that might have a positive contribution for such purpose. Target participants are the officers assigned by the corresponding regional direction, who will serve as multipliers taking this information to each one of the municipalities, activating the creation and start-up of CLOPAD as it is ordered in Decree 919 of 1998. These entities will be supported by CREPAD. The goal is to capacitate CLOPAD for forest fires and equipment handling. Topics to be treated in the capacity building workshops are as follows:

- Operation protocol.
- Generalities about forest fires.
- Fire behavior.
- Control techniques of forest fires.
- Tools and equipment for the control and extinction of forest fire.
- Water use in control and extinction of forest fire.
- Operation and maintenance of motor engines.
- Personal security in control and extinction of forest fire.
- Demonstration and practice in tools and equipment use.

c) Firemen official body in Bogotá

Seminars have targets of public institutions especially prison and police, and private sector. Major topics are:

- Management of car accidents.
- Communication system.
- Trainers' training.
- Experts training, and
- Diving.

Workshops are organized on fire fighters technique.

d) Community level

The level of organization and participation of workshops/seminars on disaster prevention differs from one district to another. It depends on the interest and awareness of chief of the locality. In Bosa locality, for example, where there are possibilities for inundation, fire and earthquake, its own budget is used for disaster prevention project with contract with a private company providing

training. The training started initially as a 2-month project. One course takes 4 hours and total hours during the project are 32. The target groups of the training are general inhabitants for basic education and experts related to disaster prevention for specific technique. The participants with over 80% of total attendance can be awarded certificates. The program of the workshop is shown below.

Table 2.10.3 Example Course of Workshop in Bosa Locality

No.	Topics	Contents
1	Earthquake	- Understanding of threat and vulnerability - Prevention, occurrence and rehabilitation
2	Inundation	- Sewerage and waste treatment - Structural change for drainage, sewerage and waste treatment
3	Fire	- Cause of fire - Threat - Handling of extinguishers
4	Evacuation	- When is the time for evacuation? - Observe the symptom - Evacuation routes
5	Various Information	- Weather information - Participation of workshop - Communication among organizations in the community
6	Local Committee	- Assistance from members of locality assembly

Source: Bosa Locality

C. Training

a) DPAE

Teachers

A 5-hour training course for school teachers on risk management and disaster prevention was provided to 1,500 teachers for methodologies of the School Plan for disaster prevention and 600 teachers for curriculum in 2000 (about 5,000 teachers during 1998-2000) using training manuals produced by DPAE as shown in Appendix 2.10.5. Methodology course is intended to target teachers and counselors in general in order to generate in the community knowledge of high risks for the people that are exposed, with the objective of formation of the process to reduce their risks and eliminate an emergency situation. Contents of methodology course are a) Diagnosis and analysis of school risks, b) Identification of preventive measures, c) Identification of response measures in an event (evacuation and practice), and d) Organizational strategies. Major materials used are "Teachers Guide I (Conceptual aspects for the risk management) and II (Methodological aspects)" and "Students Guide". The curriculum course focuses on teachers of social science, natural science and preschool education in order to incorporate in the basic education curriculum the knowledge, attitudes and values about risk management and disaster prevention, depending on the age and level of students. The contents are: a) Threat conceptualization, vulnerability, risk, disasters, emergency, b) Pedagogical approach to the natural phenomenon and its relation with the

risk and disaster situations, c) View of Bogotá risks with emphasis on seismic threat, d) Natural, social and construction environment of the buildings in Bogotá and in general the social-spatial transformations that generate imbalance in the relations between man and the environment, e) Personal security and self-protection, f) POT and the development plans as tools for the risk management, and g) Institutional aspects. The training is developed in an interactive way, in pedagogical perspectives, and uses videos as supportive material. There are also supporting materials produced by DPAE that are given, such as: a) Guide I (Pre-school and 3rd Grade), b) Guide II (4th to 6th Grade), and c) Guide III (7th to 9th Grade). Those teachers are expected to teach their students using methodologies they learned, and the follow-up activities have begun in 2001.

Initial evaluation was carried out, with six educational institutions in which 16 students participated, for a total 90 students.

School Children

On 15-30 November 1998, about 10,700 students joined a vacation training on general topics (see Appendix 2.10.6. DPAE considers that it is necessary to educate children on disaster prevention and attention, especially at ages between 5 to 12 years when they are more vulnerable to emergency cases. Also, at these ages, they have more potential for learning and they can be future advocates of the advancement of disaster prevention.

Community

DPAE provided training during 1998 to 2000 to communities covering 10,497 persons, touching on 6 topics, namely, a) Seismic threat and preparedness, b) Town plan, c) Risk management, d) Flood threat, e) Threat from mass events, and f) Threat of technological risk.

Institutions

DPAE provided training to CLE covering 1,017 persons in 2000 and collaborated with Civil Defense for training of 29 persons. Besides there are other institutions trained as shown in Table 2.10.4 below.

Table 2.10.4 Organizations Trained by DPAE in 2000

No.	Entity	No. of Participants
1	Secretary of Education	18
2	Ministry of Health	38
3	Civil Defense	29
4	Controllers of Budget Users	1
5	Firemen official Body	5
6	Controllers of Health	4
7	Ministry of Mines	59
8	Commission of Regulating Energy and Gas	13
9	Special Medicine Producers	17
10	Catholic University	68
Total		**252**

Source: DPAE

Additionally, the major topics and the number of participants to DPAE training are shown in Table 2.10.5.

Table 2.10.5 Topics and Participants in DPAE Training

No.	Topics	No. of Participants
1	Fire management and evacuation from buildings	60
2	Qualification in prevention and emergency attention	32
3	PEGR (School Plan for Risk Management)	40
4	Usage and maintenance of specialized equipment	28
5	Forest fire	68
6	Collapsed structure	50
7	Institution for instructors of disaster prevention and attention	25
8	First aid	125

Source: DPAE

It is regrettable that most of these activities are transient and not continuous. Lack of budget may stop the activities halfway, which can result in loss of motivation of the people toward disaster prevention.

b) Secretary of Health

Training and education for disaster prevention provided by the Secretary of Health of Bogotá target employees of the Secretary of Health, Metropolitan Police, and community leaders (community organizations, teachers, and religious organizations). One course is 16 hours for 2 days with 35 participants in average. The programs of the courses are as follows.

- Conceptual aspects of disaster.
- Organizational strategies.
- Possible threats in Bogotá.
- How to manage emergency with institution.
- Contingency and Emergency Plan

As the target group of employees of the Secretary of Health, 600 have been trained and the second group of community leaders has had 700 participants for the last 3 years. For the hospitals, the Secretary provides drills on fire, bomb threat and earthquake but no drills have been conducted for community. Future training plan is to cover the following:

- Secretary of Health for general contents: 200 people,
- Community leaders for general contents: 100 people, and
- Governmental institutions: 400 people.

c) Fire Department in Bogotá

There are 3 kinds of training courses provided by Centro Académico (internal, external and special ones) as listed below and 6,800 participants so far have attended one of them.

Table 2.10.6 Training Courses Provided by Centro Académico in 2000

Type	No. of Courses	No. of Modules	Total No. of Participants	Total No. of Hours
Internal Training	19	0	475	1,306
External Training	0	362	6,037	1,105
Special Course for Other Institutes	13	0	337	308
Total	**32**	**362**	**6,849**	**2,719**

Source: Centro Académico de Bomberos

The training structure is presented in Appendix 2.10.7.

Internal Training

Table 2.10.7 Training for Internal Staff of Firemen Official Body

No.	Name of Course	No. of Courses	Hours per Course	Total Hours	Total No. of Participants
1	Human Relationship	2	8	16	60
2	Management of Personnel and Leadership	2	8	16	60
3	Retaining	1	30	30	20
4	Inspection of Risks	1	16	6	42
5	Forest Fire	2	24	48	52
6	Basic Swimming	4	40	80	52
7	Machine Operation – SENA- Diving Technique	4	40	160	35
8	Basic Course for Firemen (1)	4	140	560	108
9	Basic Course for Firemen (2)	1	380	380	46
Total		**19**	**686**	**1,306**	**475**

Source: Centro Académico de Bomberos

Basic courses for firemen differ in time and target. Major topics are as follows:

- Basic concept of fire department.
- Management of chemicals.
- Forest fire.
- Emergency handling of victims.
- Rescue from high building.
- Massive events.
- Cartography.

Courses for government staff at national level focus on police and public prosecutors in jail and justice. In mid-June 2001, 65 volunteer officials at national level will be provided with training by contract with U.K. The topics are as follows:

- Hazardous materials.
- Breathalyser.
- Vehicular accident.
- Incident command system, etc.

External Training

Table 2.10.8 External Training by Centro Académico

Description	No. of Entities	Total No. of Modules	Total No. of Participants
Public	21	83	1,343
Private	46	152	2,607
Military	5	28	482
National Police	9	97	1,605
National Army	1	1	16
Civil Defense	1	1	11
Total	**81**	**362**	**6,037**

Source: Centro Académico de Bomberos

JAC and 500 schools are targeted at community level with a) Plan of emergency, b) Theory, c) Evacuation, and d) Conformation of brigades.

Special Training

Table 2.10.9 Special Training for Other Entities

No.	Name of Courses	No. of Courses	Hours per Course	Total Hours	Total No. of Participants
1	Volunteer Firefighters Training	1	30	30	15
2	Courses to Carabineers Academy	1	24	24	40
3	National Course for Firefighters	1	36	36	34
4	Rescue	4	16	64	120
5	District Brigade	1	100	200	17
6	Red Cross of Colombia	3	10	30	60
7	National Police-Policemen Club	1	12	12	21
8	National Army	1	2	12	30
Total		**13**	**210**	**308**	**337**

Source: Centro Académico de Bomberos

Module

The courses modules are shown in Appendix 2.10.8. Applicants of the modules should be registered. Enterprise brigades can also take 13 modules.

d) Civil Defense

Civil Defense provides many kinds of education and training in order to produce a lot of volunteers for their activities. The targets are general citizens and special technical staff, and 5-15 year-old children in community as future volunteers as well. Instructor courses are also included. In order to be registered as volunteers of Civil Defense, applicants should take training courses organized by Civil Defense and are obliged to carry out 500 hours of social service after training and then serve at the Civil Defense for 2 years. The courses are: a) General Information (2 hours),

b) Level I (Basic, 58 hours), c) Level II (Specialized), d) Level III (Integral), and e) Level IV (Technical).

e) CAR

CAR officers, government entities, NGOs and the community in general are involved. They get training in the technical and practical parts. At its end, they will be able to get technical and operational support, as well as learn how to handle equipment and tools.

f) Red Cross

In Tabio Municipality of Cundinamarca, training center for prevention and attention of disaster was opened on June 2, 2001. This center can play a role of piloting activities. Sixteen (16) various courses are provided to cope with 18 situations and topics of disaster and emergency, for technical experts, school children and ordinary community. However, all courses and materials are provided with rather high fee. For example, a 3-day course takes 30 hours with 2-3 million pesos per course. The Red Cross has projects in cooperation with other institutions (Civil Defense, Official Firefighter Squad, Health Department and DPAE) and also a trainer's training (see Appendix 2.10.9).

g) CLE (Bogotá)

CLE promotes the implementation of the Contingency Plan, which envisages all the actions to be performed at community and institutional training levels, as well as the necessary mitigation actions. In some localities, where the local mayor has a strong interest in the topic, CLE has achieved the formation of neighborhood emergency brigades that are working on prevention and attention of emergency. The neighborhood emergency brigades have no connection with JAL but JAC. Some of them are fortified by the efforts of different entities that comprise CLE. The training topics, for example, are:

- First Aid and Search and Rescue.
- Risk Administration.
- Seismic Hazard and Flood Hazard.
- Motor Pumps Management.
- Basic Security and Others.

D. Training materials and information

Some organizations have produced many materials for training, workshop, dissemination of information of their activities and related topics, etc. The other organizations have published only a few materials or none because of the lack of budget and technical staff. Though the focal points of the materials are different by organization, they generally cover system of disaster outbreak, behavior in case of emergency and for disaster prevention, in technical and easy ways, etc. Once

the materials are produced, however, they are left as they are and efforts of dissemination and development are not made. Even among the concerned organizations, they do not know what kind of materials is produced because of lack of information exchange.

a) Secretary of Education

The Secretary has a budget of 5 billion pesos for educational materials produced by the official institutions. Since this amount does not include specific allotment of prevention and attention of disaster, the usage depends on institutions. The situation has not been investigated.

b) OPAD

The number of materials produced by OPAD is not large. OPAD had an agreement with the Red Cross and the training manual to be used especially for CLOPAD members was produced by the Red Cross. A "chick" mascot is used, and other cartoon characters are imprinted on other materials (sticker, pen, T-shirts, etc.), which make the contents more familiar. CLOPAD is the target organization for capacity improvement under the regulation in Cundinamarca.

c) DPAE

Materials produced by DPAE are listed in Appendix 2.10.10. All materials are available to any persons at their request. DPAE made videos and guidebooks on earthquake, landslide, and flood for local mass media. For inundation and landslide, signboards are produced and put up to warn people in the high-risk areas. Massive events and accompanying instructions are informed by video clip, radio advertisement, posters and pamphlets. Information on fireproof structure is produced and disseminated to local mass media. Forest fire is informed by radio and video clip. Guide on house reinforcement, guidebook on construction in the landslide area (possible area), guidebook on regulations and procedures to apply for licenses and permits for construction are prepared by DPAE. All materials are considered as technically satisfactory. The problem is dissemination. For example, video coverage is good but has not been often presented in public. Also, pamphlets and guidebooks introducing activities of DPAE have not been distributed enough and well publicized. Public relation activities have not been organized and mass media such as radio, TV and newspaper are not utilized effectively. Teacher's Guides have not been evaluated and the teachers' activities at their schools have not been followed-up.

d) Firemen Official Body

The Firemen Official Body produced materials not only for internal but also external use. For schools, 16 fire stations in Bogotá have 60 slides and guidebooks to utilize in presentations.

e) Civil Defense

Civil Defense produced many materials for their own volunteers, the community in general, and the children, which are made in order to increase a sense of voluntarism and cultivate future

volunteers. Also, a quarterly magazine, *Defensa Civil Colombiana*, is issued regularly to introduce their activities and related events. The magazine can be obtained at the government offices and Civil Defense.

f) Red Cross

The Red Cross also produced a variety of materials, covering from prevention to rescue for general community, educational staff and technical trainers.

g) Media in municipalities of Cundinamarca and localities of Bogotá

In order to disseminate information related to prevention and attention of emergency and disaster, some segment of mass media is used. In Cundinamarca, all 8 municipalities use radio programs for dissemination of the topic and in Bogotá newspapers and magazines are more useful.

(4) Activities of communities and NGOs related to disaster prevention

Disaster prevention activities at community level are closely linked to the occurrence level of dangerous events. This means that in the localities in which occur more events are more likely to organize and prepare themselves than in which a lower number of events. In that same way the level of compromise of the mayors can be observed. Such is the case for the localities of San Cristobal, Bosa and Ciudad Bolivar. On the other hand, Teusaquillo, Martines, Candelaria, etc. are not vitalized yet as shown in Appendix 2.10.11. Local mayors do not have high interest in disaster prevention partly because the possibility of a disaster or inundation occurring is nil or low. However, some measures have been considered; educational activities for disaster prevention such as training, workshop and drill, and discussions are in progress.

Among NGOs working for the community development and poverty alleviation, some play an indirect role of prevention and mitigation of disaster. For example, the project *Sur con Bogotá*, under the international assistance of KfW (Bank for the German Development), targets environment protection in the 3 districts (San Cristobal, Usme and Rafael Uribe), which includes the activities of relocation and disaster mitigation in the communities located in the high risk areas.

(5) Public awareness of prevention and attention of disaster

A. The Quindio Earthquake

The January 25, 1999 earthquake occurred in the cities of Armenia and Pereira, almost 4 years after the 1995 Calima-Darich earthquake. "The earthquake certainly helped to raise the seismic awareness of the city and, unlike the city of Armenia, Pereira had made significant advances in a number of areas that helped them deal with the earthquake's effects through the implementation of the Seismic Risk Mitigation Project for Pereira. Specific achievements, though still in the beginning stage, had been made in the areas of assessment of regional seismic hazard, the

influence of local effects on seismic hazard; physical, institutional and social vulnerability; preparatory plans for emergency response, and the formulation of earthquake safety and mitigation measures." (Source: Special Report, Effects of January 25, 1999 Colombian Earthquake; As viewed by Authorities in Pereira Geo Hazard International)

On the other hand, "although Pereira learned many valuable lessons from the 1995 earthquake, by most accounts the city was not fully prepared to deal with the effects of the 1999 event. Problems of organization, communication, and coordination typically arise in response to any disaster, and their factors definitely complicated the situation in January of 1999." a) Lack of coordination amongst working groups: Volunteers were many, but organization was poor. b) Lack of communication amongst institutions and on different organizational levels: Few people are aware of the magnitude of the problem as a whole. The public, in general, was not well-informed. People were referred to many different organizations and locations. c) Lack of participation by the community in the reconstruction phase: The people do not know how to reach the state and the state does not know how to let itself be reached with regard to this issue. According to the case of Armenia/Pereira, it may be said that the lessons from the disaster can increase awareness and prepare against disaster at some level but it takes time to reach the level of actual responses and functions.

B. Analysis of public awareness survey for disaster prevention

Survey on Public Awareness on Prevention and Attention of Disaster was carried out by staff and coordinators working for DPAE in 15 districts in Bogotá during 24-31 May 2001. Since the sample number is very limited, the findings from the survey summarized below cannot be generalized as the sentiments of local people. However, some ideas can be drawn from the results as the input for the disaster prevention plan.

a) Awareness of disaster prevention

- People who have been affected by disaster or who live near dangerous places such as slopes and rivers or on slopes are fearful of the possibility of disaster but do not have measures of protection and evacuation. Though some respondents even recognize an important level of risk, they would prefer or have to continue living in the dangerous places for economic reason. Also, they do not have enough information about the danger in the places where they are living. Among those who answered living in a safe place, some deem that disaster could not happen in future.
- All interviewees think that measures to prevent floods and landslide are necessary. These measures include the following: to prohibit living in risk areas, to institute land use control, and to create a brochure showing places where it is not possible to live.
- People who have lived in dangerous places for many years are often reluctant to leave even in case of emergency. They can evacuate their places only when the danger is very

imminent. However, the majority would evacuate immediately in case of emergency, where previous emergencies have created some degree of consciousness of danger.

- The people consider that information is most important and needed against disaster. If they have enough knowledge of hazards, they can prevent them accurately. Most of the interviewees who have awareness of disaster have been affected by disaster before, but they are not sure of what to do in case of an emergency.

b) Tools of communication and necessary information in normal and emergency conditions

- In normal condition, the best way to inform people about disaster in the area where they live is through community organizations, announcement from a roving car for public information and TV news. These responses indicate that people are conscious of the importance of community organizations for disaster prevention. The best media of communication to utilize in case of emergency are television and community organizations, followed by radio and roving car on streets. Cundinamarca mentioned roles played by fire station and local government, which could have been more efficient in previous emergencies than other media in Cundinamarca.
- The most relevant information needed in normal condition is the presage and the history of disaster occurrence, dangerous places, a map showing areas of high possibility of occurrence, and guidance of what to do during/after disaster including evacuation routes and communication media. These answers indicate that the people do not have enough knowledge of locations appropriate for living and the difference between safe and unsafe places. These answers show that they prefer to know curative actions instead of preventive actions when they think under imminent danger. The necessary information in case of emergency is dangerous places, their conditions, communication media for help and evacuation routes as well.

c) Training and workshop

- Majority of interviewees in Bogotá has participated in trainings or workshops about disaster prevention. The respondents who have participated in training and workshops before think that the prevention and attention is important work in the community, which means that training raise the level of consciousness of the people.
- The reasons for participation are that they have had experiences of disaster and have a sense of danger. Additionally, they were informed of workshops by the government or community members. The reasons for not participating in the training/workshops are a lack of time and absence of information of the workshop. This represents a necessity of more information dissemination of these events.

- The topics of training and workshop required are first aid and prevention of emergency in general.

d) Necessity of voluntary groups in the community

- All interviewees believe that voluntary disaster response groups are necessary and many of them want to participate in such groups. Most of them consider such groups can be formed by themselves soon or after meeting or discussion among the community with support of the local government, which shows they understand its importance and the importance of working in community.
- Half of interviewees have discussed about disaster prevention among the community and for this reason they also think that it is possible to act as community members in case of emergencies. Many of them think that rescue and evacuation activities can be done in cooperation with community. However, the problem is in implementation because they do not have enough information and techniques for disaster.

e) The support from the government to the voluntary groups for disaster

The supply of equipment and tools needed in case of emergency to voluntary groups are not so homogeneous. However, majority think that groups must be prepared with equipment and tools with subsidy of the local government and some community contribution, and the rest thinks local government must provide all of them. Sometimes people affected by disaster, are displaced or poverty stricken expect that governments supply all their necessities without any contribution by the people. These characteristics vary according to locality, location and living condition.

C. Analysis of workshops and seminars

a) Stakeholder meeting

Among the points raised during discussion by the participants, five subjects mainly were focused and various aspects to be strengthened were recognized. They are: a) Infrastructure strengthening, b) Organizational and institutional strengthening, c) People and community strengthening, d) Mass media usage, and e) Information distribution system strengthening. Opinions among the participants are summarized in Appendix 2.10.12. Among them, the following three are related to education and training:

<u>People and Community Strengthening</u>

- Inter-community information network strengthening.
- Informing the related legislation and decrees.
- Community integration to the prevention plans.
- Campaign to the community for massive information.
- Education.

Mass Media Usage

- Mass media towards the disaster prevention, for spreading the information
- Introduction of international experience

Information Distribution System Strengthening

- Strengthening the method to spread information on the risks and threats.

b) PCM workshop

The participants consider the community or local level as the most important target groups for the disaster prevention. The major possible approaches to solve the problems for these target groups could mainly be categorized into three, which are: a) Institutional strengthening, b) Public awareness strengthening, and c) Capacity building. The following table shows approaches related to community and education and training.

Table 2.10.10 Possible Approaches Drawn by the Objective Analysis

No	Target Group	Core Problem	Main Objectives	Possible Approaches
1	Community Organizations	Indifference to disaster prevention problems, because of - technical limitations - ignorance of the topic - economic limitations - inadequate proceeding of the community	Cultivate interest in disaster prevention	-Disaster prevention technical information -Disaster prevention and awareness improvement -Community strengthening
2	Community	Ignorance of what to do in case of an emergency, because of - insufficient programs at local level for training - poorly spread program	Awareness of what to do in case of an emergency	-Capacity building - Enlightening activities
3	General Planning Organizations	Staff is not aware of their vulnerability, because of -inefficient education mechanisms -unawareness in prevention and attention of disaster topics - deficiency of prevention and attention of disaster policies and strategies	Staff is aware of their vulnerability	-Educational system introduction -Disaster prevention and attention improvement -Disaster prevention organization strengthening

The team attempted to apply some of these approaches to the project design matrix (PDM), as three examples such as 1) Disaster Prevention and Awareness Improvement Project, 2) Project for Disaster Prevention Institution Strengthening in Colombia, and 3) Project for Capacity Building on Disaster Management.

c) Workshop on contribution of education in disaster prevention

The teachers who participated in the workshop discussed the strategy for the education of disaster prevention in three sectors, namely, government, educational institute and educational staff. Based on the strength, opportunities, weakness and constraints of these three sectors, the participants came to the following conclusions:

Government responsibility

- Cooperation with different agencies.
- Training for the educational personnel.
- Exploitation of the governmental roles for educational awareness of disaster prevention.
- Active participation of regional, district and local committees.
- Development of curriculum guideline including the topic.
- Budget allocation.
- Continuation of projects for education on disaster prevention.
- Support NGOs and private sector.

Educational Institutions

- Preparation of their own policy.
- Coordination among institutions.
- Network of educative institutions to exchange information and experiences.
- Development facilities and equipment in physical and structural safety.
- Cooperation with community.
- Implementation of the prevention project included in the study plan.
- Risk evaluation of the institutions.
- Preparation of risk map.
- Design and implementation of drill and training.

Educational Staff

- Training, drills and research for the prevention subject.
- Increase of awareness and change of attitudes.
- Development of leadership.
- Continuous efforts and educational projects on the topic.
- Experience of multidisciplinary fields.

d) Workshop on community safety map

Based on the observation in 2 communities, the participants were fully involved into the activities for formulating community safety maps. By walking around the community and then drawing a map based on the discussion among themselves, the participants, began to recognize their places and risks of disaster as a whole. Indeed this activity increased their awareness of disaster

prevention. However, this is merely a starting point of the community disaster management and should be followed by prevention countermeasures and activities for prevention and responses, which can also be undertaken by the inhabitants with government support. Also, this activity can be applied to other communities (fortunately, already done in some communities in Cundinamarca), and the methodology should be developed in an appropriate way for this region.

D. Findings

The outputs and observation of the workshops may be concluded as follows:

- Presentation of stories of victims' experience impacted to the participants because their lessons from the disaster have not been shared before.
- Participants were well aware of the lack of coordination and information dissemination among different entities and strongly recognized that a lot of effort should be extended toward this in future. However, some of the participants still acted as though they were outsiders, not being cognizant of the fact that they are the concerned persons regarding this topic of disaster prevention and attention.
- The activities to be implemented by the participants should cost less and be easy to understand.
- Community coordinators and community leaders should be utilized for the activities with initiative of government staff.
- The level of understanding varies from one community to community. Therefore, having a good grasp of the condition of the community is indispensable.
- In the community with many unemployed, students and women, their active involvement can be considered.

2.10.2 Issues, Constraints, Potentials and Measures

Based on the above information and the results of the survey and the workshop, the present issues, constraints and potentials can be summarized from the viewpoints of education and training as shown in Appendix 2.10.13. The most important issues related to education to be addressed are considered as follows:

- Coordination among concerned entities is not enough for planning and implementation of the educational activities.
- Distribution of the related information is not well organized, not shared among the entities, and distributed to the appropriate persons. Additionally, duplication can be found in many places.
- Training and workshop are not organized continuously nor controlled. There is no systematic planning about training policy and no analysis of the training necessities from different target groups and demands. None of the organizations has done their evaluation and follow-up activities. Topics of the training are almost the same in the different

agencies. The target number of participants covered by each organization is still limited because of insufficient financial and human resources. Topics are sometimes very thematic and some of them are not specialty of the organizations.

- Educational and training materials for disaster have not been produced taking into consideration the target groups, objectives and the present situation. The evaluation of the materials has never been implemented and most of them have different terminology, generating conceptual confusion in the people who use the materials.
- Awareness of prevention and attention of disaster in the community is generally low. The efforts to increase their awareness have not been done enough.
- In spite of many regulations on education instructing the incorporation of prevention and attention of disaster into school education, the way of implementation and operation have not been clarified at national level and not achieved at the field level.
- The opinions and ideas of the local people, especially inhabitants with high possibility of disaster, have not been collected and analyzed for the planning.

On the other hand, there are some potential capacities that can be utilized for education and training on disaster prevention and attention. Those with the most potential are as follows:

- There are many organizations already established for the topics.
- Various training and workshops have been organized by different agencies to various target groups using many materials.
- There are some agencies that have been working with communities, private sector and NGOs.

2.11 Institution and Organization for Residential Housing

2.11.1 Public Housing

1) Demand

Number of housing units by income levels in Colombia are shown in Table 2.11.1. The Colombian government has struggled to cope with the housing problem, but it has never caught up with the ever-increasing demand. Only 44,958 units of socialized housing (VIS - *Vivienda de Interés Social*) were delivered in 1999.

In the case of Bogotá, it is estimated that about 80 % of the total households belong to the income levels below 4 SMLM (4 times of the monthly legal minimum salary). Though there is a need of 456,000 VIS houses (in 2,000), 14,773 housing units were provided in 1998[2-11-1].

Table 2.11.1 Number of Housing Units by Income levels in Colombia

Income per Household (SMLM)	Total Number of Households	Number of Households with Deficit of Dwellings	Percentage (%)
0 – 1	1,151,721	224,371	17.8
1 – 2	1,759,059	204,203	16.2
2 – 3	1,225,776	378,154	30.0
3 – 4	801,858	235,716	18.7
(Subtotal 1 – 4)	(4,938,414)	(1,042,444)	(82.7)
4 – 5	571,957	88,236	7.0
5 – 7	671,223	61,765	4.9
7 – 10	476,631	44,118	3.5
more than 10	503,775	23,950	1.9
Total Colombia	**7,162,000**	**1,260,513**	**100**

SMLM: Monthly Minimum Legal Salary
Source: National Development Plan 1998-2002

2) National System of Public Housing

(1) National system of VIS

The housing policy of Colombia is mainly producing low-cost housings, the so-called VIS (*Vivienda de Interés Social*) or housing of social interest. The target group of income levels are households with income levels of 4 SMLM or lower than 4 SMLM. The main entity to handle the housing needs is the Ministry of Economic Development. The housing policy is promoted to execute the Territory Ordering Plan (POT, Law 388/1997, Decree 2620/2000). Under the ministry the National System of Social Housing (*Sistema Nacional de Vivienda de Interés Social*, Law 3/1991) has been organized to involve public and private entities. On the other hand, apart

[2-11-1] Source: Metrovivienda.

from the national system, there are other low-cost housing projects promoted by the Social Solidarity Network (RSS - *Red de Solidaridad Social*) for people displaced by conflicts of guerrillas and violence.

The organizations of the National System of Social Housing are as follows:

- Organizations of Subsidies:
  a) INURBE (National Institute of Social Interest Housing and Urban Reform), promoting.
  b) CPVM (Fund of Military Housing).
  c) Family Compensation Funds.
- Organizations of Loans:
  a) FNA (National Fund of Savings).
  b) Private Funds of Unemployment.
  c) FINDETER (Financial Society of Territorial Development).
  d) Municipal Funds of Social Interest Housing.
  e) Family Compensation Funds.
  f) Corporations of Saving and Housing.
  g) Commercial Banks, and
  h) Agricultural Bank of Colombia.
- Organizations of Technical Assistance:
  a) SENA (National Service of Vocational Training).
  b) IGAC.
  c) Center of Construction and Regional and Urban Development Study and
  d) Universities.
- Coordinating Organizations:
  a) Organizations of Prefectures and Municipalities.
  b) ONG.
  c) OVPs (Popular Housing Organizations).
- Constructors:
  a) Public.
  b) Private and.
  c) ONG Constructors.
- Beneficiaries' Organizations:
  a) Postulants' Groups.
  b) OVPs.

(2) Organizations of subsidy

A. INURBE (*Instituto Nacional de Vivienda de Interés Social y Reforma Urbana)*

INURBE is a Public Establishment of the Ministry of Economic Development, which manages national subsidies to invest in the housings of social interest (Lay 3/1991). It was established in 1991–the reborn ICT (Institute of Territorial Credit).

The subsidies were given for 19,424 cases in 1999 with the total amount of investments of $113,353 million pesos for the following:

- Acquisition of houses.
- Construction of houses in proper sites and.
- Improvement of houses.

30 % of the total subsidies were in Bogotá.

In the case of the acquisition of houses, the sums of subsidy are shown Table 2.11.2.

Table 2.11.2 Subsidy for Acquisition of VIS

Type	Limit Price of House	Sum of Subsidy
1	30 SMLM (8,580,000 pesos)	25 SMLM (7,150,000 pesos)
2	50 SMLM (14,300,000 pesos)	25 SMLM (7,150,000 pesos)
3	70 SMLM (20,020,000 pesos)	25 SMLM (7,150,000 pesos)
4	100 SMLM (28,600,000 pesos)	20 SMLM (5,720,000 pesos)
5	120 SMLM (34,320,000 pesos)	20 SMLM (5,720,000 pesos)
6	135 SMLM (38,610,000 pesos)	20 SMLM (5,720,000 pesos)

Decree 2342/2001

SMLM: Monthly Minimum Legal Salary, 1 SMLM = 286,000 pesos (2001)

In the case of type 2), construction of houses in proper sites, the sums of subsidy are half of the above sums. In the case of type 3) improvement of houses, the sum of subsidy is 15 SMLM (4,290,000 pesos) each.

The most commonly authorized subsidy of acquisition is type 3: house price until 70 SMLM (20,020,000 pesos) with subsidy of 20 SMLM (5,720,000 pesos).

The subsidy for improvement of houses is limited up to 10% of total investment budget by regulation (Art.21, Decree 2620/2000). Besides there is a contradiction in the subsidy system, that is, the requirement of construction licenses which the defective houses in general do not have. So, actually, very few cases of housing improvements were authorized. Furthermore, improvements for seismic resistance are even lesser as the subsidies would have been applied to the cases of a) structural defect, b) lack of sewerage, c) lack of toilet or kitchen, d) an earth floor, e) temporary material, and f) over-inhabited dwelling.

a) Popular Housing Organizations (OPV)

INURBE is promoting the formation of Popular Housing Organizations (OPV – *Organizaciones Populares de Vivienda*) to execute VIS projects with the participation of the communities. OPVs are groups of persons who intend to advance housing programs by way of self-effort and mutual collaboration for the benefit of the popular sector. INURBE responds to the necessities of these groups by way of social and technical assistance to help them in forming autonomous and juridical recognized bodies, so as to achieve their objectives of constructions of VIS.

B. Family Compensation Funds (CCF)

CCF offers family welfare services such as family allowance, educational support, housing subsidy, loans, support for cultural, recreational, tourism and vacation activities. All of the enterprises have to join with CCF and the employers have to contribute 4% of their basic salary as membership fees. There are 55 such funds in the country, a membership of about 70,000 companies and 3,400,000 workers and a total budget amounting to 1,200,000 million pesos. The system was established in 1962.

The Funds are obligated to establish a VIS Fund (FOVIS - *Fondo para el Subsidio Familiar de Vivienda de Interés Social*), to invest 16% of their budgets for family subsidy of housing according to the national policy of VIS (Art.81, Decree 2620/2000). The funds are controlled by the Superintendent of Family Subsidy.

A total of 20,374 subsidy applications were approved in 1999 with total investment of 98,907 million pesos for 1) acquisition of houses, 2) construction of houses in proper sites and 3) improvement of houses.

The system, the objects and the sums of subsidy are the same as those of INURBE.

The following are principal Family Compensation Funds: Compensar, Colsubsidio, CAFAM, Comfenalco, Comfandi, Comfama, Comfamilia, Afidro, Comfacundi, Indufamiliar, Caja de Compensación Familiar Campesina.

C. Promoting Fund of Military Housing (CPVM)

CPVM is an Industrial and Commercial Company of the Ministry of National Defense.

Subsidies for 5,150 cases were given in 1999 for military VIS housings with total investment of $45,578 million pesos.

(3) Organizations of loan

FNA (*Fondo Nacional de Ahorro* or National Saving Fund), an Industrial and Commercial Company of the State, is a VIS loan organization. It processed 10,515 housing loans with a total

amount of $213,972 million pesos in 1999, but this was mainly for national government employees.

Corporations of Saving and Housing are banks that offer housing loans and savings service with unit of adjustment (UVR - *Unidad de Valor Real*) to the index of consumer prices (IPC). In this system of VIS subsidy, the Corporations offer to deposit the down payment (more than 10% of the house value) and give a loan to the subsidy beneficiaries amounting to the balance of payment on mortgage of the house to purchase.

In the common cases other than VIS subsidies, Corporations offer loans until 70% of value of the house to purchase on mortgage of the house. In these cases, corporations do not inspect the houses especially their seismic resistance; they only examine the economic value and physical condition of the houses.

Corporations do not give loans only for the cost of construction.

(4) Organizations of Bogotá City government

Bogotá D.C. Government has the following housing and urban development entities: as public establishments: IDU (Urban Development Institute), FAVIDI (Fund of Saving and Housing of the District), Fund of Popular Housing; as industrial and commercial companies: Metrovivienda Company, Urban Renovation Company.

IDU constructs city roads and manages them. FAVIDI supplies VIS houses to the city government's employees utilizing their resources of unemployment compensation and pension. Fund of Popular Housing supplies VIS houses for relocation of houses occupying public space and houses located in high-risk areas of disaster. Metrovivienda supplies building lots to VIS housing constructors. Urban Renovation Company manages renovation projects in the central areas.

There is no organization dealing with improvement of existing defective buildings and guiding and controlling of buildings planned/constructed by the owners themselves.

2.11.2 Common Housing

1) Housing of Low-income People

Beneficiaries of subsidy of Family Compensation Funds are contractual laborers with relatively stable income comparing with those of INURBE who are mainly non-contractual laborers with less income.

The majority does not have much luck in making use of the subsidy system, or does not qualify for public assistance.

Low-income people construct houses step by step in the processes of building the basement, structure, wall, floor, interior and exterior by contracting workers or by themselves. In many cases, there are no design plans nor construction licenses.

2) Self-Construction

For the poorer people who do not qualify for subsidies and loans, or do not have stable and enough income, so-called Self-Construction is very common in the areas of *estrato* 1 and 2 mainly located in the south of Bogotá. Though there is no statistical information, it is estimated that more than half of the buildings are self-constructed in the poorest areas of the city. People construct their houses by themselves little by little when they have time and money. Many of the people are construction workers and sometimes they construct 3 or 4 story buildings. However, almost all of them do not have construction licenses and their work are not subjected to any technical check; thus many of their constructions have structural problems. There are a few technical guides for self-construction; however, the technique is very far from what is commonly known and used.

There are no countermeasures carried out for guiding and controlling Self-Construction, nor supporting for improvement of existing buildings constructed in such a manner.

2.11.3 Organization of Control

1) Construction Guard Office

Authorizing and controlling licenses of urban development and building construction are responsibility of municipalities. Checking of seismic resistance should be included in the examination for construction license (Art.13, Decree 1052/1998).

Municipalities with more than 100,000 inhabitants should have *Curadurías Urbanas* decentralizing the jurisdiction of municipal planning offices (Art.49, Decree 2150/1995).

The *Curadurías Urbanas* are entrusted to issue licenses and execute necessary studies for the license issuance. Their responsibility is public (Art.36, Decree 1052/1998), but their business form is private (Art.35, Decree 1052/1998). They are independent economically and financially from the Municipal Government.

Municipal mayor has a duty to check and control construction guards in observance of regulations of their business (No.7, Art.101, Law 388/1997). The Ministry of Economic Development supports and orients the construction guards in their adequate implantation of local administration by way of Inspecting Commissions (No.6, Art.101, Law 388/1997; *Comisiones de Veeduría*, Art.74, 75, 76, 77, Decree 1052/1998).

Observance of the law on construction licenses should be enforced directly by the office of the mayor or indirectly by the municipal authority of construction and planning (Art.61 Decree

2150/1995). In the case of Bogotá D.C., the locality sends inspectors to check the observance of this law.

For the actions of development or construction without licenses or violation of authorized matters, the municipal mayor, the local mayor in the case of Bogotá, can oblige to stop and seal the actions (Art.103, Law 388/1997), punish the responsible person with a fine (No. 1, 2, 3, 4, Art.104, Law 388/1997), or oblige to demolish partially or totally the construction (No.5, Art.104, Law 388/1997).

2) Number of Construction Licenses

About 5,000 construction licenses are likely issued annually by the five *Curadurías Urbanas*, but a large part of the new buildings are to be constructed yearly without any construction licenses, because annual new building constructions are estimated to be 20,000 to 30,000 in the city.

The latest public selection of Guards was held in November of 2001. Five Guards were selected for January 2002 to December 2006 without changing the total number.

3) Distribution of Curadurías Urbanas

In Bogotá there are five *Curadurías Urbanas* Offices, four of which are located in the Chapinero locality in the northern part of the city, and one in Santa Fe. The distribution is inclined to the north, and the other 17 localities do not have any Guard Office.

4) License Fee

An application fee is necessary for Construction License. The rate formula is determined by the Ministry of Economic Development (No.4, Art.101, Law 388/1997; Art.57, Decree 1052/1998) and each municipality will set every year coefficients to calculate the fees (Art.68, Decree 1052/1998). Fees are usually based on the area of economic *estrato* and types of use. Fee for housing is cheaper than that for commercial use.[2-11-2]

2.11.4 Issues for Private House

1) Increase of Defective Buildings without Control

There are 20,000 to 30,000 new constructions of houses and buildings annually in Bogotá, but only 5,000 have construction licenses. There exist in the Study Area about 400,000 defective houses and buildings of little seismic resistance made of brick masonry, most of which are located in the areas of economic and social *estrato* 1 and 2 in the south of Bogotá. Almost none of them

[2-11-2] For example, in the case of housing in the area of *estrato* 1 or 2 with 50 m^2 of construction the application charge will be 175,924 pesos (2001) included 16% of IVA (Value Added Tax, Law 635/2000). There is discounted fee applicable to VIS, which costs 44,234 pesos equivalent to 4 SMDV (Daily Minimum Salary, Art.65, Decree 1052/1998). VIS fee is applicable to housing: 1) up to 90 SMLM (25,740,000 pesos) of value, 2) up to 50 m^2 of construction, and 3) of authorized VIS project. An interview consultation will be charged 22,117 pesos per hour.

have construction licenses or checks for seismic resistance. The background of this situation is supposed as follows:

- The owners do not know or disregard construction license.
- The fee of construction license is not economical for the owners of *estrato* 1 and 2.
- The capacity and number of Construction Guard Offices are not enough, and the location is inclined to the north of the city.

2) Backlog to the Demand of Low-Cost Housings

About 45,000 VIS houses were built in 1999 by the subsidy system of INURBE and Family Compensation Funds, about one third of which were in Bogotá. All the licenses are checked in the case of VIS housing.

The common low-cost housing projects other than VIS are not very well checked in seismic resistance.

3) Disregarding Seismic Resistance for Existing Defective Buildings

At this moment there is no project of reinforcement for 400,000 existing defective buildings by DPAE-FOPAE or other organizations of housing, urban development and prevention of disasters. There are subsidies for improvement of houses by way of INURBE and Family Compensation Funds; but actually they are not effective for improvement of seismic resistance because of system nature and lack of resources.

These defective houses and buildings are actually left alone and unattended.

4) Cost and Benefit for Reducing Human Casualties

It is important to gain more benefit in reducing human casualties by prevention projects utilizing limited financial resources. There is a question whether the present projects of DPAE-FOPAE are really effective or not from the above-mentioned aspect. But the more important question should be how many lives can be saved against expected risk of disaster with the same unitary cost.

It is recommended that prevention projects should be shifted and concentrated 1) to produce more seismic-resistant buildings and 2) to reinforce the existing 400,000 defective buildings.

5) No Reserved Budget for Immediate Response

Any of the following organizations studied in this project are not reserving a budget for immediate response to disasters except for FOPAE: National Calamity Fund, Calamity Fund of Cundinamarca, 8 municipal governments, road management organizations such as INVIAS, Cundinamarca Secretariat of Public Works, IDU, Lifeline Service Enterprises such as EAAB, TELECOM, ETB, Natural Gas Company, and so on.

Most of these organizations will divert budget urgently to response use; however, the availability will be uncertain and immediate disbursement will be difficult.

It is impossible for insurance companies to offer insurance of immediate cash-payment as they are always investing in money markets.

6) Reserved Budget of FOPAE

FOPAE is the only organization that has a reserved budget for immediate response to any urgent necessity after a disaster (Art.68, Decree 1148/2000), in the sum of 5,000 million pesos (2001 budget No.7240).

However, this amount cannot be carried forward to the next fiscal year; it should be diverted to other use until the end of the year because of actual budget regulations.

The 5,000 million pesos is just a little for 6 million inhabitants at 833 pesos per person.

7) Establishment of Organization for Reconstruction

In Colombia, each time after a large disaster a special organization for reconstruction was established. They are, for example, Corporation of Cauca after the earthquake of Popayán, Corporation of Nasa Ki We after the Paez River avalanche by an earthquake in 1994, FOREC after the Quindío earthquake, San Cayetano Fund after the landslide of the village, and so on. In the case of Quindio, FOREC was established only 5 days after the disaster together with a decree of additional national budget.

However, if a large seismic disaster occurs in Bogotá, a much bigger organization will be needed than those mentioned above. Some preparatory study will be needed for it.

8) Legislation

In the case of Quindío, 10 Municipal Decrees were issued within a week after the earthquake and 12 National Decrees within a month. The rush of legislations was not successful and did not really register in the people's minds; there were alterations and abolitions during a short period. Some of them were not so effective for lack of preparation and deliberation.

9) Disaster Insurance for Public Organizations

Not all of Colombian public organizations including Lifeline Service Enterprises have disaster insurances, though they are obliged to have some insurance against disaster damages (Art.101 and 107, Law 42/1993; Art.6, Resolution 5145/2000 of the General Board of Audit).

10) Disaster Insurance for the Private Sector

Disaster insurances are not yet common for private houses and buildings in Colombia. In Bogotá earthquake insurances occupy only 9% of all the damage insurances. (1,004.254 million pesos in 2000.

Law of Joint Ownership obligates joint owners to have Disaster and Fire Insurances to protect common properties. There will be a need to promote this law because it is very new (August of 2001) and no sanction is imposed for non-compliance of this law.

Also it is necessary to study the possibility to introduce the 1 % contribution system of paid insurance fees to disaster funds, referring the case of National Fire Fighting Fund receiving 1 % of paid fee insurance (National Fund of Fire Fighting, Art. 2, 3, Decree 2211/1997).

2.12 GIS and Database System

2.12.1 Introduction

In this study, attribute and GIS database creation has an important role not only to integrate the large number of data collected during the study period but also to aid and enhance the future decision making process. Keeping this in mind, the collected database is put under standard database design so that the future use is more straightforward.

To achieve this goal, the database received from different institutions were carefully analyzed and validated against standard database structure. Following can be assumed from the database construction.

1) Data Source and Compilation

- A large number of existing data and database were collected from different institutions for the study purpose. Basically, three ways were employed to get hold of them: data and information provided by each institution (past studies conducted by them form the information provided by these institutions), studies and observation carried out by JICA study team, and studies subcontracted by JICA team for the study purpose.
- The analysis of collected data revealed that a large number of data received are not consistent in quality, scale, and time period in which they had been collected. Furthermore, the data are not organized in a structured manner to be used directly for the study purpose. Many of the collected map data were not in GIS format. A great deal of the effort was put to organize and systematize the data as well as data correction.

2) Database Analysis and Modeling

- Database analysis and modeling was done by using standard querying language SQL. Following database components were completely analyzed through SQL routines.
  a) Building Database creation.
  b) Population Estimation for the year 2000.
  c) Housing Units Distribution.
  d) Building Damage Estimation and Human Casualty.
  e) Debris Generation.
  f) Property Damage (based on Cadastral Value).
  g) Flood Damage Estimation.
  h) Landslide Damage Estimation.
  i) Fire break out ratio from Chemical Industries.
- The GIS system was structured around Arc/Info topological model. The latest Arc/Info data model is geo-database. The geo-database model offers better solution than conventional topological model and enhances data validation rules inside the GIS system.

In some form, the geo-database model homogenizes the existing difference between GIS system and Database system leading to better interchange and compatibility between these two systems. This model, however, is not implemented in the present study, considering the fact that it is not backward compatible. The counterpart agencies do not have latest Arc/Info software to read the geo-database model. That means this model cannot be correctly interpreted by existing software available in DPAE and Government of Cundinamarca. They need to procure new Arc/Info release so as to interpret this geo-database model. Also, all the information received from the counterpart agencies are in Arc/Info topological model, so converting these data to geo-database require a huge task.

- The database system was finally integrated with GIS system with the common spatial units (connectors). These spatial units to connect Oracle and Access database systems are Manzana, Microzone, Locality and Municipality.

2.12.2 Database Construction

1) Information Provided by the Entities

Following entities provided GIS and non-GIS database for the study.

- DPAE
- Planning departments of eight Municipalities
- Cadastral Department, Bogotá
- Secretary of Education, Bogotá
- Parks and Open Spaces, Bogotá
- Planning Department of Bogotá
- Government of Cundinamarca
- IDU
- Water Supply Company, Bogotá (EAAB)
- Telecommunication Companies (CAPITEL, ETB)
- Natural Gas Company
- DABS
- Electricity Supply Company (CODENSA)
- Ecopetrol
- Ingeominas

2) Database Quality Checking

The collected databases were checked for their present structure, level of detail, quality, consistency, time period in which data were collected and relevance of them to this study. Mainly database quality checking was done for three aspects.

- Attribute database quality.
- Spatial database quality.
- Relevance to present study.

A summary of the attribute and GIS database quality checking for major database received is given below. Mainly following information were rigorously checked:

1) Base map collected from Government of Cundinamarca.
2) POT data and map collected from municipalities.
3) Cadastral database.
4) Seismic Microzoning Study carried out by Los Andes University and Ingeominas.
5) DPAE's GIS database.

2.12.3 Revision and Correction of GIS and Attribute Database

1) Base Map Preparation

The study team established GIS base map for the study area through sub contracting to the Colombian firm. The existing data base and maps are constructed Bogotá City and Cundinamarca separately. Within the study, integrated map for the study area was established.

2) Coordinate System

There are two types of Coordinate System in use in the Study Area. Almost all the information received for Bogotá has its local Coordinate system. Similarly, all the national entities including eight municipalities use the Bogotá national coordinate system.

Finally, for this study the JICA team chose the Bogotá National system as a unique coordinate system for the following reasons.

- The Bogotá local system can be transformed to Bogotá National system with less error in coordinate transformation as the data from Bogotá were prepared in major scales.
- The tendency is to work in a unique system so as to facilitate easy interchange of data.

2.12.4 Design and Structuring of Database and System

1) Introduction

The fundamental points for the design of database for the present study were:

- Understanding the requirements before beginning to build the solution.
- To follow the existing and accepted standards for the design.
- Writing code that is readable.
- Separate user interface and data management.
- Design for the most efficient use of the program by the user.

- Program codes that can be re-used.

The database design process consists of the following steps:

(1) Requirements collection and analysis

The study requires setting up microzones, setting a database for existing buildings (both for residential and other use) and setting up the population data in these microzones.

(2) Conceptual database and GIS design

The goal of this stage is to analyze the application and do a conceptual design on the application to provide a description of reality. The figure below shows the flow of the information from different entities and their organizations.

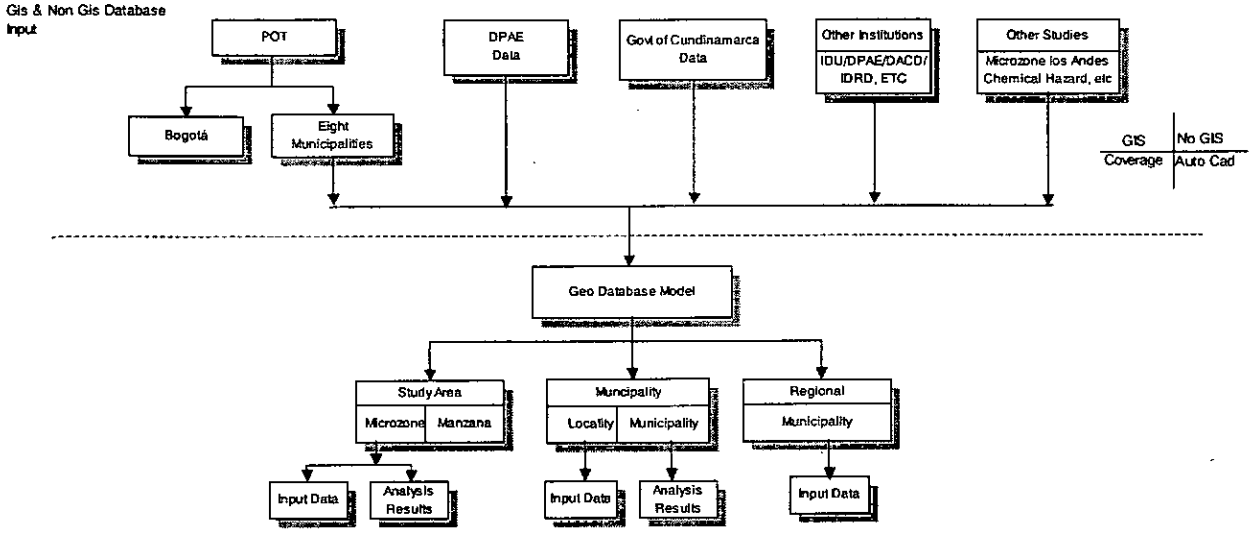


Figure 2.12.1 Organizational Design of Database

A conceptual design should reflect all the components of the designed database. The flow chart in the next page shows the different components and subcomponents of the constructed database and its hierarchical order.

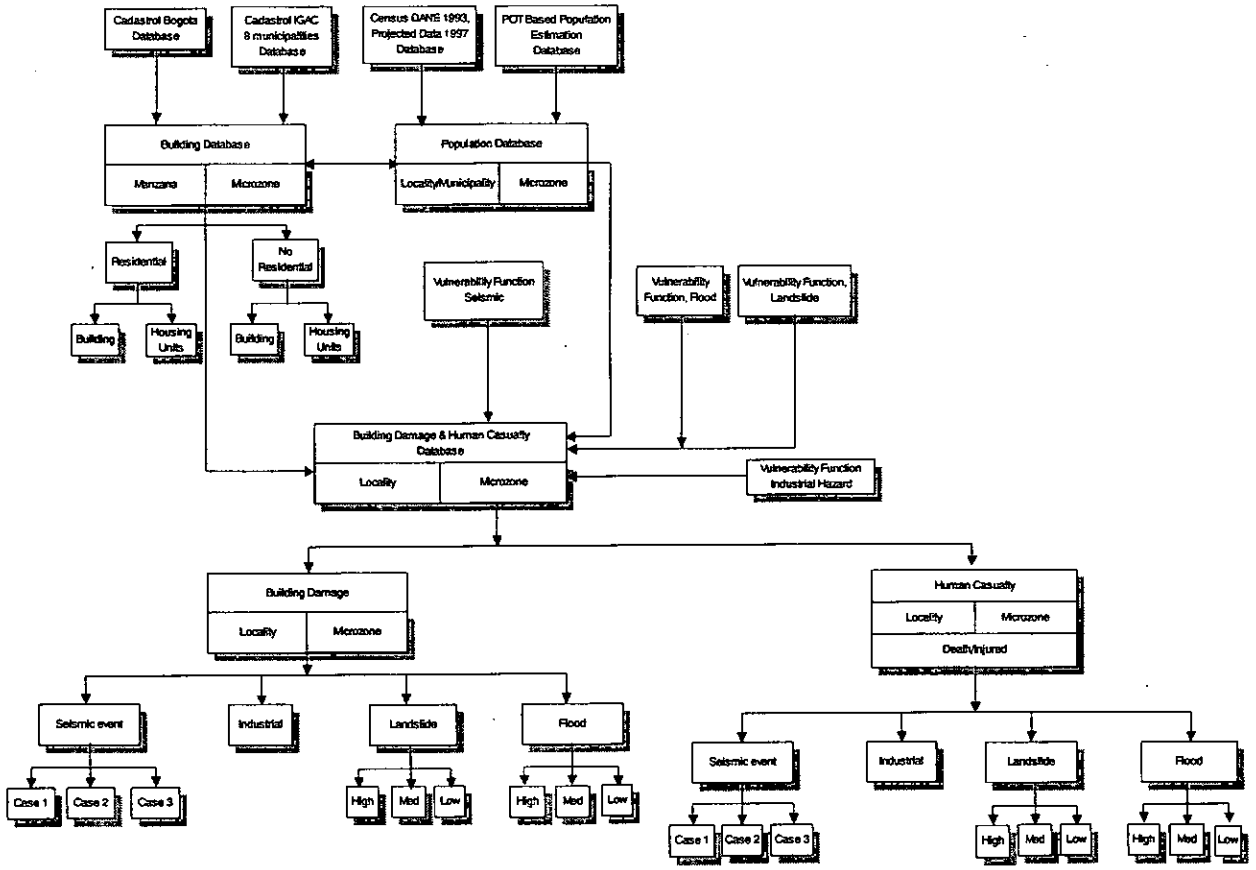


Figure 2.12.2 Components of the Database

(3) Choice of a DBMS and GIS

A decision was made to choose Personal Oracle database system to be used as the desktop database. This has all the features of a Server database but could be used in only one computer at a time. This gave an excellent solution to the need of power, flexibility and scalability of server database at very low cost.

For the Geographic Information System, ArcGIS (new version of Arc/Info family) is chosen as it is versatile, reliable and widely used GIS system. Further, most of the data collected in Bogotá are already in Arc/Info coverage while GIS data from the municipalities are in Arc/View shape file. Almost all of the entities using GIS has either Arc/Info or Arc/View software.

(4) Database and GIS system implementation

The database system implementation involves the setting up of procedures for communication between the Database System and GIS system. Through proper communication system and suitable spatial and attribute connectors, the GIS and Database system can interact with each other. Four spatial units (common connectors) were defined so that the attribute and spatial database could communicate with each other. These spatial units can be modified or deleted at any time in

the database making it flexible for database aggregation and changes. Equally, new connectors can be added to both attribute and GIS database.

- Manzana.
- Microzone.
- Locality.
- Municipality.

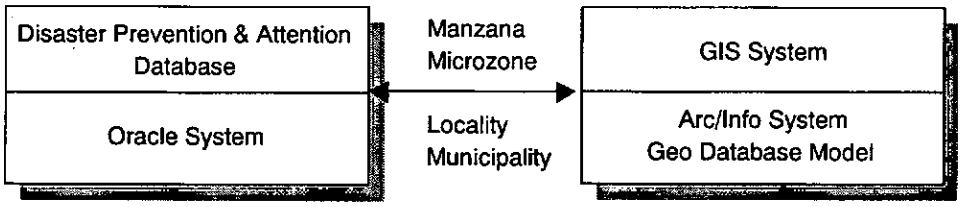


Figure 2.12.3 Relationship between Database and GIS System through Common Connectors

2.13 Summary of Donor Activities

2.13.1 UNDP

In the mid 1980s, the Colombian government started a disaster management project with cooperation with the United Nation Development Program (UNDP). The study done by UNDP proposed to establish the disaster management system in Colombia. The project recommended establishing a National level organization to deal with disasters as well as local level organizations. The Colombian government has established the national level organization and the four local level organizations, i.e. Cali, Bogotá, Ibague and Tumaco, for high risk areas. Since then, UNDP has given assistance to the Colombian Government on this field.

UNDP has assisted rehabilitation of the Choco province, which was hit by an earthquake in 1992. The project has focused on five municipalities of Vigia de Fuerte, Carmen de Atrato, Bojaya, Murindo and Medio Atrato, and implemented the relocation of people as well as the development of agriculture. It will continue to develop community level organizations with participation of the people.

2.13.2 GTZ and KfW

GTZ has carried out the feasibility study on the Bogotá Metropolitan Area. As the results of the feasibility study, the Government of Germany, through KFW (Bank for the German Development), gives the financial assistance to the Bogotá City. The project calls "Project to Improvement of Neighborhoods SUR with Bogotá". The project intends to develop community level planning, coordination, and administrative capacity through participation.

2.13.3 On-going Project

The disaster management project is relatively new area in Colombia and there are four disaster management projects in Colombia in 2001. The list of the projects is shown as follows:

Table 2.13.1 Summary of the Donor Activities for Disaster Management Projects in Colombia

Name	Counter Part Organization	Objectives
Program for Prevention and Mitigation of the Risks in the Andean Region	Andean Region	Formulation of national and sectoral policies on prevention and mitigation
The recovery of earthquake damaged area in the Atrato Medio	Direction General of Prevention and Attention of Disasters	Rehabilitation and reconstruction of the earthquake damaged area
Disaster prevention in the Bogotá Metropolitan Area	Direction of Prevention and Attention of Disasters	Formulation of disaster prevention master plan in the Bogotá City.
Donation of Medical equipment for four hospitals in Quindio Prefecture	Ministry of Health	Renewal of medical equipment in the earthquake damaged area

2.13.4 Emergency Assistance

1) Armenian Earthquake

The Colombian government received assistance from various organizations for rehabilitation of the coffee-growing region. The Inter-American Development Bank (IDB) would provide about US$ 180 million and other donors (USAID, the Government of Italy and Spain) would provide US$ 70 million. The World Bank provided US$ 225 million for the various projects. The projects are consists of the five groups: 1) shelter assistance, 2) rehabilitation and retrofitting of social infrastructure, 3) rehabilitation of public infrastructure, 4) capacity building for natural disaster management, 5) social capital restoration and 6) project management.

To rehabilitate Armenian area, the Colombian government established a new organization, Fondo para la Reconstrucción y Desarrollo Social del Eje Cafetero (FOREC), to finance, execute, and coordinate the economic, social and ecological reconstruction of the disaster affected region[2-12-1]. The organization is just for reconstruction of the coffee growing area and only limited to three years. FOREC organizes 32 Non-Governmental Organization (NGO) to reconstruct the areas. It is estimated that the more than 90 percent of the funds is invested to the reconstruction of the area.

2) Summary of the Donor Activities

The summary of the donor activities in the coffee growing area is shown as follows:

[2-12-1] Project Appraisal Document on A Proposed Loan in the Amount of US$225.0 million to Forec Guaranteed by the Republic of Colombia for An earthquake Recovery Project, February 25, 2000

Table 2.13.2 Summary of Donor Activities in the Coffee Growing Area

Name of the Project (Project Location)	Activities	Beneficiary	Project Costs	Implementation organization
Alimentary assistance of emergency to the affected population by the earthquake in the coffee area of the Colombian west center (12 municipalities of the Quindio Prefecture)	Cleaning of rubbish Opening and rehabilitation of access roads Reconstruction of destroyed housing Reconstruction of basic services Reconstruction of productive infrastructure	115,000 people in total	US$ 1.5 million From PMA	PMA
Emergency Program	Mental treatment for affected children Reconstruction of portable water system Public awareness camping Return to school	10,000 children in the area 90,000 inhabitant	US$ 1.2 million From UNICEF	UNICEF
Technical Assistance for the Rehabilitation and Reconstruction of the municipalities in the coffee zone, affected by the earthquake in January 25th , 1999	Recruitment of specialized technical personnel to advice the local and prefecture authorities Organization and promotion of thematic meetings Co-financing of other UN system	Regional and Local Emergency Committee 1 million of people	US$ 113 thousand	UNDP is co-financing other 13 project within the UN system
Support to the Alimentary Safety for the Affected Communities project	Promotion of mixed families orchards Training to government officials Acquisition of seeds and agricultural inputs	5,000 farmers	225 million pesos	FAO
Support to the Housing Construction and Rehabilitation	Technical support of damaged housing	10,000 inhabitants	US$ 504 thousand	GTZ
Reestablishing of Health Services in the Quindío Prefecture.	Endowment of medical-surgical equipments	Four hospitals in different municipalities	9,917 million pesos	Government of Japan

Chapter 3

Vulnerability Analysis

CHAPTER 3 VULNERABILITY ANALYSIS

3.1 Hazard Assessment

3.1.1 Earthquake

1) Hazard Assessment in Colombia

In 1996 the Seismic Hazard Maps for the territory of Colombia for based on the Colombian Standard for Earthquake Resistant Construction were made by the Colombian Association of Earthquake Engineering, the Los Andes University and INGEOMINAS.

The hazard assessment study used the seismic event catalogue database containing 11,088 events, and evaluated the seismic activities of 32 seismic faults identified.

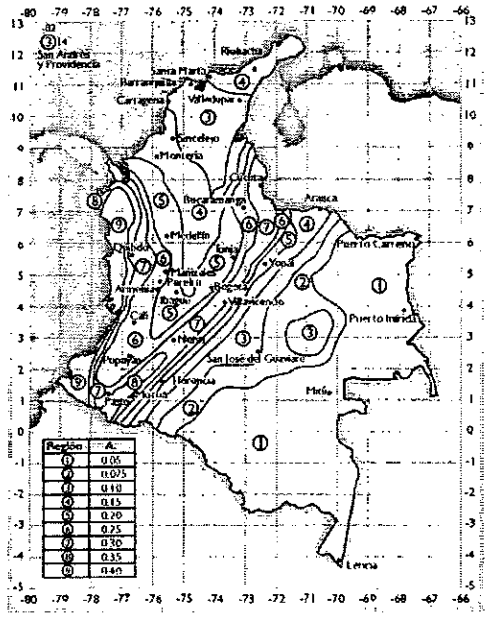
Together with the available historical information of past earthquakes, they the study also prepared a map of the effective peak acceleration with over 10% probability of exceeding of 10% in 50 years (Aa) for all the territory of Colombia, and damage threshold acceleration to be used in the design of essential facilities (Ad), which is compatible with the requirements of the Colombian standard.

As the result, the territory of Colombian is categorized into nine zones according to the expected maximum acceleration (Aa) and shown in Figure 3.1.1. The potential of seismic hazards in the Study Area is categorized in the medium level zone and the Aa and Ad values of the city and municipalities are shown in the following Table 3.1.1.

Table 3.1.1 Aa and Ad by City/Municipality in the Study Area

Municipality	Aa (g)	Ad	Hazard level zone
Bogota	0.2	0.04	Medium
Chia	0.2	0.04	Medium
Cota	0.2	0.04	Medium
La Calera	0.2	0.04	Medium
Facatativa	0.2	0.04	Medium
Funza	0.2	0.04	Medium
Madrid	0.2	0.04	Medium
Mosquera	0.2	0.04	Medium
Soacha	0.2	0.04	Medium

Source: Estudio General de Amenaza Sismica de Colombia, AIS, 1996



Source: Estudio General de Amenaza Sismica de Colombia, AIS, 1996

Figure 3.1.1 Zones for Expected Maximum Acceleration in Colombia

2) Earthquake Hazard Assessment in Cundinamarca

The Cundinamarca government and INGEOMINAS studied on the environmental disasters in Cundinamarca for the period of 1923-1997. The events reported in the major newspapers in Colombia have collected and studied. The results are summarized and shown in Table 3.1.2. Among the environmental disasters, earthquakes occurred 68 times and the event that caused the biggest damage was in 1923.

Table 3.1.2 Human Damage Due to Ambient Disaster in Cundinamarca

		Human damage		
Event type	No. of event	Dead	Injured	Affected
Earthquake	68	40	107	915
Innudation	248	16	18	514,931
Flood	57	82	28	5,933
Fire	46	8	1	1,550
Contamination	11	0	0	0
Landslide	121	783	33	9,719
Hurricane	20	4	13	2,001
Dries	16	0	0	0
Tempest	60	13	7	795
Total	647	946	207	535,844

Source: Catalogo de desastres ambientales de Cundinamarca, Gobernación de Cundinamarca, INGEOMINAS, 1997

Table 3.1.3 Summary of Damage Due to Earthquakes by Municipality

Municipality	No. Of event	Human damage			Property damage							
		Dead	Injured	Evacuated	Roads	Pub. Services	Life lines	Buildings	Farmland	Forests	Domestic animals	Others
Bogotá City	29	25	102	900	2	2	2	10	1	1	0	2
Chía	2							1				
Cota												
Facatativá	1							1				
Funza												
La Calera												
Madrid												
Mosquera												
Soacha	2								2			
Total	34	25	102	900	2	2	2	12	3	1	0	2
Cundinamarca	68	40	107	915								

Source: Catalogo de desastres ambientales de Cundinamarca, Gobernación de Cundinamarca, INGEOMINAS, 1997

Besides, the Cundinamarca government has a "Map of is-acceleration in Cundinamarca," based on the result for nation wide study of seismic hazard by INGEOMINAS in 1996. However, a geological model for micro zoning in Cundinamarca is yet to be made.

3.1.2 Landslide

1) Hazard Area

(1) Data

The Study Team has prepared a datasheet form to compile landslide disasters in the past five years and to identify hazardous slopes at present in the Study Area. The datasheet covers place and date, if recorded, and type of disaster, trigger, inherent causes, activity rate, and damages (human and property or potential objects to be protected). It also includes responses after disaster and risk evaluation in terms of urgency and scale for objects to be protected. The "diagnosis" forms documented through field observation by DPAE was used as raw data in Bogotá. Articles in major newspapers are sources of information for the eight municipalities in Cundinamarca.

Prior to the field survey the Study Team made interpretation of aerial photographs taken in 1993, 1994, 1996, 1997, and 1998 to identify hazardous slopes.

Also the satellite 3D image taken on March 2001 were used to study on changes in landform, vegetation and landslides after 1998. The satellite images were taken by ASTER (Advanced Space borne Thermal Emission and Reflection radiometer), using visible band with a resolution

of 15m on ground surface. The satellite images were used to supplement the aerial photograph information.

The field survey of typical sites were conducted to verify the status, and to check the data and the results of photo interpretation.

(2) Evaluation

The Study Team assessed the potential risks of the identified sites in case of a slope disaster based on diagnostic documents by DPAE and through filed survey.

The principal factor used in evaluation is urgency to mitigate human damages by non-structural measures like evacuation. The secondary factor is scale of object to be protected, whose damage is difficult to be avoided by non-structural measures.

Principal factor: Urgency for damage mitigation:

- The slope disaster would claim casualties.
- The slope disaster would cause damages within several days after its occurrence.

Secondary factor: Scale of potential damages:

- The slope disaster would affect more than two objects for prevention.
- The slope disaster would affect one object for protection or cause only insignificant damages.

Using above-mentioned two factors, the hazardous slope areas are classified into the three grades as shown in Table 3.1.4.

Table 3.1.4 Assessment of Hazardous Slope Classification

Urgency of evacuation	Scale of damage	Influential to multiple and large facilities a	Influential to single and/or minor facilities b
Urgent	A	Aa→Grade 1	Ab→Grade 1
Dangerous in a few days after disaster	B	Ba→Grade 2	Bb→Grade 3

Basic ideas for future attention are described as follows:

Grade 1 (Aa, Ab): Structural measures or relocation of inhabitants are needed.

Grade 2 (Ba): Some structural and/or non-structural measures would be required.

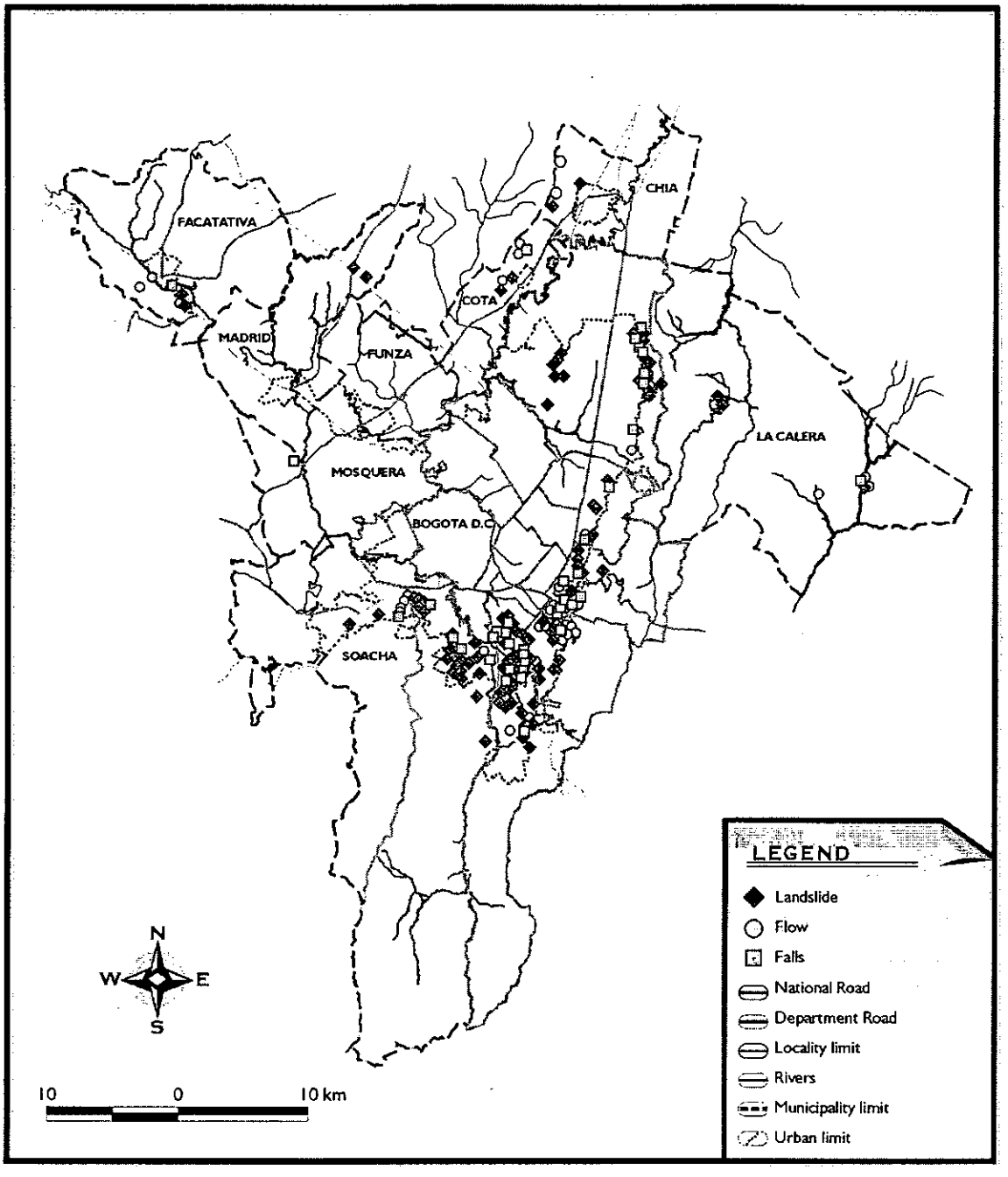
Grade 3 (Bb): Only non-structural measures would be required.

2) Results of Hazard Assessment

Figure 3.1.2 shows the distribution of hazardous slopes disaster identified in this study as classified by hazard types. Number of slopes classified by process for each municipality is shown in Table 3.1.5. Figure 3.1.3 shows the distribution of hazardous slopes as classified by risk levels. Number of hazardous slopes classified by risk for each municipality is shown in Table 3.1.6.

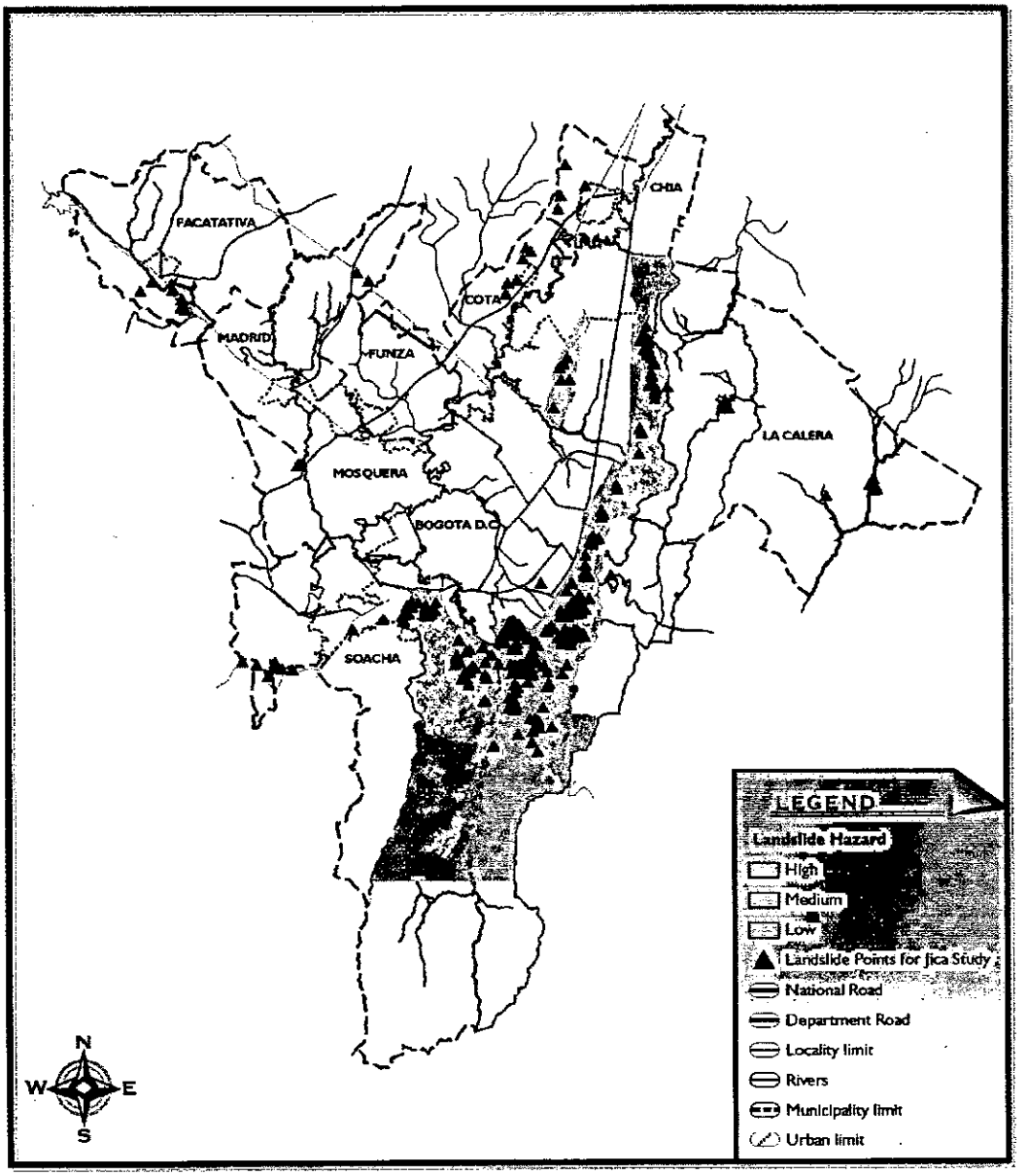
The result of this study shows that hazardous slopes are concentrated at where housing area is close to or on the slope, and located in the southern and southeastern part of Bogotá or in Soacha. In such places, houses are constructed near or on the slopes that are intrinsically hazardous. In this sense, many of these hazardous slopes are not necessarily to be called as natural hazard.

Some rock fall hazardous areas locate at the side slope along the main road. Rock fall would occur and at least one side lane would be impassable in a sever earthquake.



Source: JICA Study Team

Figure 3.1.2 Distribution of Hazardous Slopes Classified by Disaster Type



Source: JICA Study Team

Figure 3.1.3 Distribution of Hazardous Slopes Disaster as Classified by Risk

Table 3.1.5 Number of Slope Disaster as Classified by Process

	Process Type									
Municipality	Rotational landslide	Traslational landslide	Rock fall	Debris fall	Debris flow	Earth flow	Mud flow	Subsidence	Total	%
Bogota	236	47	56	6	1	21	5	0	372	87.9
Chia	2	0	0	0	1	1	0	0	4	0.9
Cota	0	0	3	0	0	3	0	0	6	1.4
Facatativa	2	0	1	0	1	2	0	1	7	1.7
Funza	0	0	0	0	0	0	0	0	0	0.0
La Calera	4	0	0	0	1	3	0	0	8	1.9
Madrid	0	0	2	0	0	0	0	0	2	0.5
Mosquera	0	0	2	0	1	0	0	0	3	0.7
Soacha	3	2	8	0	3	5	0	0	21	5.0
Total	247	49	72	6	8	35	5	1	423	100.0
%	58.4	11.6	17.0	1.4	1.9	8.3	1.2	0.2	100.0	

Source: JICA Study Team

Table 3.1.6 Number of Slope Disaster as Classified by Risk

	Risk				
Municipality	Grade1	Grade2	Grade3	Total	%
Bogota	77	50	245	372	87.9
Chia	0	1	3	4	0.9
Cota	2	2	2	6	1.4
Facatativa	2	3	2	7	1.7
Funza	0	0	0	0	0.0
La Calera	2	2	4	8	1.9
Madrid	1	0	1	2	0.5
Mosquera	2	1	0	3	0.7
Soacha	8	9	4	21	5.0
Total	94	68	261	423	100.0
%	22.2	16.1	61.7	100.0	

Source: JICA Study Team

3) Major Findings

In the Study Area, "earth flow", a type of disaster in which surface soil or part of weathered base rock flows is remarkably recognized. Collapse of base rock at the wasted quarries is also prominent. These phenomena should be differentiated from "landslide" in narrow sense.

Such types of hazardous slopes distribute in gentle slope areas in wasted quarries and along the Blanco River in La Calera. Almost of those hazardous slopes disasters are classified as "earth flow". The basic cause of such abundant earth flow are precipitation, deep weathering due to the slow emergence movement that allows slow erosion in periphery of Bogotá basin, and abundant organic surface soil whose thickness is from 1 to 2 m from Sabana formation.

In the western side of western end backbone from Soacha to Facatativa, erosion prevails over weathering so that the slopes with underdeveloped weathering are the majority. Therefore earth flow is limitedly seen in the re-movement of glacial deposit.

The types of slope disaster in the future are earth flows in steep slopes, rock fall at the foot or on the edge of wasted quarries and large scale landslide in the inhabited area. Hazardous locations in each municipality are described as follows:

(1) Bogotá

Landslide records and hazardous landslide areas are concentrated in slope areas that were developed without proper stabilization works due to the rapid expansion of housing area. In many cases, supply of piped water without installation of sewer pipes caused infiltration of wastewater and triggered earth flow together with rainfall.

(2) Chia

Small-scale landslides exist at the east slope of Majuy Mountain. However, the record of landslide is very limited. No slope and landslide exist in the urban area. Some slopes are unstable at the valley along the Frio River due to erosion.

(3) Cota

There are no slope or landslide areas in the urban zone. Hazardous landslide and rock fall areas are identified at the eastern side of the slope of Majuy Mountain, where operative or abandoned quarries exist. However, there is little landslide record.

(4) Facatativá

Earth flows exist at the both sides of the valley slopes near Sorrento, located in the east of the urban area. Heavy damages are anticipated in the densely populated northern slopes.

(5) Funza

There is no slope in the municipality.

(6) La Calera

Earth flows are widely recognized on slopes near El Manzano along the Blanco River. Landslides one in progress there due to the constant erosion at the foot of the slopes by river flows. Debris flows would occur if a landslide occurs there, river water is dammed up about 10 m, and the water head would remove finally blocking soil. On the other hand, ruins of the destructed bridges in the Blanco River indicate the several occurrences of debris flows.

In western side of the urban area, earth flow marks with about 5.0 m deep are observed on the slopes. Its movement is prominent in earth cut area.

In the western mountainous part of the municipality, a river with a relatively large river basin, flows into the urban area. Flooding were repeatedly happened in the parking area of apartment houses near the junction of flows.

(7) Madrid

There is no landslide in the urban area. But there are some rock fall areas which would cause traffic interference on the road that cross the Majuy Mountain in the northern part of the municipality in case of an earthquake.

(8) Mosquera

There is no slope in the urban area. But there are a few hazardous slope areas with rock fall at the southern part of the municipality, where residential buildings exist beneath the abandoned quarries.

(9) Soacha

Rock falls with 1.0 m in diameter are observed at the slope along the road from Soacha to Granada. Rock falls will possibly occur there in future due to its dip slope structure. One road lane would probably be blocked in case of a sever earthquake.

Similar conditions are also observed at the slope along the road (Soacha-Santandercito) at El Charquito.

In the southwestern part of the urban area, there is a high possibility of rock falls at the dense house buildings near the abandoned quarry at El Altico.

A large-scale landslide occurred in January 2000 at the right side slope of the downstream from the lake Terreros. The area is currently stable due to the counter embankment. However, it is possible to slide again due to the lack of a drainage system.

In Pavimentos Roka, there was a circular slide from the crest of the scarp at the abandoned quarry, and some houses had been damaged. The area is still in dangerous state because houses gather atop of the scarp.

3.1.3 Flood

1) Hydrological Aspects

(1) Rainfall

There are two rainy seasons such as April to June and October to November in this area. Annual rainfall depth varies from less than 500 mm to more than 1,500 mm.

Among many rainfall gauging stations, with the consideration of distribution and observation period, ten stations of EAAB were selected for analysis of rainfall characteristics (Locations, see Figure 3.1.4.). As for the analysis, one-day rainfall data for these stations were collected.

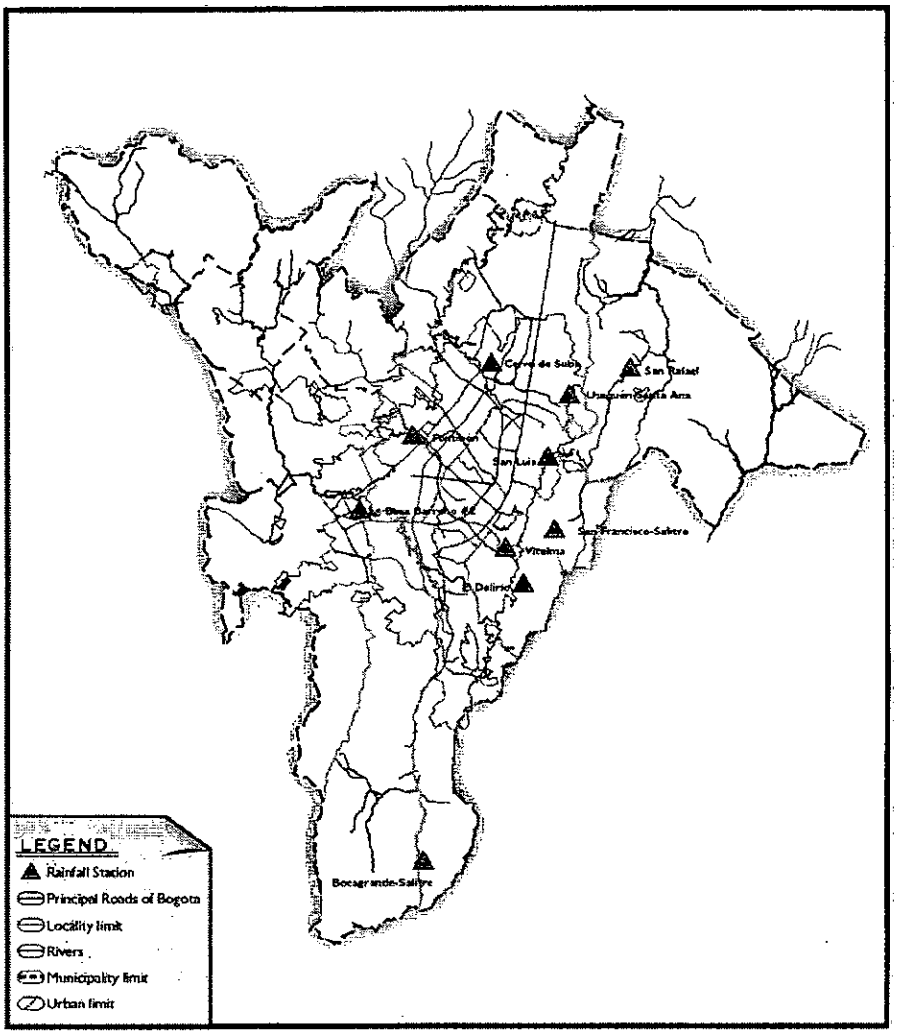


Figure 3.1.4 Location of Rainfall Station Analyzed

Maximum one-day rainfall among the analyzed station is recorded at San Luis and amount is 129.0 mm (Apr. 12, 2000).

According to the comparative study of large amount of rainfall day, it was found that there are few relationships of rainfall amount among these stations. Therefore, it is judged that a heavy rainfall usually restricted in the small area.

Table 3.1.7 Probable One-day Rainfall in the Study Area

Unit: mm

	5-year	10-year	50-year	100-year
Cerro de Suba	49	55	69	75
Fontibón	45	52	68	75
Bosa Barreno No.2	40	46	60	66
Usaquén-Santa Ana	65	75	99	109
San Luis	66	78	103	114
San Francisco-Salitre	67	78	100	110
Vitelma	56	64	82	90
El Delirio	56	63	78	84
Bocagrande-Salitre	49	55	69	75
San Rafael	56	64	82	90

Source: JICA Study Gumbel Method

Table 3.1.8 shows the relationship between duration and rainfall by probability.

Table 3.1.8 Relationship between Duration and Rainfall

Unit: mm

	Suba			Juan Amarillo		
	1 hour	3 hours	6 hours	1 hour	3 hours	6 hours
10-year	45.7	54.1	54.7	29	45	52
50-year	60.2	72.3	73.1	-	-	-
100-year	64.2	76.6	77.3	39	52	67

Source: EAAB, DPAE

Since the table was prepared as a result of combining of different data source, some discrepancies could be found out. Causes of these discrepancies could not be confirmed in this study, because the reports presented only the results of analysis and not presented and/or mentioned the original data and method of process.

The results of analysis show that the one-day rainfall amount is almost same amount of 6-hours rainfall. According to this result, it is supposed that duration of rainfall would be short and usually less than 6-hours.

(2) Run-off analysis

There are several water level gauges along the Rio Bogotá and the discharges of the river have been estimated using "water level - discharge curve." During the study in Colombia, efforts were made to obtain the water level records, but they all proved futile.

Several runoff analyses for the Rio Bogotá have been conducted. The latest study is *Estudios Hidraulicos Geotecnicos y Topograficos para Definir el Nivel de los Jarillones y Obras Requeridas para Mitigar el Riesgo de Inundacion del Rio Bogotá, en el Tramo Alicachin Humedal la Conejera*, which was conducted by EAAB. The runoff simulations in this study were

carried out by using the same model as the one used in the previous study in 1985, with the following conditions:

Table 3.1.9 Summary of Conditions for Run-off Discharge Analysis (EAAB Study)

Item	Conditions
Rainfall Pattern	TORCA FUSAL
River Section	Conejera – Juan Amarillo Juan Amarillo – Fucha Fucha – Tunjuelo Tunjuelo – Arlcachin
Return Period	5-year 10-year 25-year 50-year 100-year
Rio Fucha Retention Pond	With retention pond Without retention pond

Source: EAAB Study

The simulation results of the EAAB study are shown in Table 3.1.10.

Table 3.1.10 Simulated Run-off Discharge of Rio Bogotá (EAAB Study)

	TORCA				FUSAL with Regulation pond				FUSAL without Regulation pond			
Return Period	5	10	50	100	5	10	50	100	5	10	50	100
Conejera – Juan Amarillo	62	70	90	99	43	49	62	67	45	51	64	69
Juan Amarillo – Fucha	83	97	133	148	71	83	114	128	76	91	122	136
Fucha – Tunjuelo	110	123	160	175	121	135	173	189	171	189	227	243
Tunjuelo – Alicachin	140	152	186	201	166	193	259	287	190	220	287	315

Source: EAAB Study

The runoffs of the three tributaries were calculated as a part of the flood risk zoning study conducted by DPAE; however, there was no information on runoff of the tributaries in the western side of the Rio Bogotá because the hydrological study has not been conducted on the western side of the river.

All the studies for the three tributaries have applied HEC for calculation of flood runoff, and it can be judged that the analysis was conducted appropriately by reviewing the study report.

Figure 3.1.5 shows the flood run-off discharge distribution of the Rio Bogotá system in the Study Area. The figure was prepared by combining the several information obtained from the reports

prepared by EAAB and DPAE, because there are no hydrological and discharge analysis which is targeted to the whole river system of the Rio Bogotá.

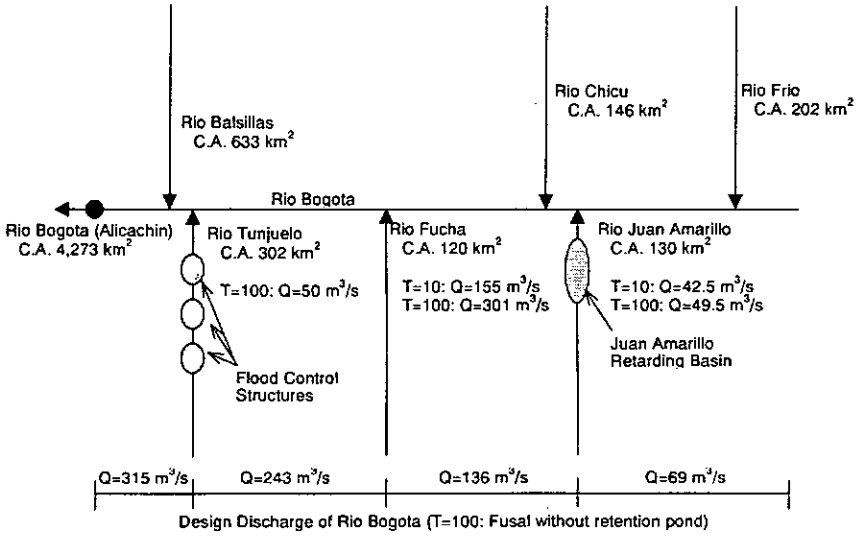


Figure 3.1.5 Flood Run-off Discharge Distribution (Rio Bogotá System)

2) Flood Damage

(1) General

In order to estimate the flood damage, it is necessary to carry out the flood condition survey (depth, duration, frequency, etc) and assets survey (value of house/commercial building, assets value per household/commercial by position from the floor, etc.). However, since these kinds of survey works were not included in this study, it is impossible to estimate the flood damage in the monetary term. Thus, the flood damage of the Study Area will be shown using the number of population/household, the area of inundation by flood frequency. These calculations have been done using the GIS database prepared by this Study.

(2) Areas affected by inundation

Affected areas by risk zone are shown in the Table 3.1.11. Total inundation area of 6,760 ha represents 18 % of urban area of Bogotá City of 37,964 ha, which is based on JICA Study Team's database.

Table 3.1.11 Areas Affected by Inundation (Bogotá City)

	Inundated Area (ha)
High Risk Zone	2,300
Medium Risk Zone	3,500
Low Risk Zone	960
Total	**6,760**

Source: JICA Study

Affected areas of inundation by municipalities in Cundinamarca are shown in Table 3.1.12. The areas calculated using the inundation map provided by the municipalities. Since the maps have no classification of risk zone, only total affected area could be calculated.

Table 3.1.12 Areas Affected by Inundation (Municipalities in Cundinamarca)

Name of the Municipalities	Inundated Area (ha)	Ratio of Affected Area (%)
Chia	520	6.5
Cota	920	17.2
Facatativa	210	1.3
Funza*1	80	1.1
La Calera	1,320	4.2
Madrid	-	-
Mosquera*1	20	0.2
Soacha	980 *2	5.3

Source: JICA Study

*1: Municipalities that do not have their own POT data for Flooding. Data obtained from flood risk of neighboring Municipality

*2: Figures for Soacha City includes the affected area of dam failure of terreros dam.

(3) Population and households affected by inundation

Affected population and households by risk zone are summarized in the table below.

Table 3.1.13 Affected Households and Population by Inundation (Bogotá City)

	Affected Household	Affected Population
High Risk Zone	16,200	84,400
Medium Risk Zone	46,900	284,100
Low Risk Zone	20,800	128,300
Total	**83,900**	**496,800**

Source: JICA Study

Affected numbers of populations and households by inundation by City in Cundinamarca are shown in Table 3.1.14.

Table 3.1.14 Affected Households and Population by Inundation (Municipalities in Cundinamarca)

Name of the City	Affected Household	Affected Population	Ratio of Affected Population
Chia	860	3,140	4.8
Cota	410	1,610	10.7
Facatativa	2,450	16,520	18.3
Funza	10	40	0.1
La Calera	120	440	1.9
Madrid	-	-	-
Mosquela	5	20	0.0
Soacha	12,160 *	96,660 *	17.6

Source: JICA Study

*: Figures for Soacha Municipality includes the affected area of dam failure of terreros dam.

3) Existing Flood Risk Map

(1) Bogotá City

A. Existing flood risk map

The existing flood risk map was prepared by DPAE in 2000 based on the Flood Risk Zoning Studies, which were conducted from 1999 to 2000 for all possible inundation areas of Bogotá City.

The studies have included risk analysis, which has been carried out based on the analysis of hazard, vulnerability and prevention. However, the prepared flood risks map for the POT Bogotá only shows the flood hazard areas by the probable floods of 100-year and 10-year return periods under the current land use and river conditions.

According to the flood risk map, the areas along the Rio Bogotá, the Rio Tunjuelo and the Rio Juan Amarillo are identified as the flood risk areas.

B. Evaluation of existing flood risk map

Based on the results of review of flood risk zoning studies and the topography, and the observations of field investigation, it is possible that the map shows the flood hazard areas.

(2) Other municipalities

A. Existing flood risk map

Some municipalities have included flood (or inundation) hazard maps in their POT, which are prepared based on the flood records in the past; however, no hydrological/hydraulic conditions

have been studied based on them. The possible flood areas in the past would be assessed from hydrological and hydraulic aspects.

B. Evaluation of existing flood risk map

The existing flood risk maps have been prepared based on the past flood records, but no hydrological/hydraulic assessment has been conducted. Accordingly, the existing flood risk maps only show the past flood (or inundation) areas; an assessment would be necessary in future.

3.1.4 Industrial Facilities

1) Bogotá city

- The directed management towards the prevention and control of the technological risk is not known in the micro and small companies, including the concepts of basic risk prevention activities that have to be sponsored by the professional risks administrators–the ARP.
- The micro and small companies have difficulties in responding to the environmental management and the industrial safety-related subjects, because they do not have the appropriate personnel and knowledge.
- There exists a conceptual and technical disregard referent to the technological risk prevention as well as the seismic threat. Many companies do not have an adequate methodology of danger identification and risk evaluation, that would facilitate the prioritising of the prevention and control measures, and would allow to estimate the possible consequences in case of a dangerous accident. This situation implies that the internal as well as external respond-to-emergency entities are ineffective in the control of such accidents despite the generalized schemes outlined in the current respond-to-emergencies plans.
- The preparation and response to emergency plans do not include preventive strategies and the environmental impact minimization, during and after a serious accident.
- Other faulty aspects as to its administration are the ones related to the information and managing of the preventive operations as well as the chemical substances in the companies, because the minority got acceptable score in these aspects, generally coinciding with bigger international companies. However, even these international companies do not have enough countermeasures to the seismic threats.

2) Eight Municipalities

In order to find out the vulnerability of the eight municipalities, the gathered information was analyzed in terms of preparedness level to handle an emergency, preparedness for earthquake and community risk.

(1) Preparedness level to handle an emergency

The preparedness level of municipalities to handle an emergency is shown in Table 3.1.15 and a brief description follows.

Table 3.1.15 Preparedness Level to Handle an Emergency in Eight Municipalities

Municipality	Good (%)	Regular (%)	Poor (%)
Chía	0	13	87
Cota	3	31	66
Facativá	4	41	55
Funza	0	26	74
La Calera	0	14	86
Madrid	4	38	58
Mosquera	7	60	33
Soacha	7	18	75

Source: Study on the Prevention of Industrial Disasters in the Bogotá Metropolitan Area (2001) by CCS "

- Chía: In general, most enterprises were equipped for fire-fighting but lack equipment and plans to control leaks and spills, and 100% were "deficient" or "poor" for level of preparedness for emergencies, "poor" being the larger group.
- Cota: In general, the companies have resources to handle fires but they lack appropriate elements and plans to control spills or leaks. Their emergency preparedness level falls under deficient or poor at 97% with the former being more predominant 66%.
- Facatativa: In general, companies have resources to attend to fires, but lack appropriate elements and plans to control spills or leaks, and the preparation level for emergencies is in 96% of the cases between deficient and bad.
- Funza: In general, the enterprises have fire-fighting equipment, but they lack equipment and plans to deal properly with spills or leaks and the level of preparedness for emergencies is 100% deficient or poor, with "poor" having the greater edge 64%.
- La Calera: In general, the companies have resources to handle fires but lack the appropriate elements and plans to control spills or fires and the emergency preparedness level is 100% between deficient and poor, with the latter having the greater share.
- Madrid: In general, the companies have resources to handle fires but have inappropriate elements and plans to control spills or leaks, and 96% of the evaluated sample has an emergency preparedness level between deficient and poor, with the latter prevailing 58%. Four percent has a satisfactory level in this aspect.
- Soacha: The events of greatest importance are fire followed by spills. In general, most enterprises are equipped to fight fires, but lack proper plans and equipment for spills or leaks.

(2) Preparedness for earthquake

Preparedness for earthquake is shown in Table 3.1.16.

The results are not so reliable since most of the survey respondents had no knowledge of the subject matter, and no other sources of information were available. However, it is clear that there is no regulation for anti-seismic design for the industrial facilities and even the bigger international companies do not pay attention to the seismic threats.

Table 3.1.16 Preparedness for Earthquake

Municipality	None (%)	Deficient (%)	Acceptable (%)
Chía	74	20	6
Cota	31	48	21
Facatativa	38	48	14
Funza	47	29	24
La Calera	86	14	0
Madrid	51	33	16
Mosquera	27	73	0
Soacha	62	36	2

Source: Study on the Prevention of Industrial Disasters in the Bogotá Metropolitan Area (2001) by CCS

(3) Community risk

Evaluation and cross analysis of variables, type of threat, preparation level for attention of emergencies and distance to the community are made and the results are shown in Table 3.1.17.

Table 3.1.17 Analysis Results to the Community Risk

Municipality	High Risk Company		Medium Risk Company	
	Number	(%)	Number	(%)
Chía	1	2	41	89
Cota	0	0	11	38
Facatativa	7	24	15	52
Funza	10	13	48	63
La Calera	1	7	13	93
Madrid	16	36	20	44
Mosquera	3	20	6	40
Soacha	18	15	79	67

Source: Study on the Prevention of Industrial Disasters in the Bogotá Metropolitan Area (2001) by CCS

- Chía: Only one food producer represents a high risk to the community due to the quantities and nature of the substances it handles, the low level of preparedness for emergencies, and its physical closeness to the community.
- Cota: Six companies represent a major threat for the community, due to the quantity and nature of the substances they handle. But, differently from other municipalities, in Cota there were no systems identified as representing high level of risk for the community, basically because the community is far from the industrial establishments.
- Facatativa: Twelve 12 companies represent a major threat for the community due to the quantities and nature of the substances that they work with. However, only 7 of these enterprises have a high-risk level for the community due to their deficient preparation for emergencies and their proximity to the community. This group includes, as mentioned

before, wholesale commerce of LPG and other systems four of the industrial sector, one of the commercial sector of gasoline service station.

- Funza: Twelve companies are a major risk to the community due to the quantities and nature of the substances handled; most then are high community risk, given the lack of preparedness for emergencies and their closeness to the community. This group includes retail LPG and other industrial compressed gas outlets. Thus, the substances which appear most often as a major threat are LPG and acetylene, also related to the fact that leaks and explosion have a higher preponderance than spill in the rating of events.
- La Calera: Just the service station represents a major threat for the community due to the amount of gasoline stored therein. However, there were no serious accidents involving them (even in time of earthquake in Japan), because gasoline is stored in the underground tank. The remaining companies are classified as minor threat and offer a medium level of risk for the community.
- Madrid: Twenty-one companies represent a major threat to the community due to the amount and nature of the substances they handle. 36 percent of them represent a high level of risk for the community due to deficient emergency preparedness and closeness to the community.
- Mosquera: Seven companies represent a major threat for the community due to the amount and nature of the substances they handle, but less than half display a high level of risk for the community since the others are far from the community.
- Soacha: There are 18 enterprises in the Soacha sample which show high community risk, since the volume and character of the substances handled mean that the risk of accidents might be high. According to the replies to the surveys, these enterprises are not prepared or badly prepared to react to possible accidents identified; they do not have any proper system to mitigate earthquake damage, or have none at all. And in an emergency, the community might suffer serious harm since it is close to the premises of those enterprises.

3) Transportation System of Hazardous Materials

There are a lot of emergencies with chemical substances enroute their transportation through different highways connecting cities across the country and going through municipalities as mentioned before. It is important to note the fact that at the moment there are no regulations in Colombia that control the transportation of this kind of materials, causing situations like the ones given below:

- Transportation in vehicles that do not meet safety standard regarding the design of the vehicle nor the transporting unit (container).
- The driver lacks minimum knowledge of the dangers of the chemical product being transported.

- Several chemical substances are transported in one vehicle, ignoring incompatibility among the materials.
- The response mechanisms to emergencies, when they occur, are limited and in most cases, transporters fail to react.
- For some transportation companies, the interest is usually limited to the immediate delivery of the material, ignoring many times the dangerousness of the chemical substances on board.
- Most of the vehicles are not marked with labels as established in the Norm ICONTEC NTC 1692 (based on the International Classification System of the United Nations), which is mandatory. This norm establishes the use of labels that identify the dangerousness of the substance being transported, as Inflammable Liquid, Corrosive, Inflammable Gas, etc.

3.2 Vulnerability Analysis

3.2.1 Physical Vulnerability

1) Buildings

(1) Building regulations for earthquake resistant design and construction

A. Historical review of Colombian seismic regulations

Establishment of Colombian seismic regulation is surveyed by the Study Team and summarized as listed in the following table:

Table 3.2.1 Historical Review of Building Regulation in Colombia

Year	No. of Law or Decree	
		--- Before 1984, No regulation for earthquake resistant design and construction
1983	National Law 11	Announcement of the first law for earthquake resistant design and construction (Due to Popayán earthquake (March 31, 1983))
1984	National Decree 1400	Issue of the first regulation for earthquake resistant design Almost dead copies regulations of the United States' regulations (The related decrees of Law 11, 1983)
1995	City Agreement 20	Introduction of micro-zoning* (Due to enforcement of National Law)
1997	National Law 400	Establishment of own regulations of Colombia (According to recommendation of IAEE**)
1998	National Decree 33	Covering almost all the items in relation to building design and construction (Progress of work by AIS)
1999	National Decree 34	Modification of Decree 33 (Progress of work by AIS)
2000	National Decree 2809	Repair, Reinforcement and Rehabilitations of Buildings (Due to lack of regulations)
2001	City Decree 74	Renewal of micro-zoning identification

* For Bogotá City Only

** IAEE: International Association of Earthquake Engineering

*** AIS: Colombian Earthquake Engineering Association

a) Law 11 of 1983 and decree 1400 of 1984

It is to be noted that the building regulation in the Republic of Colombia was, for the first time, established in 1984 after the Popayán earthquake in 1983.The earthquake occurred in March 31 at 10-kilometer depth in the Southwestern region of Colombia with magnitude 5.5 causing 241 deaths and 1,500 injured in the city of Popayán and surrounding local towns. Until that time, all the buildings in the Republic of Colombia were designed and constructed without any legal constraint with respect to seismic resistant capability, even if the building was too high to properly resist an earthquake force. Only experienced structural engineers used the United States' building code (UBC: Uniform Building Code) as a general guide for design and construction code and

SEAOC code (SEAOC: Structural Engineers Association of California) as a guide for an earthquake resistant design code.

In the end of 1983, Law for Earthquake Resistant Construction (Ley 11 de 1983) was announced and the related Decree was issued (*Decreto 1400 de 1984:Codigo Colombiano de Construcciones Sismo-Resistentes*).After 1984, related building regulations such as construction enforcement law were issued accordingly.

b) NSR 98

As the aforementioned regulations were are almost dead copies regulations of the United States' regulations, and as the International Association of Earthquake Engineers (IAEE) strongly recommended the member countries to establish their own regulations, the members of the Colombian Earthquake Engineers Association (AIS) headed by Professor Sarria info the Los Andes University had made an effort to revise and update the regulation since around 1993.Then, in 1997, the national law for the earthquake resistant design and construction for the buildings was issued, which was followed by several decrees issued in 1998, 1999 and 2000, respectively. The latest decree states the Repair, Reinforcement and Rehabilitation of buildings. These sequential law and decrees have been compiled into two volumes of publication as NSR-98 (*Normas Colombianas de Diseno y Construccion Sismo Resistente*: Colombian Regulations for Earthquake Resistant Design and Construction) by the Colombian Earthquake Engineering Association (AIS). NSR-978 is composed of Ley (Law) 400 de 1997, and these were followed by Decreto (Decree) 33 de 1998, Decreto 34 de 1999 and Decreto 2809 de 2000, respectively.

Among these law and decrees, Decreto 33 is the most important and covers almost all the items in relation to building design and construction, which is composed of the found in the following chapters: as;

- General requisitions for earthquake resistant design and construction (124).
- Loadings (42).
- Concrete structure (228).
- Masonry structure (68).
- Housing with 1-2 story (18).
- Metallic structure (380).
- Wooden building (60).
- Geo-technical studies (56).
- Technical supervision (14).
- Requisitions for fire protection of building (12).
- Complementary requisitions such as wind load (34).

* Number in ( ) is page amount.

c) Microzoning study

Under the framework of these national laws and decrees, it is recommended that the big cities with more than 100,000 populations in Colombia are recommended to issue their own decree for the design and construction practices based on the microzoning studies. Therefore, the city of Bogotá issued several decrees under the name of the mayor.

For instance, in 1995, Construction code for the city of Bogotá was issued as Agreement of 1995 (Acuerdo 20 de 1995). The latest mayor's decree was issued on January 30, 2001 as Decree of 74 (Decreto 074) by which the Construction code for the city of Bogotá was partly modified and seismic microzoning was newly identified. Referring to the decree, the city of Bogotá is divided into 10 micro zones, i.e., 1A, 1B, 2A, 2B, 2C, 3A, 3B, 4, 5A and 5B.Design spectrum is also identified in the decree for the application to Bogotá City.

B. Status of present regulations

Status of Colombian building regulation and its organization are illustrated as shown in the following Figure 3.2.1.

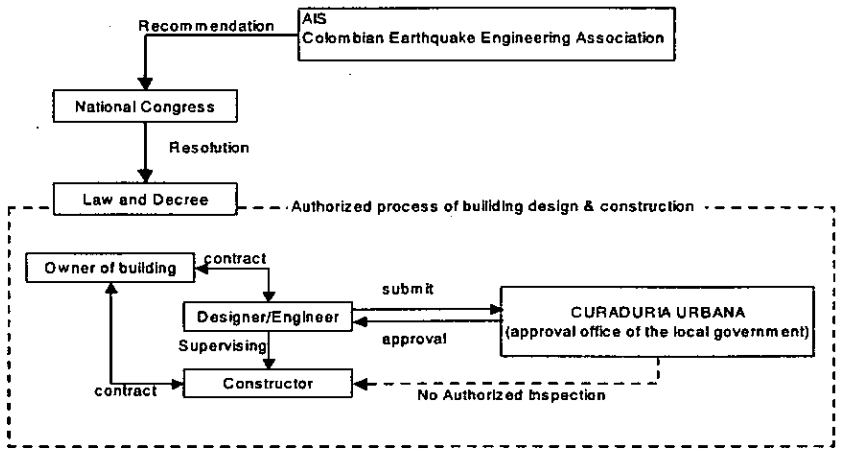


Figure 3.2.1 Status of Building Regulation and Organization

It is found throughout the brief review of the aforementioned laws and decrees by the Study Team, that the regulatory guides for the earthquake resistant design and construction in Colombia and in the city of Bogotá is, to some extent, satisfactorily prepared. The items and contents of the regulation cover almost all the factors that are now taken into consideration in the USA as well as in Japan. For example, the concept of Soil-Structure Interaction is formulated in the decree, which necessitates highly sophisticated knowledge and experiences of the designers/engineers.

C. Discussions of on building regulations

a) Masonry structure

The description for the masonry structure should be increased and reconsidered with much more careful attentions. For example, the minimum thickness of masonry wall (approx.100mm), defined in the decree, should be reconsidered, because, with the thickness of 100 mm of brick, seismic resistance of masonry structures is not guaranteed due to the rather rigid stiffness and consequent bigger earthquake forces. In Japan, non-reinforced masonry is prohibited and minimum thickness of masonry wall is 15 cm for a one- story housing unit.

b) Inspection process

Regarding the inspection during and after the construction work, moreover, it is said that there is no legislated and/or authorized process. Although before the construction of the building, the designers/engineers in Colombia have to submit all the building documents to the CURADURIA URBANA (approval office of the local government) in order to get the construction approval, the consequent inspection by authorized institutions during and after construction is not mandatory. In the USA as well as in Japan, the inspection of the construction site by the authorized institution is mandatory in order to guarantee the quality of the building constructed. Therefore, establishment of the inspection process as well as the full enforcement of the decree should be of the most urgent matter.

c) Provision for informal building

It is also regrettable that the unskilled laborers, who lack the sense of law abiding, have been constructing many informal buildings during long periods even after 1984.It is attributed to shortage of systematic process to stop to build informal buildings this practice because of the lack of related regulations and enforcement of law and so forth. The informal buildings are mostly lack the resistance to the earthquake forces and cause the tremendous damages to the residents as well as the properties when earthquakes attack.

d) Provision for retrofitting

Seismic retrofitting is also of the other urgent matter. From the practical viewpoint, the regulation above gives, although necessary items for the retrofitting design are described in the regulations mentioned above, no practical methods to be applied to the retrofitting works for the existing building are given. As Japanese building engineers, based on accumulated earthquake experiences and consequent researches and developments, have sufficient technologies and knowledge on this matter, it is possible to transfer these necessary techniques as well as preferable materials to the Republic of Colombia.

(2) Vulnerability of existing important/essential buildings

A. Diagnostic investigation of existing important/essential buildings by the study team

a) Objectives of diagnostic investigation

The Study Team investigated several existing important/essential buildings in the City of Bogotá and in the eight municipalities with its counterpart, of DPAE. The objectives of the investigation are 1) to check the present condition of the existing important/essential public buildings and 2) to clarify the seismic performance of the buildings, because these buildings are supposed to play important roles at the time of earthquake.

b) Method of investigation

Perfect diagnosis on the seismic performance of existing buildings can be done by the combination of many experimental and computational findings and by the professional experiences and judgments as shown in the following Figure 3.2.2.

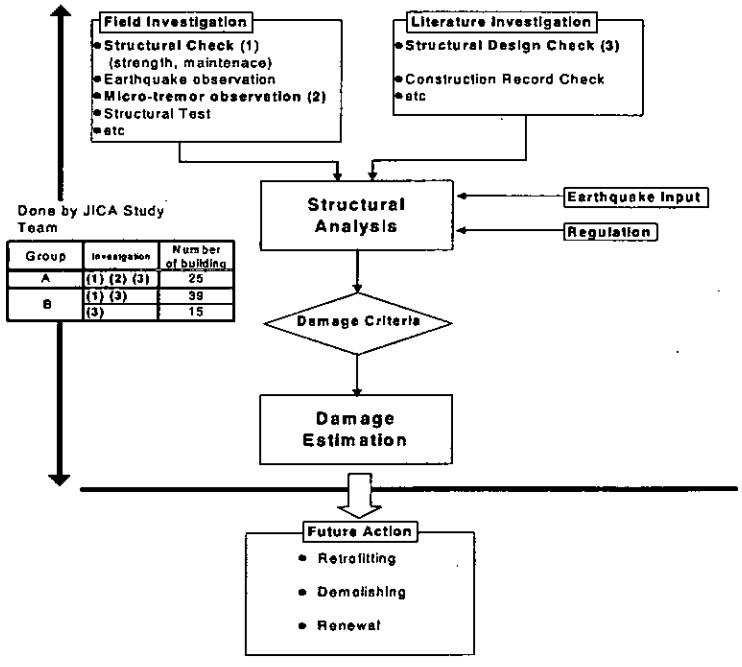


Figure 3.2.2 Flow Chart of Diagnosis of Existing Buildings and Scope of the StudyTeam

During the present phase of this study, site investigation with micro-tremor and structural design check were implemented by two groups (Group A and Group B) as shown in the figure. Group A visited 25 buildings while Group B visited and studied 54 in total. (Refer to Technical Report).

c) Micro-tremor measurement

The objective of micro-tremor measurement is to obtain the predominant period of the building. Predominant period is closely related to the vibration of the building not only in normal time but

also in the event of an earthquake. The predominant period is determined by peak period of the power spectrum obtained and processed after micro-tremor measurement.

B. Results of diagnostic investigation of existing buildings

Diagnostic investigation was implemented from mid May to the beginning of June 2001.The results of the investigation on a total of 79 buildings are summarized in the following Table 3.2.2.

Table 3.2.2 Summary of Diagnostic Investigation by JICA Team

	Type	Location		Diagnosis				Sum
		Bogotá	Cundinamarca	Minor damage	Middle damage	Severe damage	Unknown	
Group A (Micro-tremor)	Housing	1				1		1
	Transport	1		1				1
	Government	7	3	2	2	6		10
	Medical	4	1		1	4		5
	Police	2			1	1		2
	School	4	2	1	1	3	1	6
	Sub-total	**19**	**6**	**4**	**5**	**15**	**1**	**25**
Group B	Church		2			2		2
	Commercial	2		1		1		2
	Transport	9				9		9
	Government	14	4	3	7	8		18
	Medical	8	1	1		8		9
	Police	5			1	4		5
	School	3	5	1	1	6		8
	Military	1			1			1
	Sub-total	**42**	**12**	**6**	**10**	**38**	**0**	**54**
TOTAL	Housing	1				1		1
	Church		2			2		2
	Commercial	2		1		1		2
	Transport	10		1		9		10
	Medical	21	7	5	9	14		28
	Government	12	2	1	1	12		14
	Police	7			2	5		7
	School	7	7	2	2	9	1	14
	Military	1			1			1
	Total	**61**	**18**	**10**	**15**	**53**	**1**	**79**

Source: JICA Study Team

C. Evaluations and findings of the results of investigation

From these investigations, several findings with respect to the vulnerability of existing buildings were obtained. Almost all the buildings visited and studied in this report were designed and constructed before 1984.Therefore, it was found that structures of these building did not have sufficient resistance or ductility against horizontal forces, which would cause serious damages when a moderate earthquake with a Peak Ground Acceleration (PGA) larger than 0.1g hit the building in future. Other findings are described as below:

- Masonry structure is in general categorized into three structures. One is non-reinforced masonry where masonry materials such as adobe, stone and brick are piled up with mortar and/or mud but without any reinforcing steel bars. The others are confined frame masonry where reinforced concrete frame composed of columns and/or beams are used together with masonry wall material, and reinforced wall masonry where masonry bricks are connected to each other by reinforcing steel bars. Because of high price of reinforcing steel bars and difficulty of getting these reinforcing bars at the time of construction, it seems that many of the old masonry buildings are of non-reinforced masonry structures and very vulnerable to even the small horizontal forces induced by earthquakes with a PGA less than 0.1g.
- Many buildings made of concrete structures are, as far as in this study scope, composed of relatively small sized columns in comparison with Japanese practice. Size of reinforcing steel bars are also very small in comparison with Japanese practice. For instance, one building has columns with only 0.3 x 0.3 square meter cross section area for a 7- meters span length. Concrete strength seems also seems very low because of the deterioration as well as due to the lack of quality assurance at the time of construction.
- Most of the concrete structures do not have beam but have waffle or joist slab. Slab thickness is between 15 centimeters and 40 centimeters, which cause the loss of structural integrity when subjected to horizontal forces. Because rigid connection of columns by using reinforcing steel bars to horizontal elements such as slab and joist is generally very difficult due to the small size of columns. As a result, the punching shear failure at slab portion is expected at the time of an earthquake.
- Moreover, it seems common that brick or concrete is used for the interior partition wall and/or façade wall as non- structural elements, which cause the heavy fixed weight of the building. Even more, as these non-structural elements are attached to structural columns, the bending capability of columns would be lost resulting in the shear failure of columns at the time of an earthquake. Lack of the transverse reinforcing steel bars would accelerate the shear failure and collapse of columns.
- Measured vibration periods of 25 buildings are shown in the Figure 3.2.3 below.

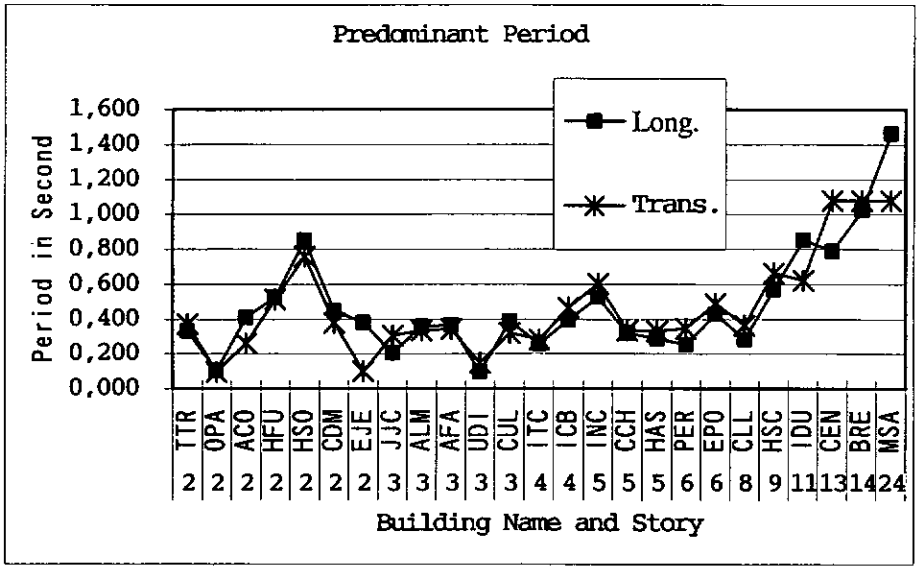


Figure 3.2.3 Predominant Period

From this figure, it is pointed out that 1) There are no general tendencies of the predominant periods of low-rise buildings, lower than 10 stories and that 2) However, predominant periods of high-rise buildings, higher than 10 stories, are proportional to the number of story.

- The aforementioned measured periods of low-rise buildings are largely attributed to the local soil conditions while those of high-rise buildings are due to their own structural characteristics. Because the soil's vibration characteristics are not filtered by the low-rise structures due to the short length of the structural height.
- Except for very few buildings, almost all buildings described in this report need, to some extent, retrofitting works considering the importance of the functions, seriousness of future damage due to the scales and number of users of each building. Retrofitting must be done urgently not only for structural elements but also for non-structural elements as well as mechanical equipments.
- The biggest problem in relation to construction quality is non-engineered structure mainly witnessed in the lower classed district Estrato bajo which makes the structural categorization difficult.

(3) Existing building's vulnerabilities

A. Building damages in Quindío earthquake

In the Quindío earthquake on January 25, 1999, the report by Los Andes University on building damages stated that " It was proven how dangerous it is for a city to count on an inventory of fragile buildings made of brick un-reinforced masonry and on of reinforced concrete structures with in adequate dimensions and steel reinforcement, that do not comply with the minimum

earthquake resistant standards" and that " the benefits of designing and constructing structures using earthquake resistant standards, in accordance with the current art and knowledge, were proven, signifying not only the protection of life, but also of the citizen's patrimony."

Moreover, the University of Quindío and INGEOMINAS also published the damage report where the relation between building damages and earthquake intensity is represented as shown in Figure 3.2.4.

By using these relations, the building vulnerability in the city of Armenia at the time of Quindío earthquake is obtained in the form of damage function or fragility curve by the Study Team as shown in the following Figure 3.2.5.

VULNERABILITY	A			B			C			D			E			F		
DESCRIPTION	Constructions in diverse materials without mortar			Constructions in diverse materials with mortar			Structures in reinforced concrete without SRD			Constructions with reinforced concrete and several levels of seismic resistant designs								
KIND OF CONSTRUCTION	Adobe, bahareque, tapia pisada and others			Non reinforced masonry, blocks of stone			Reinforced masonry, with concrete plates			Confined masonry, RD with a minimum level of SRD, metallic structures and wooden constructions			Reinforced concrete (RC) with moderate level of SRD			Reinforced concrete (RC) with a high level of seismic resistant design		
PERCENTAGE (%) DAMAGE	0-10	10-50	50-100	0-10	10-50	50-100	0-10	10-50	50-100	0-10	10-50	50-100	0-10	10-50	50-100	0-10	10-50	50-100
1. LIGHT. Small on few walls. Fall of stucco. Fissures at the adage between the structure and dividing wells	V	VI	VI	VI														
2. MODERATE. Small fissures con many walls. Fissures on columns and girders. Fall of stucco.	VI	VI	VI	VI	VII	VII	VII	VIII	VIII	VIII				X	X	X	XI	
3. SERIUS. Wilde and widespread fissures on many walls. Fall of tiles. Detachment of concrete places. Fissures on girders	VI	VII	VII	VII	VIII	VIII	VIII	IX	IX	IX	X	X	X	XI	XI	XI		
4. SEVERE. Serious damages on walls. Partial damage of the structure. Damages on columns nodes. Deviation on columns. The reinforce is exposed.	VII	VIII	VIII	VIII	IX	IX	IX	X	XI	X	XI	XI	XI					
5. DESTRUCTION. Almost total collapse of the structure.	VII		X		X	XI	X	XI	XI	XI								

RD: Reinforced Concrete
SRD: Seismic Resistant Design
EXPLANATORY NOTE: Each intensity and its representative colors results from the combination of the damage percentage and the neighborhood vulnerability

Figure 3.2.4 Relation between Building Damage & Earthquake Ground Intensity in Armenia City

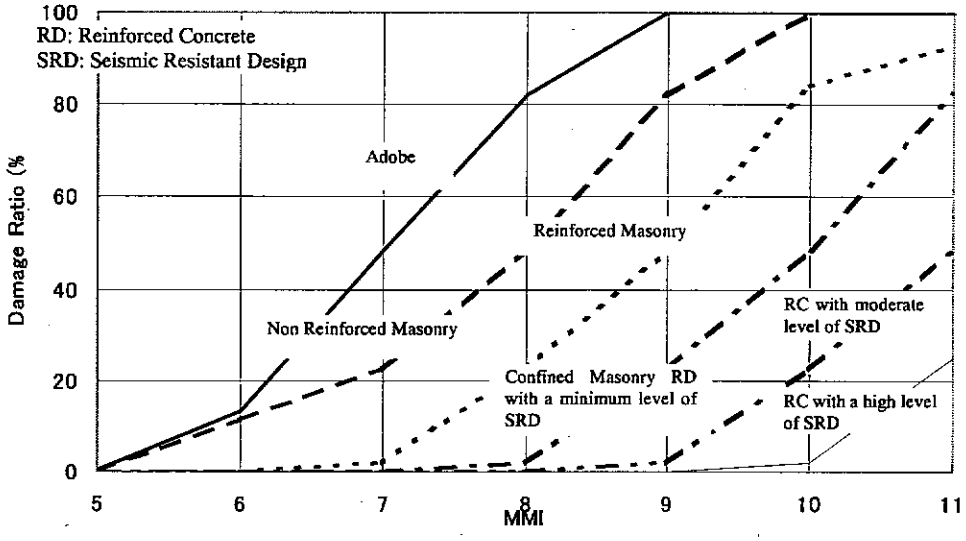


Figure 3.2.5 Damage Functions of Building Types in the 1999 Quindio Earthquake

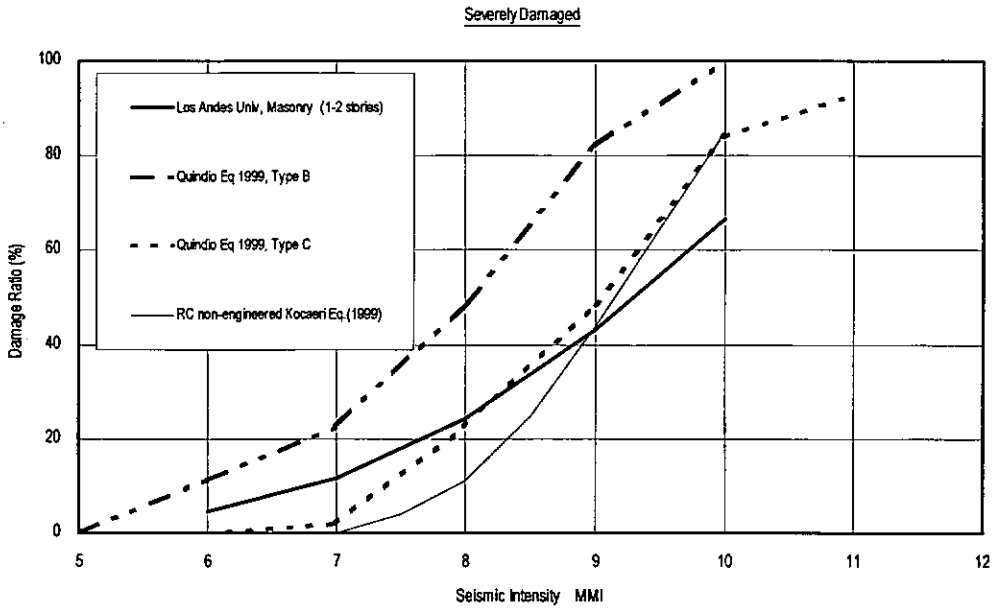
B. Comparison of damage functions

As described before, INGEOMINAS and the Los Andes University conducted the Microzoning Study from 1993 to 1997. In their study for of damage estimation of the buildings, the damage function was assumed and adopted in accordance with the definition by the Applied Technology Council (ATC) and the buildings' vulnerability was categorized into 7 types mainly for residential units. Their damage function for the masonry structure is compared with those obtained from the Quindío Earthquake and also. The damage function obtained at from the Turkey Earthquake [3-2-1] . They are shown in Figure 3.2.6.

In this figure, the earthquake intensity is expressed by Modified Mercalli Intensity (MMI) scale. If the earthquake intensity is expressed by Peak Ground Acceleration (PGA) instead of MMI, the relation between MMI and PGA described below is mostly used where G is gravity acceleration (9.8 meter/square second):

Log (PGA) = 0.3 MMI + 0.04

[3-2-1] (Kocaeri, August 17,1999).



(A: Adobe, B: Non Reinforced Masonry, C: Reinforced Masonry Others: Concrete)

Figure 3.2.6 Comparison of Damage Functions for Masonry Structures

2) Infrastructure

Information on vulnerability of infrastructures is very important for the preparation of a disaster prevention and mitigation plan. In this section, vulnerability analysis of infrastructures is described.

(1) Road facility

Following problems and issues have been identified from the point of view of physical vulnerability about the road facility.

A. Incomplete principal road network

a) Bogotá city

The principal road network in Bogotá City is generally formed by ring and radial road network pattern. There are, however, some missing links out of area bounded by the ring road of Avenida Boyacá Rd. The area of missing links are as follows: Suba, Engativá, Fontibón and Bosa. The gateways and principal roads are important element for preparation of disaster prevention with regard to securing evacuation route, and transportation of emergency supplies material. The principal road should be connected in accordance with the road classification or road hierarchy, and should be formed with the complete links, taking into account the transport operations and traffic safety. The missing links implies that it is necessary to improve such weakness by construction of new principal roads. Table 3.2.3 shows the incomplete principal road network.

Table 3.2.3 Missing Links of Principal Road by Area

District	Missing Links of Principal Road		
	Name of Rd.	Section of Ring Rd.	Section of Radial Rd.
Suba	Av. Boyaca	1. Av. San Jose-Boundary of BGT	-
	Av. Ciudad de Cali	2. Av. San Jose-Boundary of BGT 3. Autopista Medellin-Av. La Conejer	-
	Av. Longitudinal de Occidente	4. Autopista Medellin-Boundary of BGT	-
	Av. Elpolo	-	5. Av. Boyaca-Boundary of BGT
	Av. Guaymaral	-	6. Av. Longitudinal de Occidentente-Boundary of BGT
	Transversal de Suba	-	7. Av. Longitudinal de Occidentente-Boundary of BGT
Engativa & Fontibon	Av. Longitudinal de Occidente	8. Av. Jose Celestino Mutis-Av. Centenario	-
Bosa	Av. Longitudinal de Occidente	9. Av. Centenario-Boundary of BGT	-
	Av. Ciudad de Cali	10. Av. Diagonal 43 Sur-Boundary of BGT	-
	Av. Ciudad de Vellavicencio	11. Av. Primero de Mayo-Autopista del Sur	-
	Av. de las Americas	-	12. Av. Ciudad de Cali-Boundary of BGT
	Av. Primero de Mayo	-	13. Av. Ciudad de Cali-Boundary of BGT

b) Eight municipalities

The road networks of the urban areas in the eight municipalities in Cundinamarca are complex and immaturity. Besides, the maintenance of existing roads is very poor, especially for pavement and drainage facilities. In summary, the physical vulnerability of road network in the eight municipalities is shown in Table 3.2.4.

Table 3.2.4 Physical Vulnerability of Road Networks in the Eight Municipalities

Physical Vulnerability	Eight municipalities							
	La Calera	Chia	Cota	Funza	Facatativa	Madrid	Mosquera	Soacha
1. Road network is poor.	0							
2. Road network is immaturity.							0	
3. Road network is complex.								0
4. Role of principal road is unclear.		0	0			0		
5. Major gateway is insufficient in number.	0		0	0	0			
6. Major principal road is insufficient in number.			0	0			0	0
7. Major distributor as ring road is not formed.	0		0		0		0	

B. Insufficient capacity of major principal road

a) Bogotá city

The principal road network in Bogotá City is comprised of comprises V-0 class of 12 lanes, V-1 class of 10-6 lanes, V-2 class of 6 lanes and V-3 class of 6-4 lanes. The most of principal roads have more than 6- lanes road. There is, however, there are 4-lane road of major roads as well. The principal road network should be formed by 6-lane roads indicating a design capacity of about 6,000 PCU for dual both ways. Besides, the capacity of six 6 gateways from the other cities municipalities should be promoted an increased of the capacity to more than 6—lanes road. Following gateway and principal roads are insufficient in number of lanes.

Table 3.2.5 Insufficient Capacity in Bogotá's Principal Road

Type of Roads	Name of Roads
Gateway:	La Calera Rd. (Los Patios-La Calera-Briceño Rd.)
	Avenida Villavicencio Rd.
Principal Road:	Avenida Suba Rd
	Avenida Cota Rd
	Avenida 68 Rd.
	Avenida Luis Carlos Galan
	Avenida 13 Rd.
	Avenida 11, 15, 19 Rd.

b) Eight municipalities

The number of lanes of principal roads in the eight municipalities ranges between 2-lane and 4-lane, dual both ways. These principal roads in the urban area of each city municipality are generally insufficient in number, especially the number of principal roads in the municipalities of Cota, Funza, Mosquera and Soacha.

C. Insufficient alternatives of major gateway

a) Bogotá city

In order to secure the evacuation route of emergency material supplies for Bogotá City, an alternative route of the major gateway is important. There are six major gateways entering Bogotá City. There are two gateways from Northern Colombia. However, the capacity of La Calera Rd is insufficient as an alternative route for Autopista del Norte Rd. Meanwhile, the gateways from Western Colombia are three routes, namely, Autopista Medellín Rd, Avenida Centenario Rd and Autopista Sur Rd. The alternative route of the gateway from Southern Colombia is difficult to find. As the result, the gateways, which have not any alternatives are listed as follows:

Table 3.2.6 Insufficient Alternative in Bogotá's Principal Roads

Gateway from Northern Colombia:	Autopista Norte Rd.-Tunja/Cucuta/Venezuela
Gateway from Western Colombia:	Autopista Sur Rd.-Armenia/Cali
Gateway from Southern Colombia:	Avenida Villavicencio Rd.-Villavicencio

b) Eight municipalities

The inter-city municipal roads among cities are major gateways for entering each municipality. The following inter-city roads are seen with insufficient alternative route. It is necessary to reduce such weakness by protecting the physical vulnerability of road facility.

- Inter-city municipal road of Avenida Centenario Rd. between Facatativá and Mosquera.
- Inter-city municipal road between Mosquera and Chía.

D. Lack of contingency plan for road facility

The contingency plan for the road facilities in Bogotá City was not prepared by the IDU. With regard to the prefecture road and the municipal roads, the plan is not considered by the Cundinamarca and each municipality. It is, therefore, highly recommended that the contingency plan should be planed as soon as possible.

(2) Bridge facility

Following problems and issues have been identified from the point of view of physical vulnerability about the bridge facility.

A. Design code for bridges

a) Vehicular bridges

Before 1971 the seismic effects were not considered important in the calculation and design of structures. It was likely to take horizontal forces depending on each designer's choice with reference the general parameters given by AASHTO.

It was thought that the horizontal forces should be function of the displacement of the structural elements, and the horizontal force was determined based on an established displacement. The estimation of horizontal force was settled down without certain seismic coefficients depended on geotechnical condition of the construction site.

Table 3.2.7 Chronological Evaluation of the Codes used for the Seismic Design of Bridges

Period	Code	General Considerations	Liquefaction
Before 1971	AASHTO	Coefficients that depended on the type of soil were applied as a percentage of the dead load to obtain the horizontal force.	Liquefaction was not considered in code.
1972 to 1977	AASHTO	It was supposed a relative horizontal displacement of "1" on infrastructure elements such as piles and the forces that produces. It was calculated in this way. This force was considered as the force caused by the seismic movement.	Liquefaction was not considered in code.
1977 to 1995	AASHTO	At this time AASHTO already considered two methods for seismic assessment; the first one was the static equivalent force, second method was the dynamic spectral response, specially for complex structures.	Liquefaction was considered in code. The liquefaction potential area was not identifed by officially.
1995 to at the day (2001)	Colombian Seismic Design Code for Bridges (CCP94) and Seismic microzoning of Bogotá 97.	Different methods of Seismic assessment are considered depending on the structural layout of the bridge, its importance and specially on its location within the hazard seismic zones. At the beginning of this period, the seismic movements were considered according to the Colombian Code for bridges. But since May of 2000, IDU demands that the bridges located in Bogotá should be designed and checked using the Seismic Microzoning study for the city. On last March (2001), by law, it is obligatory to use of the microzoning study. The results of the study should be applied to all kind of structures to build or repair in Bogotá.	Liquefaction is considered in the design code. The liquefaction potential area was identified in microzoning in Bogotá 97.

AASHTO propose methods of evaluation of the earthquake forces based on the experience earthquakes happened in the United States. These methods and recommendations began to be applied in Colombia in 1977 until the establishment of the Seismic Colombian code of bridges in 1995.

The methods proposed by AASHTO for this time were the equivalent static force for structures with elements of similar rigidities and that of the dynamic spectral response for complex and irregular structures. The latter method takes some importance with the creation of computer programs in the structure where dynamic spectral response was already contemplated.

Starting from the year 1995, with the appearance of the Seismic Colombian code of Bridges, the necessity of the seismic study in the bridges is bigger concern and it began to classify the structures according to its importance and to the coefficient of acceleration of the site. A certain category of seismic behavior is introduced to define the seismic procedure to use. They are the following ones: simplified seismic analysis, spectral method in the fundamental mode, spectral method with several vibration modes, method of the response against the time with acceleration families.

With the study of the seismic microzoning in Bogotá, it was settled down different spectra of acceleration area by area in Bogotá City. At the present time in all the structures that are designed or repaired in Bogotá, the microzoning should be considered.

b) Pedestrian bridges

There is not specific code for pedestrian bridge design in Colombia. Therefore, the design code of vehicular bridges is adopted with recommendations for pedestrian bridges of AASHTO.

B. Investigations of bridges

Information on bridge investigation is collected by the Study Team. Table.3.2.8 shows number of investigated bridges in the Study Area.

Table 3.2.8 Number of Investigated Bridges in the Study Area

	Bogotá		Eight municipalities	
	Vehicular	Pedestrian (Flyover)	Vehicular	Pedestrian
Organization	IDU		INVIAS	Municipalities and concession
Total number of bridges	177	146	36	19
Visuale inspection bridge	122	134	17	0
Were re-calculated bridge	44	58	0	0
Replaced or reinforcement bridge	42	58	0	0
Replaced or reinforced bridge	16	33	0	0

Source: JICA Study Team, 2001

a) Vehicular bridges in Bogotá

70 of vehicular flyover bridges and 52 vehicular river bridges were investigated by IDU in 1998. This investigation consisted of two steps. The first one was visual inspection, which screened bridges, which should be re-calculated. The second one was re-calculation. The bridges, have any problems, are listed in reinforcement list or replacement list.

Comments on this investigation are as follow.

- The investigation did not cover all vehicular bridges. 70% of total bridges were inspected by visual inspection and 25% of that are recalculated.
- The visual inspection did not concern seismic matter.
- The re-calculations were appropriate since it followed latest design code and using the design acceleration of micro-zoning study 97.

Re-calculation of the structure of vehicular bridges takes long time and is far difficult than that of pedestrian bridges. Re-calculation, however, is important in order to clarify the portion where modification is necessary or to clarify whether reconstruction or replacement of bridge is required or not.

b) Recommendation

- Seismic diagnosis is recommended to make re-calculation priority.
- Establishment of simple visual seismic diagnosis is recommended. It is useful to modify a Japanese seismic diagnosis scheme.

c) Pedestrian bridges in Bogotá

All pedestrian bridges in Bogotá have been investigated by IDU in 1998. Earthquake-resistance of all bridge was re-calculated according to proposed ground acceleration of micro-zoning study 1998. A scheme of reinforcement and replacement of pedestrian bridges is on going currently. Figure 3.2.7 shows the current situation of pedestrian bridges according to the result of investigation 1998.

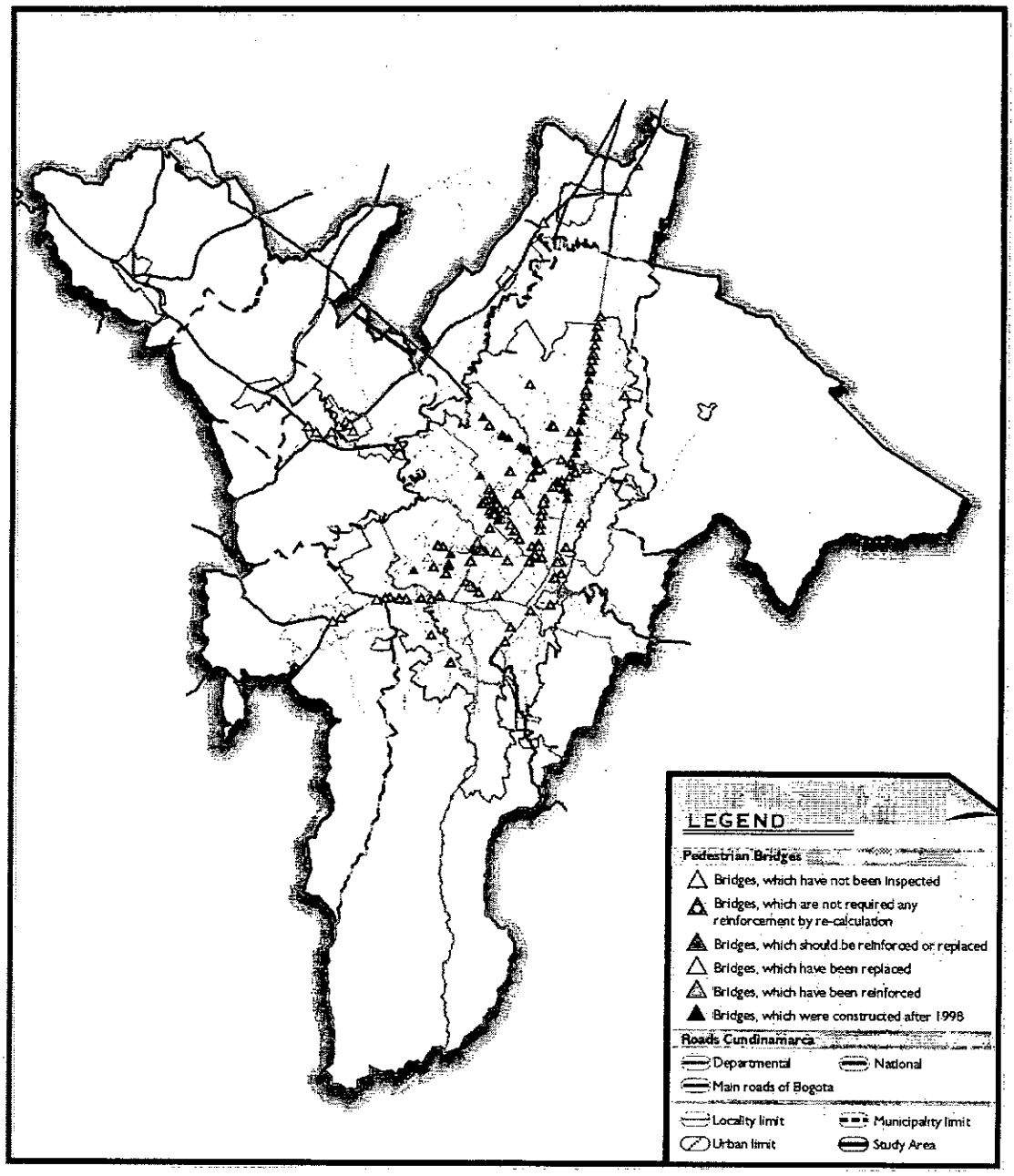


Figure 3.2.7 Pedestrian Bridge Situation according to IDU Investigation 1998

The investigation is appropriate for super structure. However, detail information on foundation and liquefaction is not available during the inspection. Therefore, IDU intends to investigate foundation of all of pedestrian bridges.

The Study Team recommend that liquefaction factor should be included in the investigation on foundation for bridges, which is located in liquefaction potential area.

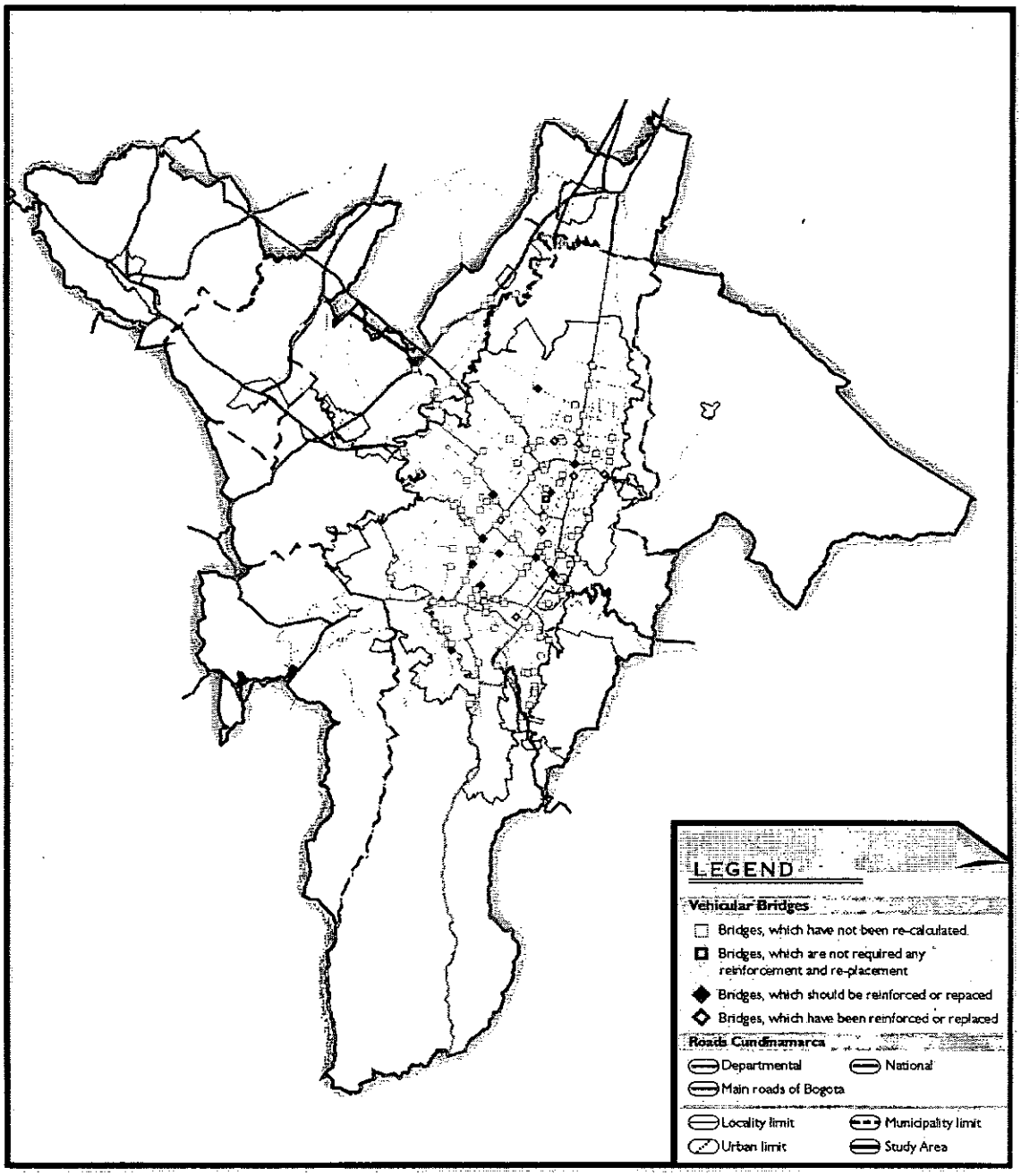


Figure 3.2.8 Vehicular Bridge Situation according to IDU Investigation 1998

C. Vehicular bridges in the eight municipalities

Vehicular bridges in the eight municipalities are river bridges except flyovers in Chía. Flyovers in Chía are relatively new. Therefore, the reliability of the flyover is relatively high.

On the other hand, some of river bridges are very old. It is doubtful that old bridges have enough seismic resistance.

D. Pedestrian bridges in the eight municipalities

Structure of most pedestrian bridges in the eight municipalities is simple beam. The characteristics of the pedestrian bridges are summarized as follows:

- Risk of destruction is high since the pier is slender.
- Risk of collapse is high since the seat width is very narrow.

(3) Railway facility

Following problems and issues have been identified from the point of view of physical vulnerability about the railway facility:

- Deterioration of railway facilities.
- Poor transport capacity, and
- Poor operation system.

3.2.2 Social and Economic Vulnerability

1) General

The urbanization is inevitable phenomena in the whole countries. As the economy grows, the people tend to live in urban places. The urbanized area provides better living conditions and job opportunities for the people. The economic activities in the urbanized area have diversified to grow industrial and service sectors and have become more links to other areas within the country as well as oversea countries.

Within the urban area, the transportation system has developed to commute people from living place to working place. Information and communication network also has developed to support the industries. The city expansion, however, has not considered the risks for the urbanization. Urban area has formulated risks associated with their nature of expansion. Therefore, it should be recognized that the urban area itself produces the risks for the natural disasters.

In this section, vulnerabilities for the urbanized area have analyzed in three categories: social, economic and environmental aspects. Those items are interrelated to formulate compounded vulnerabilities for the urbanized area.

2) Social Vulnerability

(1) Definition

The measurement of social vulnerability is still under the development. Attention has been paid on special categories of vulnerable groups: livelihoods at risk, perception of risk, existence of local institutions and level of poverty.[3-2-2] In this study, social vulnerability is defined by using

[3-2-2] Carter, W. Nick (1991) Disaster Management A Disaster Manager's Handbook, Asian Development Bank

several variables of social class and population, which includes expansion of urban population, age composition and density

(2) Social class

Reference is made to Section 2.2.3 of this report. In poverty level of the communities, classification by the *estrato* will be reliable indicators of the Study Area. Colombia has established social-economic class based on residential area's characteristics and the tariff of the public utilities such as electricity, water supply, sewage and telephone. The low estrato has obtained low tariff structure of the public utility based on the local government regulation, while high estrato has to pay higher utility tariff to cover the low estrato. Therefore, *estrato* can be used for the general guideline for the social classification in Colombia. It implies that low estrato is relatively low-income community, which means socially vulnerable.

The social vulnerability is defined as the poverty level of organization. One of indexes to define the poverty level is developed by the Mision Social, Department of National Planning for measuring poverty level, which called *Sistema de Seleccion de Beneficiarios para Programas Sociales* (SISBEN). SISBEN was designed to provide local governments for the targeting of social expenditures to the most poor and vulnerable groups. DAPD was carried out survey on December 2000 and shows the results. SISBEN classified the six groups based on the survey results. According to SISBEN classification, level 1 and 2 is classified as poverty. The results show that more than 25 percent of surveyed population are classified as level 1 and 2. In estrato 1 and 2, the share of level 1 and 2 population has become 29 percent.

A. Level 1

Corresponds to families that are in extreme poverty conditions, it means that families with two or more basic necessities are unsatisfied. As the results of survey, the localities of Ciudad Bolivar and Usme show the biggest percentage of population in level 1.

B. Level 2

For Level 2, families with one basic necessity are unsatisfied. From the surveyed results, the localities with more people in level 2 of SISBEN are Ciudad Bolivar, Usme, Suba, Kennedy and San Cristobal.

The Table 3.2.9 shows the distribution of poor population defined by SISBEN.

Table 3.2.9 Summary of Poverty Population by SISBEN

Locality	Population		Population		Population	
	Level 1	(%)	Level 2	(%)	Level 3	(%)
Usaquén	4,871	4.23	32,096	4.37	61,080	4.10
Chapinero	1,755	1.53	6,699	0.91	10,064	0.68
Santa fe	6,111	5.31	38,022	5.18	58,404	3.92
San Cristobal	7,125	6.19	56,792	7.74	114,960	7.72
Usme	20,017	17.40	96,593	13.16	143,306	9.63
Tunjuelito	901	0.78	22,289	3.04	69,433	4.66
Bosa	6,716	5.84	74,327	10.12	155,153	10.42
Kennedy	7,741	6.73	56,089	7.64	146,818	9.86
Fontibón	841	0.73	13,164	1.79	51,759	3.48
Engativá	1,841	1.60	34,052	4.64	120,023	8.06
Suba	5,018	4.36	65,782	8.96	150,281	10.10
Barrios Unidos	1,301	1.13	8,319	1.13	32,405	2.18
Teusaquillo	67	0.06	526	0.07	1,511	0.10
Los Mártires	1,356	1.18	10,471	1.43	21,905	1.47
Antonio Nariño	275	0.24	4,501	0.61	14,475	0.97
Puente Aranda	1,589	1.38	8,326	1.13	25,770	1.73
La Candelaria	522	0.45	5,855	0.80	9,092	0.61
Rafael Uribe	5,624	4.89	47,838	6.52	95,592	6.42
Ciudad Bolívar	38,444	33.42	152,038	20.71	206,428	13.87
Sumapaz	2,903	2.52	337	0.05	118	0.01
Total	**115,018**	**99.97**	**734,116**	**100.00**	**1488,577**	**100.00**

Source: Información para el Plan Local 2001

The table shows that level 1 is concentrated in Ciudad Bolivar, followed by the Usme. In Ciudad Bolivar, the level 1 and 2 population exceed more than 50 percent of total population. It means that more level 1 and 2 population has concentrated locality would be high-risk area.

(2) Population

A. Urbanization

The urban area has experienced rapid urban population increase. Rapid urban population increase has led to many urban problems, such as transportation, housing, public facilities etc. As urban population has increased, the linkage of the community has become weak. After a disaster, the community organization should have played important role. The most of important social issue is formulation of community level organization for the disaster management. The past experience shows that community level search and rescue operation saves many lives in the community.

Bogotá City has experienced rapid urban population increase during 1960s and the annual average population increase has reached at more than 7 percent. Reasons of the population increase are natural increase associate with improvement of infant mortality rate. For social increase, it can be observed refugee of the civil war in Colombia, although the economic reasons, which can be the essential reasons for migration in other countries, are one of the factors. The population of Bogotá was only 660 thousands in 1951 and it became more than 2.8 millions in 1973. It is more than four times increase during 22 years. Since then, Bogotá City as well as adjacent Cundinamarca municipalities has experienced population increase. The share of population in Bogotá City to national population has become 16.1 percent in 1993. According to DPAD estimation, Bogotá City will increase population about 130,000 annually.

B. Population composition

The population composition is another issues. The past experience shows that the children and elderly population would be high risk for the disaster. It is important to identify the high-risk personnel.

Table 3.2.10 Distribution of High Risk Personnel

Locality	0 - 4 years	% total Bogota	55 years and more	% total Bogota	Total Population in Risk	Total Population Locality	% total Bogota
USAQUEN	45,191	6.53	43,136	6.94	88,327	421,320	6.60
% population of locality	10.73		10.24		21		
CHAPINERO	7,700	1.11	18,736	3.02	26,436	122,991	1.93
% population of locality	6.26		15.23		21		
SANTAFE	10,836	1.57	11,262	1.81	22,098	107,044	1.68
% population of locality	10.12		10.52		21		
SAN CRISTOBAL	53,676	7.76	42,173	6.79	95,849	455,028	7.13
% population of locality	11.8		9.27		21		
USME	33,103	4.78	15,182	2.44	48,285	244,270	3.83
% population of locality	13.55		6.22		20		
TUNJUELITO	21,530	3.11	18,697	3.01	40,227	204,367	3.20
% population of locality	10.53		9.15		20		
BOSA	52,330	7.56	23,054	3.71	75,384	410,099	6.43
% population of locality	12.76		5.62		18		
KENNEDY	97,903	14.15	93,457	15.04	191,360	912,781	14.31
% population of locality	10.73		10.24		21		
FONTIBON	29,898	4.32	28,540	4.59	58,438	278,746	4.37
% population of locality	10.73		10.24		21		
ENGATIVA	80,343	11.61	76,695	12.35	157,038	749,068	11.74
% population of locality	10.73		10.24		21		
SUBA	75,780	10.95	72,341	11.64	148,121	706,528	11.08
% population of locality	10.73		10.24		21		
BARRIOS UNIDOS	12,870	1.86	26,068	4.20	38,938	176,552	2.77
% population of locality	7.29		14.77		22		
TEUSAQUILLO	7,225	1.04	20,173	3.25	27,398	126,125	1.98
% population of locality	5.73		15.99		22		
LOS MARTIRES	7,761	1.12	11,683	1.88	19,444	95,541	1.50
% population of locality	8.12		12.23		20		
ANTONIO NARIÑO	8,441	1.22	11,815	1.90	20,256	98,355	1.54
% population of locality	8.58		12.01		21		
PUENTE ARANDA	24,914	3.60	30,494	4.91	55,408	282,491	4.43
% population of locality	8.82		10.79		20		
LA CANDELARIA	2,336	0.34	3,511	0.57	5,847	27,450	0.43
% population of locality	8.51		12.79		21		
RAFAEL URIBE	41,254	5.96	39,379	6.34	80,633	384,623	6.03
% population of locality	10.73		10.24		21		
CIUDAD BOLIVAR	78,853	11.39	34,641	5.58	113,494	575,549	9.02
% population of locality	13.7		6.02		20		
TOTAL BOGOTA	692,120	100.00	621,234	100.00	1,313,354	6,378,928	100.00
% population of Bogotá	10.85		9.74		21		

Source: Informacion para el Plan Local 2001

The high-risk personnel are found in the whole Bogotá City at rate of about 20 percent. It is not clear which locality has more risky age structure than that of others.

C. Density

Table 3.2.11 shows that average population density in estrato 2 and 3 is more than 400 persons/ha, while average population density in estrato 5 and 6 is approximately 100 persons/ha. Estrato 1 and 2 is four times more populous in comparison with estrato 5 and 6. There is approximately 300 persons/ha in Estrato 1. The low estrato community would be socially vulnerable for having relatively low income with high population density.

Table 3.2.11 Population Distribution by *Estrato*

LOCALITY		ESTRATO Not Classify	1	2	3	4	5	6	TOTAL
1. USAQUEN	Area (Ha)	900.70	60.39	228.20	342.13	354.36	277.88	382.27	2,545.93
	Population	9,521	11,395	37,943	108,639	96,290	53,950	69,535	387,271
	Density	10.57	188.67	166.27	317.54	271.73	194.15	181.90	152.11
2. CHAPINERO	Area (Ha)	101.63	33.84	146.74	53.48	155.38	96.65	301.05	888.77
	Population	1,587	5,680	10,638	9,899	32,759	14,007	48,422	122,991
	Density	15.62	167.83	72.49	185.10	210.83	144.93	160.84	138.38
3. SANTA FE	Area (Ha)	71.41	13.53	167.77	130.40	8.69	0.93		392.75
	Population	1,349	3,389	72,690	26,213	3,393	11		107,044
	Density	18.89	250.45	433.26	201.01	390.19	11.84		272.55
4. SAN CRISTOBAL	Area (Ha)	99.02	71.51	586.07	153.48				910.08
	Population	4,370	34,029	341,107	66,030				445,535
	Density	44.13	475.84	582.02	430.22				489.56
5. USME	Area (Ha)	163.98	365.35	216.86					746.20
	Population	2,074	58,929	161,912					222,915
	Density	12.65	161.29	746.62					298.73
6. TUNJUELITO	Area (Ha)	226.75	3.71	231.60	128.45				590.51
	Population	2,745	26	130,014	71,582				204,367
	Density	12.11	6.92	561.37	557.29				346.09
7. BOSA	Area (Ha)	214.00	142.93	734.49	29.47				1,120.89
	Population	1,588	2,749	286,655	20,707				311,698
	Density	7.42	19.23	390.28	702.61				278.08
8. KENNEDY	Area (Ha)	651.33	22.28	564.46	846.48	20.29			2,104.83
	Population	5,935	12,905	327,347	486,060	7,790			840,036
	Density	9.11	579.34	579.93	574.21	383.98			399.10
9. FONTIBON	Area (Ha)	830.94		305.39	398.87	137.16			1,672.36
	Population	2,555		17,509	180,677	40,631			241,372
	Density	3.07		57.33	452.97	296.24			144.33
10. ENGATIVA	Area (Ha)	637.18	10.27	359.91	1082.64	89.76			2,179.76
	Population	8,386	4,351	75,276	596,039	27,988			712,040
	Density	13.16	423.65	209.15	550.54	311.80			326.66
11. SUBA	Area (Ha)	709.27	8.67	829.18	587.84	357.11	675.08	395.79	3,562.92
	Population	6,243	1,788	216,349	223,336	79,140	96,887	10,926	634,669
	Density	8.80	206.35	260.92	379.93	221.62	143.52	27.61	178.13
12. BARRIOS UNIDOS	Area (Ha)	241.73	0.06	21.62	296.40	222.58	22.41		804.80
	Population	2,207			112,634	57,744	3,966		176,552
	Density	9.13			380.00	259.43	176.99		219.37
13. TEUSAQUILLO	Area (Ha)	479.24		14.50	93.99	367.37	21.72		976.82
	Population	613		18	22,291	95,299	7,905		126,125
	Density	1.28		1.25	237.15	259.41	364.00		129.12
14. LOS MARTIRES	Area (Ha)	84.93		19.92	316.97	10.55			432.37
	Population	510		5,185	85,405	4,441			95,541
	Density	6.01		260.33	269.44	420.93			220.97
15. ANTONIO NARINO	Area (Ha)	59.50		8.47	252.42				320.39
	Population	98		7,833	90,424				98,355
	Density	1.64		925.14	358.23				306.98
16. PUENTE ARANDA	Area (Ha)	464.83	0.20	10.15	640.90				1,116.07
	Population	2,283	171	709	279,329				282,491
	Density	4.91	839.49	69.83	435.84				253.11
17. LA CANDELARIA	Area (Ha)	41.00		49.07	33.47				123.54
	Population	980		18,190	8,280				27,450
	Density	23.89		370.72	247.37				222.19
18. RAFAEL URIBE U	Area (Ha)	68.10	36.25	224.18	364.15				692.67
	Population	3,628	18,578	166,078	194,517				382,801
	Density	53.27	512.55	740.84	534.17				552.65
19. CIUDAD BOLIVAR	Area (Ha)	143.39	561.42	272.62	56.82				1,034.25
	Population	5,395	231,771	239,081	21,929				498,177
	Density	37.63	412.83	876.96	385.98				481.68
TOTAL	Area (Ha)	6,188.93	1,330.41	4,991.20	5,808.36	1,723.23	1,094.66	1,079.11	22,215.92
	Population	62,065	385,759	2,114,533	2,603,991	445,473	176,725	128,883	5,917,430
	Percentage	1.05	6.52	35.73	44.01	7.53	2.99	2.18	100.00
	Density	10.03	289.96	423.65	448.32	258.51	161.44	119.43	266.36

Note: 1) The area classified as non-residential areas such as factory, commercial and parks.
Source : DAPD. Subdirección de Desarrollo Humano y Progreso Social

It is pointed out that the southern part of Bogotá shows a higher population density of more than 400 persons/ha and the most populous localities include San Cristobal, Rafael Uribe and Ciudad Bolivar. Despite the estrato, these localities show high population densities in addition to high population increases in the last five years as well. Therefore, those localities may expand residential development areas and newly developed areas are likely to be pose higher risky area due to low land prices.

3) Economic Vulnerability

(1) Definition

Economic vulnerability measures the risk of hazards causing losses to economic assets and processes. It focuses on evaluating the direct loss potential such as damage or destruction of physical and social infrastructure and its replacement cost. Indirect loss potential includes impact on lost production, employment, vital services and income-earning activities. The secondary loss is defined as epidemics, inflation, and income disparities and isolated outlying area[3-2-2].

In this study, economic loss is calculated for the physical assets of buildings, bridges and vital lifeline. In the case of commerce and industry, the direct economic losses are buildings, machinery, stocks and products, yet there is a limitation to estimate those losses excepting building assets. The secondary losses are difficult to estimate.

(2) Economic loss

The economic activities have progressed in the urban areas. Concentration of economic activities would benefit to whole economic sector, because urban area could provide services products in low prices. The urban area usually imports food and agricultural commodities from outside area and export industrial goods and services. Those economic linkages have developed between urban and rural areas.

Bogotá City is the economic center of Colombia and it produces more than 23 percent of Gross Domestic Product (GDP) in 1998. The geological location of Bogotá City has to depending on energy, agricultural commodities, and consumer goods from the outside of Bogotá. The statistics shows that Bogotá City produces high value added products and service goods.

The disaster damage on the economic sector in Bogotá City would lead economic confusion to the countries. The economic damage would have great influence of the economic activities of whole economy, because economic linkages have already established between Bogotá City and other regions. The economic damage would extend as delay of economic recovery activities. Therefore, disaster damage on economic sector would not only Bogotá City but also whole economic activities.

[3-2-2] Carlos Eduardo Velez, Elkin Castaño and Ruthanne Deutsch (1998), An Economic Interpretation of Colombia's SISBEN: A Composite Welfare Index Derived from the Optimal Scaling Algorithm
Carter, W Nick (1991) Disaster Management: A Disaster Manager's Handbook, Asian Development Bank, Manila, Philippines

(3) Estimation of direct economic losses

A. Building

In order to estimate economic losses, the building damage can be calculated from the building damage estimation. It is estimated at 100 percent of building value for severely damaged or destroyed buildings.

The building value is derived from the cadastral value of the building. The purposes of the cadastral value are property tax collection and it represents real value of the building. Therefore, the cadastral value is used for the estimation.

B. Infrastructure

The value of bridge and vital infrastructure is estimated at construction costs. The replacement cost is derived from the actual construction costs in the Study Area.

C. Results

The estimation results are shown in Chapter 4.2 of this report.

4) Environmental Vulnerability

(1) Definition

Environmental vulnerability can be categorized into natural and social aspects. A general methodology to measure environmental vulnerability is still being developed. In this study, environmental risks can be categorized into three items:

- Natural Conditions.
- Location of industrial area for industrial disaster; and
- Waste management.

(2) Natural conditions

The urbanized area has developed in the relatively flat area because of easy construction of buildings and facilities. Those areas are usually composed of the river deposit and reclamation of lake and sea. The soft soil area in the urban area can be observed in the many urbanized areas.

The Study Area has situated in the soft soil area. The composition of the lake clay in the central part of plain is over 500m deep. This study found that the approximately 25% of the Study Area is classified as soft lake deposit area and 4% of land falls into sandy soil area, where it is the problems of the liquefaction. Moreover, the edge of the mountain area has high risk of amplification of seismic intensity, which shares about 13 percent of the Study Area.

(3) Industrial area

The distribution of the industrial facilities shows that the eight localities have 78% of the total industrial facilities. The eight localities include Puente Aranda, Fontibón, Kennedy, Enqativá, Barrios Unidos, Usaquén, Los Mártires and Suba. The area has faced great potential for leakage, fire, spilling and explosion. Puente Aranda has 23 % of the industrial facilities and high potential for disaster events. The industrial facilities are located in the designated area, yet those areas have developed since then. The land use has changed to develop more attention toward residential and industrial mixed use. Those facilities are mixed among with the residential areas and have great impact on natural and social environments when industrial disaster has happened.

(4) Waste management

After the earthquake disaster, the debris disposal would be a problem and disposal place should be determined before a disaster. After the Armenia earthquake, the amount of debris was 1.8 million m^3 in population of 280 thousands, according to the Armenian government report. If this figure would apply to the Bogotá Metropolitan Area, it would become 41 million m^3. Therefore, the earthquake damage would have huge environmental impacts on the Study Area.

3.3 Regional Risk Analysis

3.3.1 General

Prior to designing preventive programs for disasters, it is important to know which type of risk each region has to face.

The objective of this analysis in this part of the study is to determine the regional risk by disaster type. The result will be used specifically for two purposes as follows:

- Classification of risk to each locality and municipality; and
- Selection of priority UPZ for earthquake risk.

3.3.2 Methods of Analysis

1) General

Four types of disasters, namely, earthquake, landslide, flood, and fire in industrial facilities were analyzed. The results of analysis were used to produce two major outputs: a map of degree of regional risk, and a map of priority UPZ distribution.

Analysis was done by three steps, as shown in Figure 3.3.1. Step 1 determines each disaster's risk component with the scale of 1 to 5. Step 2 investigates the integrated risk of each disaster also with the scale of 1 to 5. Step 3 analyzes the degree of risk to each UPZ. However, in this section, the result of analysis only until step two is presented. Step 3 is discussed later in section 5.2.2.

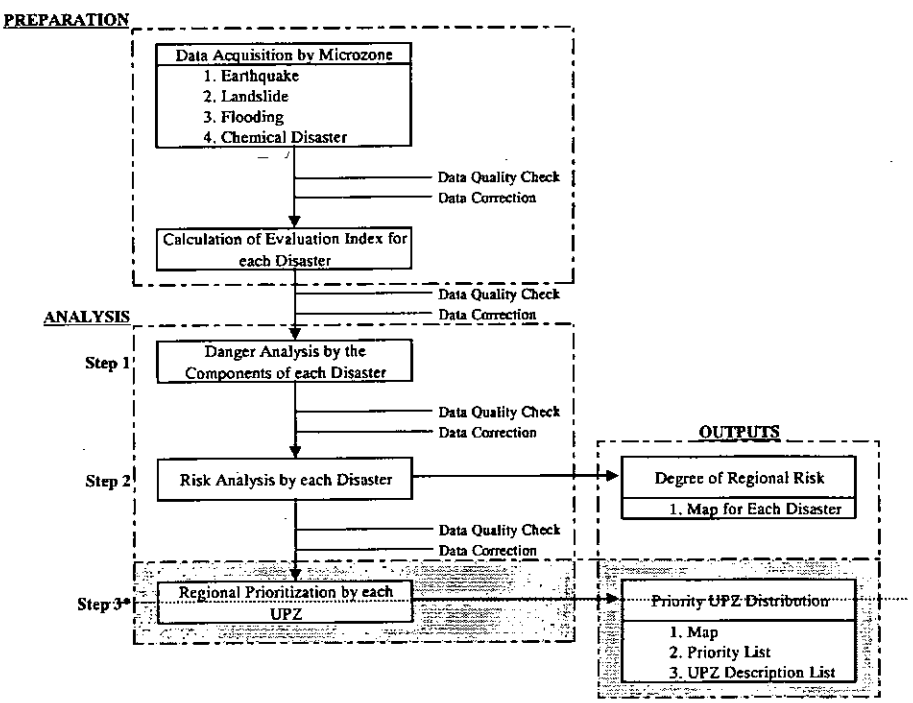


Figure 3.3.1 Flowchart of the Regional Risk Analysis

For the analysis in this section, the microzoning for the Study was used in general. Basically, the analysis took into consideration only the urbanized area. The rural area was excluded because its population is small and thus the risk is not high.

Table 3.3.1 shows the methods for analyzing the regional degree of risk for all the disaster types, and their significance for the analysis is provided in the latter section.

2) Earthquake

For the regional risk analysis of earthquakes, the Guayuriba fault (medium distance) model was applied, because the damage estimation with this model was considered most severe by this study.

For the analysis, following procedures have been adopted:

For step 1, risk classification by the components of each disaster, three variables were used for this event. The variables are:

- degree of risk for buildings.
- degree of risk for human casualties, and
- degree of risk for evacuation.

Variable used to the building risk was the result by the damage estimation on the percentile of the severely damaged buildings. Within the analysis on the vulnerability analysis of building damage, building structure type, such as wood, prefabrication, masonry and reinforced concrete, number of stories, and estrato has been taken into consideration.

Variable used to the human casualty degree is the population density of each microzone.

Degree of danger for evacuation, which indicates the difficulty of evacuation in case of emergency, was calculated for the third index. In this, percentage of open space to the total area for microzone was calculated. The open space here defines the road and the public parks, and undeveloped open space is not included.

Table 3.3.1 Methods for Classification of Regional Degree of Risk

Degree of Risk	Items	Index	Descriptions	Points
Earthquake	Building Damage	Heavily damaged building damage ratio	Results from the damage estimation.	0 < 20% to 1 20 < 40% to 2 40 < 60% to 3 60 < 80% to 4 80 < 100% to5
	Human Causality	Population density	Population Density of each microzone.	0 < 150 to 1 150 < 300 to 2 300 < 450 to 3 450 < 600 to 4 600 < up to5
	Evacuation	Rate of open space	Open space ratio (Open space + Road space)/Total area of microzone)	80 < 100% to 1 60 < 80% to 2 40 < 60% to 3 20 < 40% to 4 0 < 20% to 5
Landslide	Building Damage	Percent of the risk area out of the total area of the microzone.	Physical Degree of Danger = (Danger Area ha (km^2)) / Total Area in the Microzone	0 < 20 to 1 20 < 40 to 2 40 < 60 to 3 60 < 80 to 4 80 < 100 to 5
Flood	Building Damage	Percentage of the building located in the flooding risk area.	Degree of Danger for Buildings = (Area of H in unit×2) + (Area of M in unit×1.5) + (Area of L in unit×1.2))/Total Area of Unit×100	0 < 40 to 1 40 < 80 to 2 80 < 120 to 3 60 < 80 to 4 80 < 100 to 5
	Human Casualty	Number of people living in suffering from the disaster.	1) No. of Possible Affected Population in Unit = Σ (Population Density of the unit× ha (km^2) of dangerous area in unit × probability) 2) Degree of Danger for Human Casualties = No. of Possible Affected Population / Total Population in the Unit	0 < 2 to 1 2 < 4 to 2 4 < 6 to 3 6 < 8 to 4 8 <10 to 5
Fire	Fire Breakout ratio	Rate of fire break out for the industrial facilities	Result of the fire break out rate of damage estimation for an earthquake	0 < 0.2 to 1 0.2 < 0.4 to 2 0.4 < 0.6 to 3 0.6 < 0.8 to 4 0.8 < 1.0 to 5

3) Landslide

For the regional risk analysis of landslide, DPAE's hazard map for landslides was used. The high hazard area was considered as the physical high-risk zone. Also, the data accumulated throughout this study of high-risk landslide-points were integrated into the consideration of giving regional priority.

For the analysis, Table 3.3.1 can be also referred for the procedures and detailed description of the calculation. For step 1, risk classification by the degree of risk for building was only used. First,

the ratio of area where distinguished as danger area to total area in the microzone was calculated. Then, the landslide points where evaluated as risky areas, were overlaid to the calculated microzone for the conclusion.

4) Flood

For the regional risk analysis of flood, existing hazard maps were used for Bogotá City and some of the municipalities of Cundinamarca.

For the analysis, Table 3.3.1 can be referred for the detailed methods and descriptions. For step 1, two variables were used for this event. The variables are:

- degree of danger for buildings, and
- degree of danger of human casualties.

For the degree of risk for buildings, percentage of the buildings located in the flood risk area was calculated by microzone. Within this calculation, flood areas where evaluated as high, medium, and low within the microzone were weighted, and then divided by the total area of the microzone.

For calculating the degree of human casualties, the number of people with the possibility of and probability of suffering from the disaster in the microzone was used. It was calculated by two steps: First, the possible affected population in the microzone was calculated. This included the population density, hectares of danger area, and the flood return probability. Next, the degree of danger for human casualties was calculated. In this, number of possible affected population was divided by the total population in the microzone for each microzone.

5) Fire in Industrial Facilities

For the regional risk analysis of industry, result of fire outbreak risk-points in case of an earthquake was used. It was calculated by the Study Team for the industrial facilities. The Guayuriba Fault (medium distance) Model was also applied, because the damage estimation with this model was considered most severe.

Result was used to generate a map on the degree of risk for industry where the darker color indicates a higher risk.

3.3.3 Results

Brief descriptions on the results for all the disaster events are given below. Appendix 3.3.1 contains a rough indicator for the map of degree of risk. This can be referred with the maps of degree of regional risks for earthquake, landslide, flood and industry. However, the result of the risk level is only a relative comparison within the Study Area; therefore, it does not mean that the area with low risk is safe in anyway.

A. Earthquake

In this event, results from steps 1 and 2 are presented as follows.

- Step 1: Risk classification by the components of each disaster.
- Step 2: Risk classification by each disaster.

For the result of step 1, risk analysis on buildings, human casualties and evacuation are shown in Appendices 3.3.2, 3.3.3 and 3.3.4, respectively. These maps show which microzones are relatively at high risk and which are not by each index. With the degree of danger for buildings, the zones with building collapse areas are distributed all over the Bogotá Metropolitan Area, and the high collapse rate for risk 5 is mainly distributed in the southern part of Bogotá and Cota.

With the degree of danger for human casualties, it is obvious that the highly dense areas or the high-risk area of 4 and 5 are concentrated to the southern part of Bogotá and Soacha. There are several highly dense areas in the north-western part.

Regarding the degree of danger of evacuation, high-risk areas are distributed in the very southern part, the northern part excluding the environmental protection area, and the eastern part close to the hills.

A result of degree of risk is shown in Figure 3.3.2. In this figure, the high-risk area of point 5 is distributed in the south, point 4 in the south and several in the north, and in the municipalities of Soacha, Facatativá, and Cota.

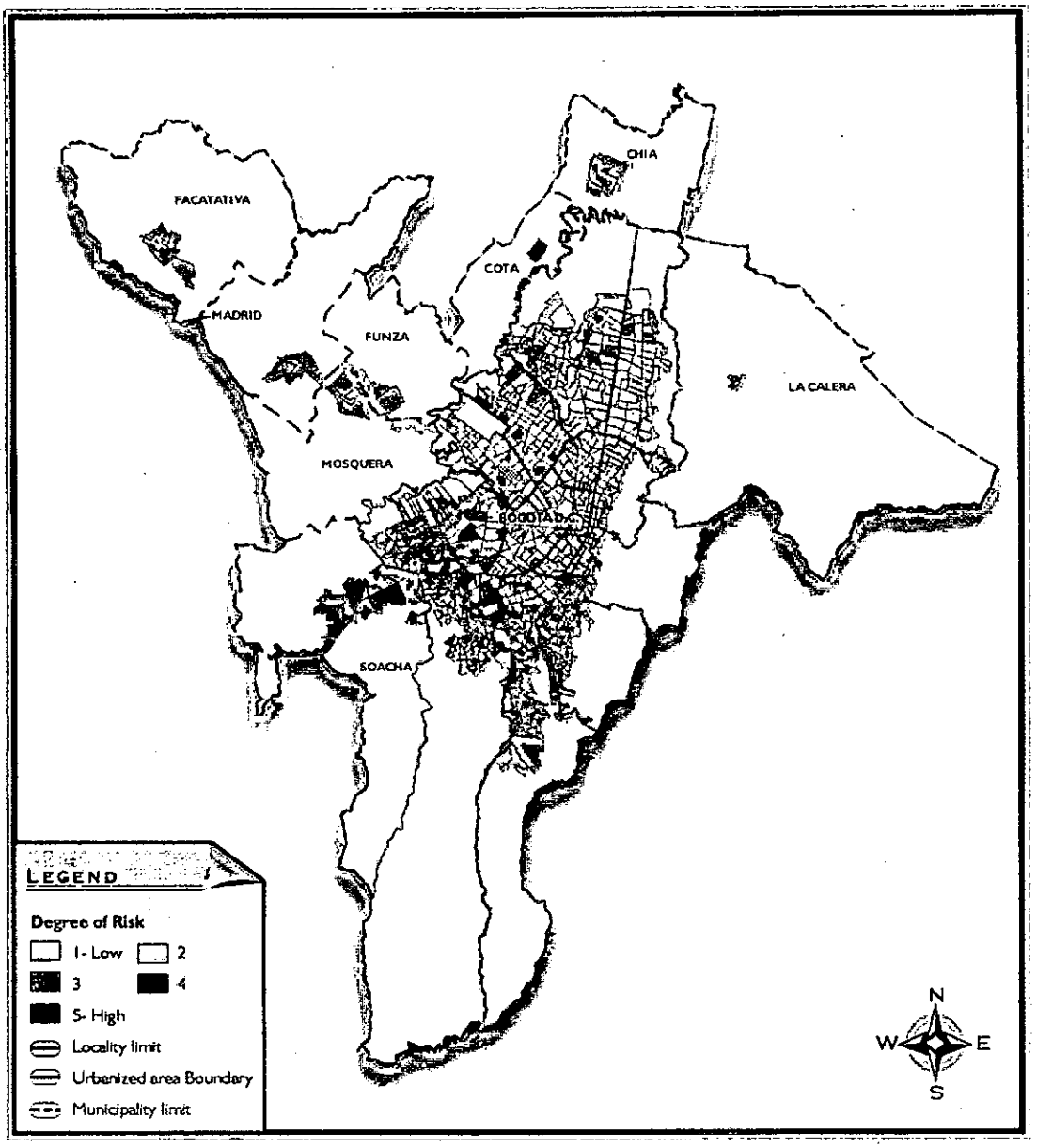


Figure 3.3.2 Degree of Regional Risk for Earthquake

B. Landslide

Figure 3.3.3 shows the result of the analysis of landslide. The microzone which includes more of the high-risk area should consider measures for landslides. Also, the points selected as high-risk areas through the study are overlaid, showing the region requiring landslide measures. Although high-risk evaluated landslide-points are fairly distributed to the locality of high-risk zone, it shows that the high-risk landslide-points are more concentrated in the southern part of Bogotá.

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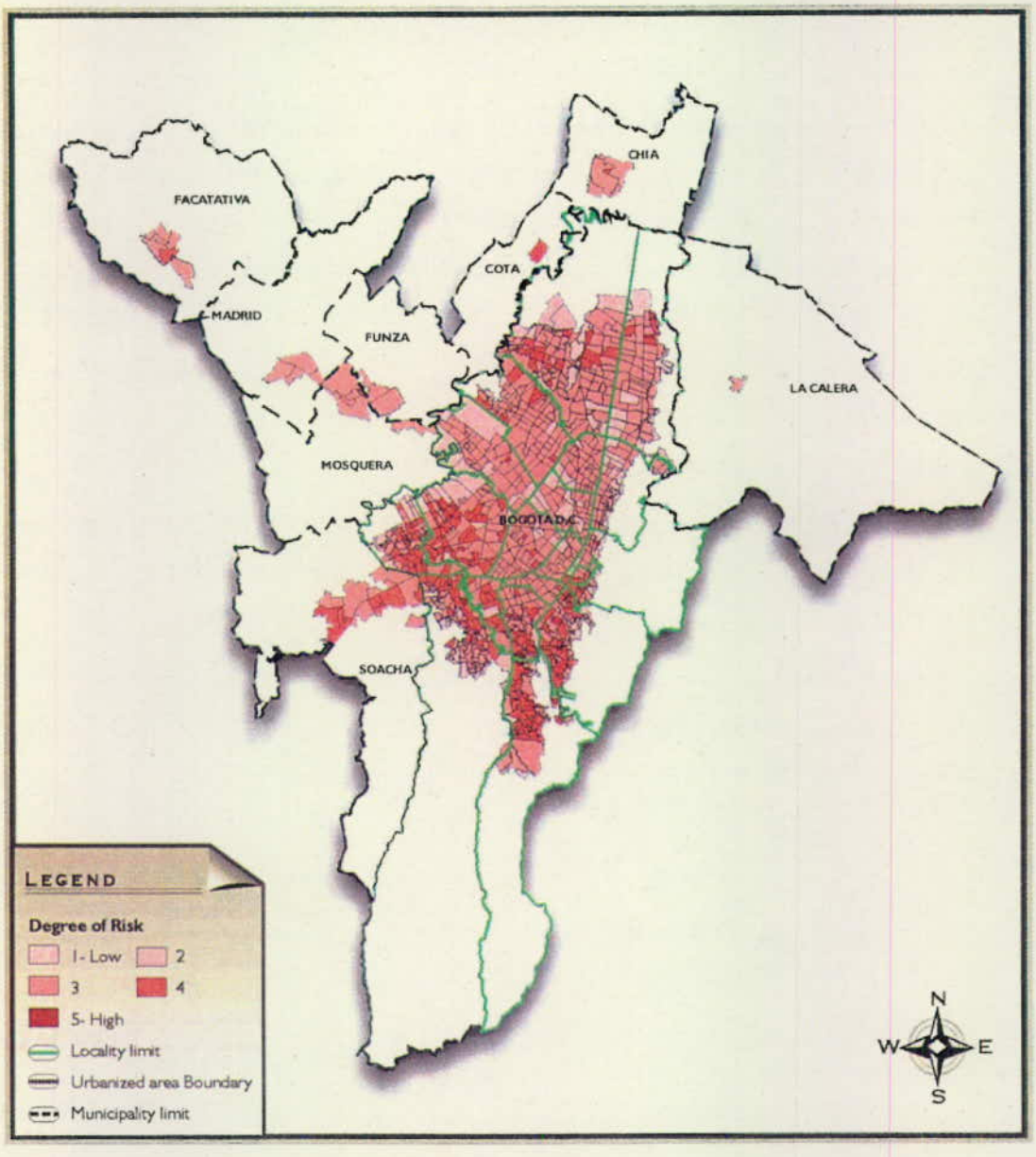

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C. Flood

Figure 3.3.4 shows the result of risk analysis of flood. In this figure, it is clear that all the area near the Rio Bogotá has to consider flood measures; however, the north western part of Bogotá has higher risk as shown by the analysis.

D. Fire in Industrial Facilities

Figure 3.3.5 shows the result of risk distribution of industrial facilities. It is obvious that the risk area of industry is concentrated in the area of industrial zones.

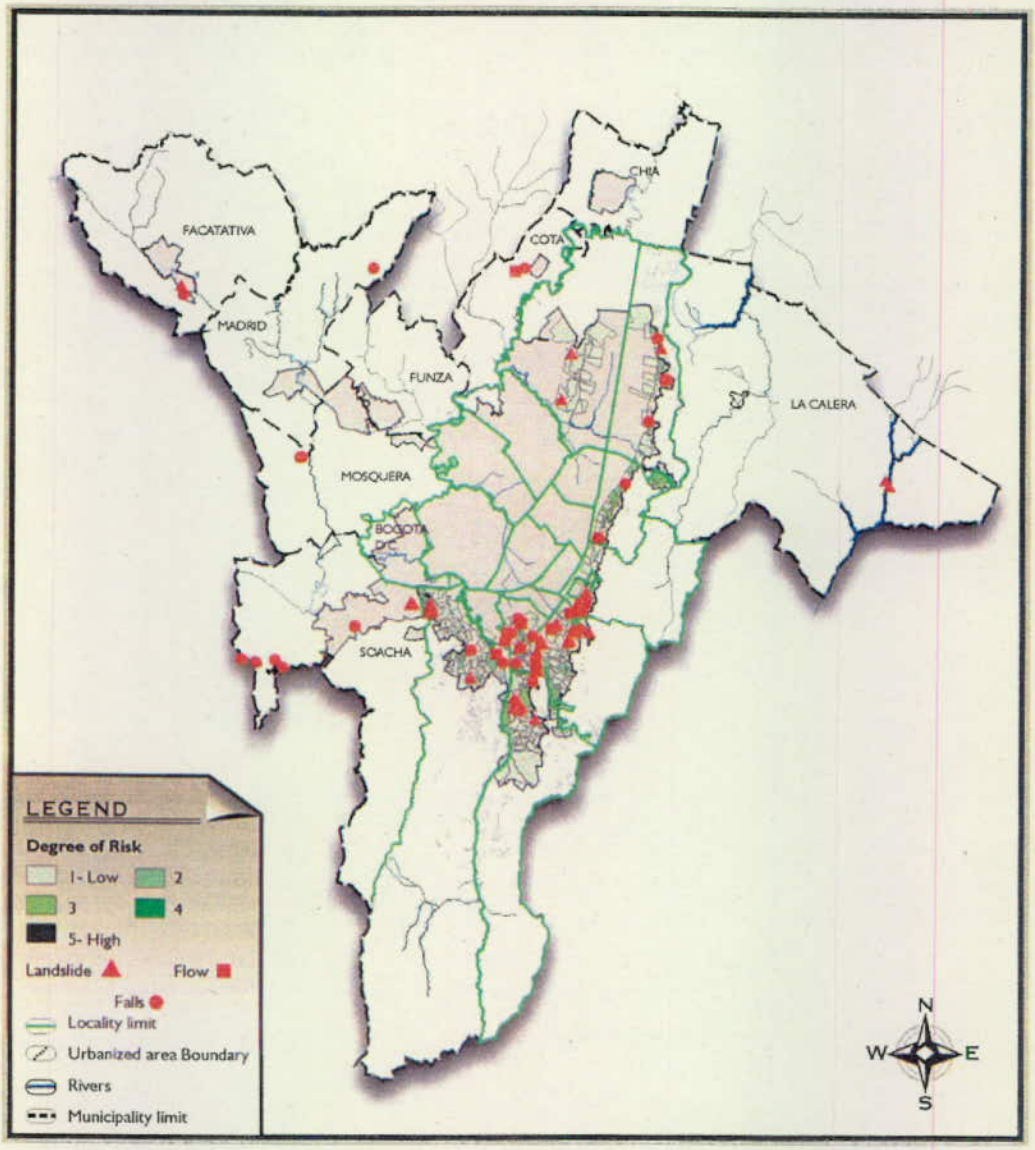


Figure 3.3.3 Degree of Regional Risk for Landslide

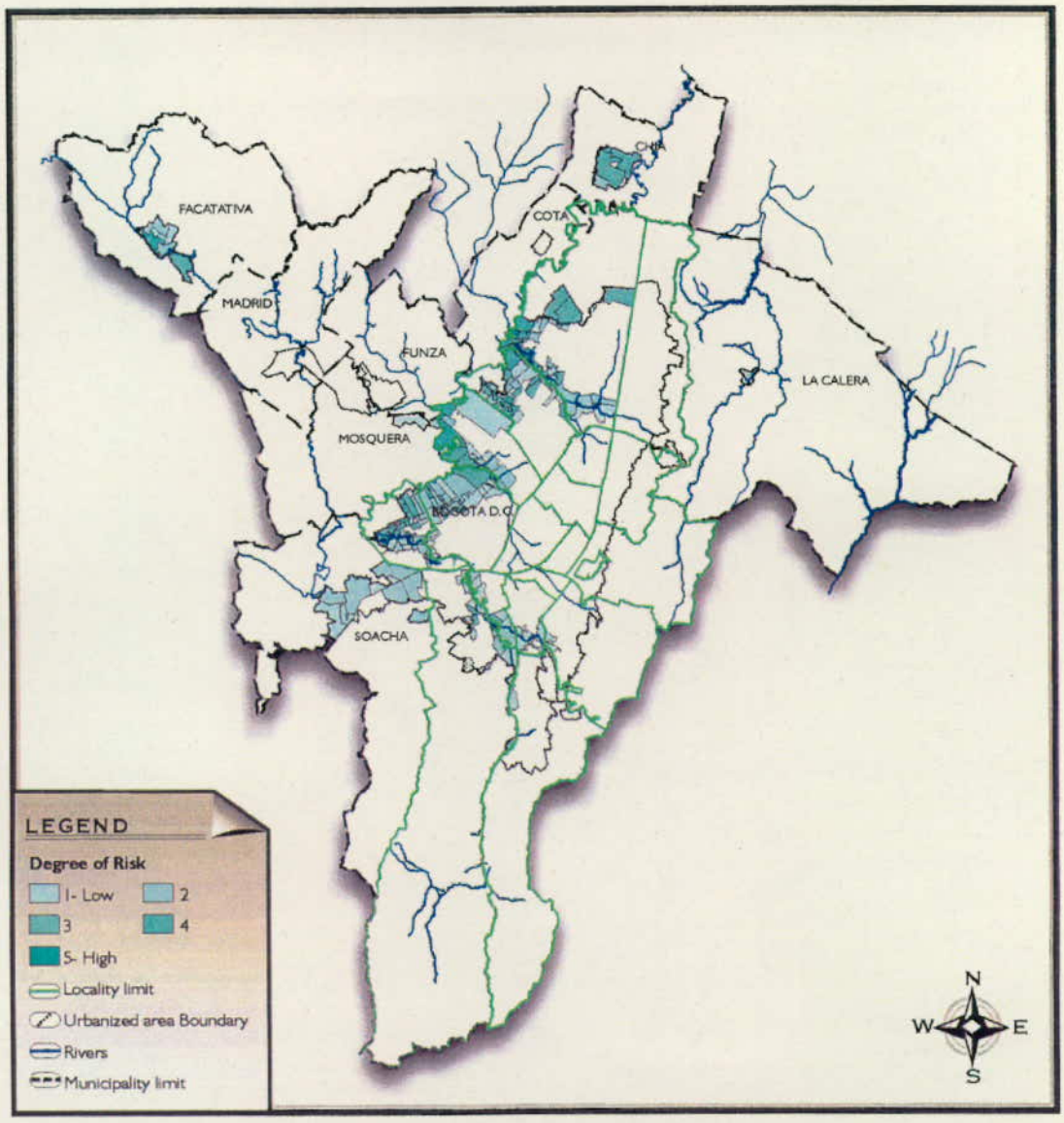


Figure 3.3.4 Degree of Regional Risk for Flood



Figure 3.3.5 Degree of Regional Risk for Industrial Facilities

3.3.4 Regional Evaluation

Table 3.3.2 shows the result of regional evaluation by risk types.

1) Evaluation Criteria

The Study Team carried out regional evaluation by risk types. The criteria for the evaluation are shown as follows:

- High-Risk area: Locality including rank 4 and 5.
- Medium-Risk area: Locality including rank 3.
- Low-Risk area: Locality including rank 2 and 1.

It should be noted that the regional classification map shows the relative risks among localities in the Study Area and it could not provide a comparison among the disaster types.

For the landslide evaluation, the evaluation for the high risk area is exceptional; it is defined as follows:

- High-Risk area: Includes rank 4 and 5, and the high risk evaluated landslide points.

Table 3.3.2 Result of Regional Evaluation by Risk Types

Locality	High-Risk Area*				Evaluation	
	Earthquake	Landslide	Flood	Industry	Disaster Type	Risk Type
1. Usaquén	◎	○	-	○	Earthquake, Landslide, Industry	F
2. Chapinero	○	○	-	-	Earthquake, Landslide	B
3. Santa Fe	◎	○	-	-	Earthquake, Landslide	B
4. San Cristobal	◎	○	-	-	Earthquake, Landslide	B
5. Usme	◎	○	-	-	Earthquake, Landslide	B
6. Tunjuelito	◎	○	○	-	Earthquake, Landslide, Flood	E
7. Bosa	◎	-	◎	-	Earthquake, Flood	C
8. Kennedy	◎	-	○	-	Earthquake, Flood	C
9. Fontibón	◎	-	◎	-	Earthquake, Flood	C
10. Engativá	◎	-	◎	-	Earthquake, Flood	C
11. Suba	◎	○	◎	-	Earthquake, Landslide, Flood	E
12. Barrios Unidos	○	-	-	-	Earthquake	A
13. Teusaquillo	○	-	-	-	Earthquake	A
14. Mártires	○	-	-	-	Earthquake	A
15. Antonio Nariño	◎	-	-	-	Earthquake	A
16. Puente Aranda	◎	-	-	◎	Earthquake. Industry	D
17. La Candelaria	◎	◎	-	-	Earthquake, Landslide	B
18. Rafael Uribe	◎	○	-	-	Earthquake, Landslide	B
19. Ciudad Bolívar	◎	◎	○	-	Earthquake, Landslide, Flood	E
20. La Calera	○	-	○	-	Earthquake, Flood	C
21. Chía	◎	-	○	-	Earthquake, Flood	C
22. Cota	◎	-	◎	-	Earthquake, Flood	C
23. Facatativá	◎	○	◎	-	Earthquake, Landslide, Flood	E
24. Funza	○	-	-	-	Earthquake	A
25. Madrid	○	-	-	-	Earthquake	A
26. Mosquera	○	-	-		Earthquake	A
27. Soacha	◎	○	○	-	Earthquake, Landslide, Flood	E

Note: ◎ High-Risk Locality ○ Medium-Risk Locality

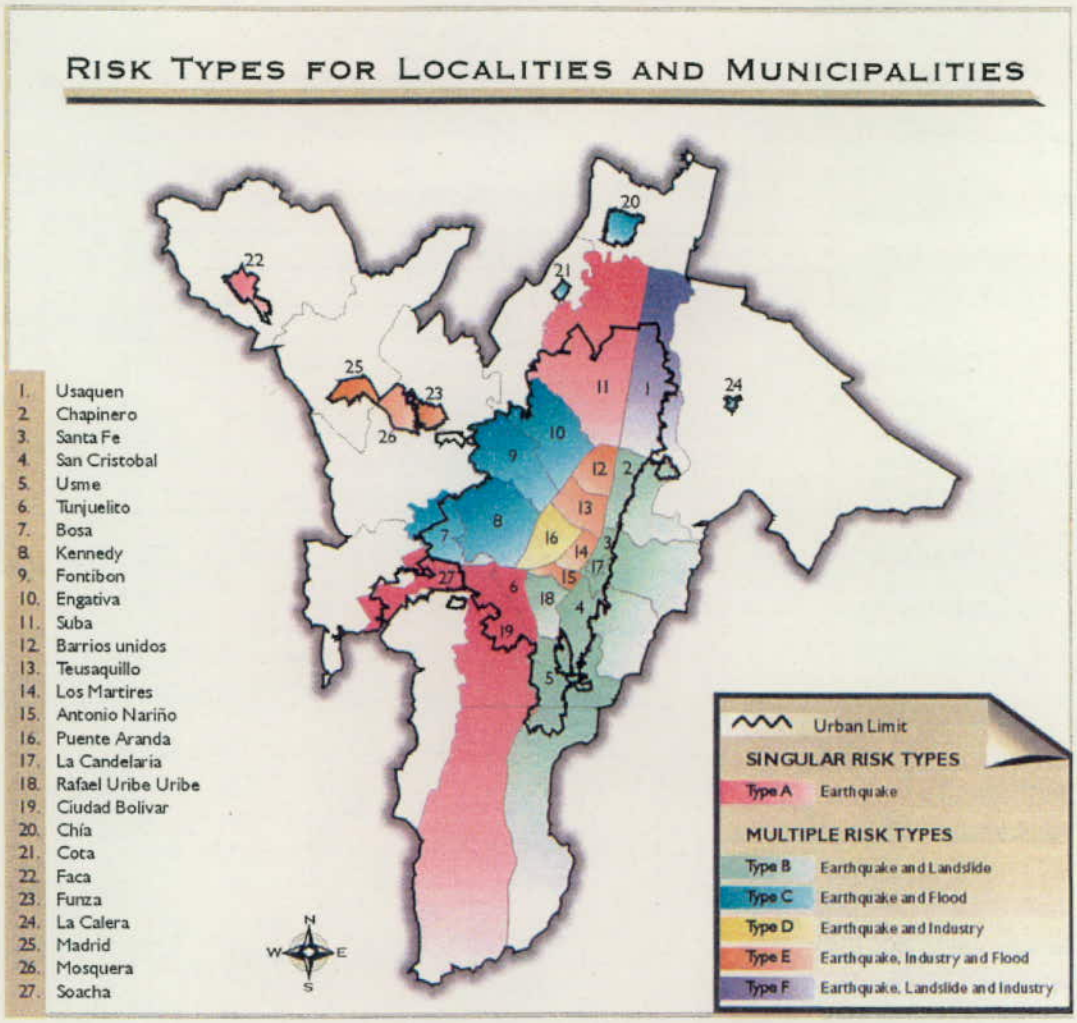


Figure 3.3.6 Distribution of the Risk Types per Area

Disaster types can be categorized into six types, from type A to type F. Type A is the only entry in the singular risk disaster category; the rest is classified as multiple risk disasters. Table 3.3.3 describes the classified risk types for localities and municipalities.

Table 3.3.3 Types of Disasters

Singular Risk Types	
Type A	Earthquake
Multiple Risk Types	
Type B	Earthquake and Landslide
Type C	Earthquake and Flood
Type D	Earthquake and Industry
Type E	Earthquake, Industry and Flood
Type F	Earthquake, Landslide, and Industry

Based on this classification, the urban area of 19 localities of Bogotá city and of eight municipalities of Cundinamarca were classified as follows.

- Type A: Barrios Unidos, Teusaquillo, Mártires, Antonio Nariño, Funza, Madrid, Mosquera.
- Type B: Chapinero, Santa Fe, San Cristobal, Usme, La Candelaria, Rafael Uribe.
- Type C: Bosa, Kennedy, Fontibón, Engativá, La Calera, Chía, Cota.
- Type D: Puente Aranda.
- Type E: Tunjuelito, Suba, Ciudad Bolívar, Facatativa, Soacha.
- Type F: Usaquén.

Figure 3.3.6 describes the distribution of the risk types per area.

CHAPTER 4 DISASTER SCENARIO

4.1 Review of the Existing Disaster Scenario

4.1.1 Earthquake

1) Background

In order to review the existing disaster scenario, the previous microzoning study for Bogotá City, completed in 1997, was reviewed. For the previous microzoning study, an extensive database should have been developed to evaluate the seismic hazards and risks in Bogotá City using the GIS function. However, the Study Team could not find the basic data in the database of DPAE's developed for the microzoning study. The Study Team has tried to re-collect original numerical data set from the INGEOMINAS or Los Andes University, but they were not successful. The results published on the web pages of the DPAE or INGEOMINAS are in image format, not reusable for the Study.

Therefore, the Study Team had to develop a new GIS database for the Study.

The problems of DPAE's database are summarized as follows:

- Mostly image files, not re-usable for further analysis.
- Lack of file organization.
- Lack of basic data of infrastructures for risk analyses.
- Lack of description of its contents; and
- Lack of human interface for end users.

Also the review study on the sub-project reports for the previous microzoning study has revealed the lack of basic information as follows:

- Numerical model used for the ground motion calculation is not described.
- Calculated acceleration distribution in Bogotá is not found anywhere in any form.
- Basic input data for risk analysis is not described at all; and
- Methods used for risk analysis are not fully described in the reports.

For all these reasons mentioned above, the Study Team could review only the results of the previous study.

2) Seismic Microzoning Study in Bogotá

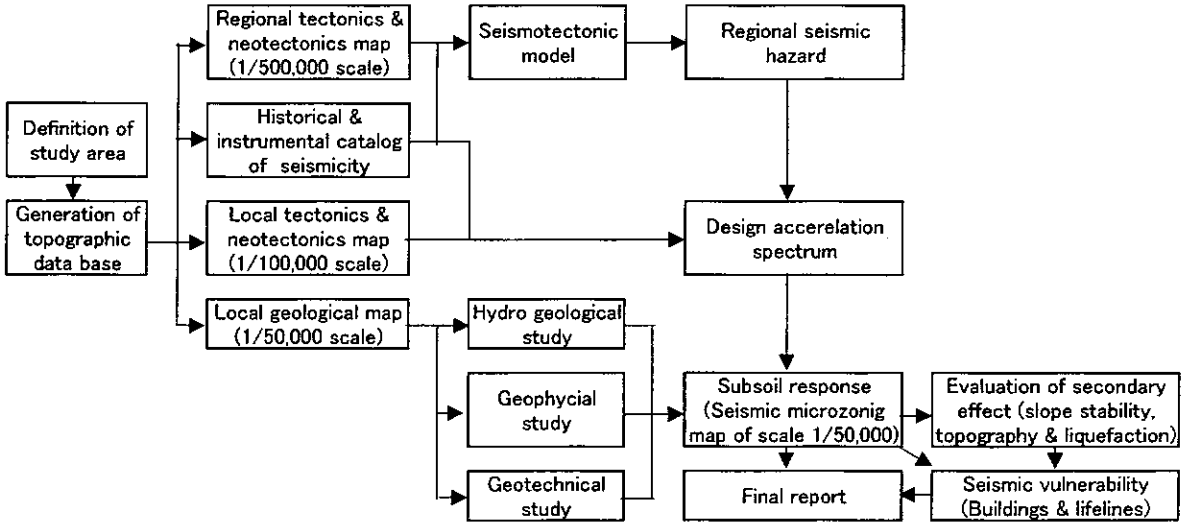
The seismic microzoning study for Bogotá City was completed in 1997 by INGEOMINAS and Los Andes University, in collaboration with UPES and DNPAD. The study consisted of seventeen sub-projects as shown in Table 4.1.1 and lasted 28 months in total.

Flowchart of the microzoning study is illustrated in Figure 4.1.1. The main objective was to evaluate design spectra for Bogotá City according to the geological zoning by seismic response of subsoil.

Table 4.1.1 List of Sub-Projects and Executed Organization

No	Name of sub project	Executed organization
1	Technical direction	INGEOMINAS
2	Geological study	INGEOMINAS
3	Tectonics and neotectonics study	INGEOMINAS, UNIANDES
4	Hydro geological study	INGEOMINAS
5	Seismological study	INGEOMINAS
6	Microtremor	UNIANDES, INGEOMINAS
7	Geophysical study	INGEOMINAS
8	Recompilation of geotechnical information	INGEOMINAS
9	Boring execution	PSI limited.
10	Laboratory and field soil test for geotechnical zoning	UNIANDES
11	Seismic microzonation	UNIANDES
12	Interim and final reporting	INGEOMINAS
13	Technical direction	INGEOMINAS
14	Regional seismic hazard	UNIANDES
15	Seismic vulnerability	UNIANDES
16	Seismic vulnerability	UNIANDES
17	Interim and final reporting	INGEOMINAS

Source: Microzonificacion seismic de Bogotá City, INGEOMINAS 1997



Source: Microzonificacion sísmica de Bogotá City, INGEOMINAS 1997

Figure 4.1.1 Flowchart of Existing Earthquake Hazard Assessment

3) Geological Study

In the Study, three types of earthquakes (subduction, medium and near faults) were selected as the earthquake scenarios as shown in Table 4.1.2. An attenuation formula was developed using

observed ground motion data in Colombia. The input acceleration at bedrock was calculated by the attenuation formula.

Table 4.1.2 Earthquake Scenarios Used in the Seismic Microzoning Study in Bogotá

Type	Source	Distance(km)	Input acceleration at bedrock
Distant	Subduction	400	0.038g
Medium	Frontier of Cordillera Oriental	60	0.12g
Near	Local in Bogota area	15-20	0.20g

Source: Microzonificacion sismica de Bogotá City, INGEOMINAS, 1997

In the study, potential earthquake faults are delineated for three levels: across the country, within a radius of 200km and within a radius of 50km from Bogotá. Thus, this delineation covers sufficient areas of known potential faults, which would affect the Study Area.

These faults were examined to give characteristics such as length, type, annual movement etc. In the study, not only fault length but also fault types were used to estimate the probable maximum magnitude.

As to the attenuation of ground motion, attenuation curve was constructed in the study using observed data in Colombia with limited numbers of data. There are regional characteristics in attenuation, thus it would be appropriate to follow the existing curve.

For the reasons above, it is but proper to follow the procedure and the result of bedrock motion calculation in the previous study over the Study Area, and the acceleration values at ground surface are to be estimated by the Study.

4) Geophysical Study

The extensive set of geophysical studies was conducted to characterize the soil properties in Bogotá. The methods employed for geophysical exploration and their results are listed in Table 4.1.3. The results of these studies are synthesized to construct a numerical ground model to calculate seismic response.

Table 4.1.3 Methods and Results of Geophysical Study

No	Method	Quantity	Maximum depth of	Result
1	Vertical geoelectric sounding	50 lines	<500m	Resistively profile
2	Gravity survey	320 points	<1600m	Distribution of bedrock depth
3	Seimic reflection	15 lines, 10.12km	<2760m	P wave velocity structure profiles
4	Seimic refraction	15 lines, 10.12km	50m to 170m	P&S wave velocity structure profiles
5	Down hole logging	2 points	<13m	P&S wave velocity structure profiles
6	Microtremor	72 points		Distribution of predominant period of ground vibration

Source: Microzonificacion sísmica de Bogotá City, INGEOMINAS 1997

5) Geotechnical Study

Existing boring data were collected and recompiled, including geotechnical boring and groundwater boring. In addition, 38 boreholes were made and distributed across all areas in Bogotá and geotechnical testing using obtained soil samples were done as shown in Table 4.1.4.

The results were used to evaluate dynamic properties of soil for the calculation of seismic response of the subsurface. A formula of rigidity and damping curve versus shear deformation and plasticity index was constructed.

The area having liquefaction potential in Bogotá mentioned in the study was not evaluated quantitatively, but the area is defined on the basis of historical record.

Table 4.1.4 Geotechnical Test Performed and its Quantities

No.	Geotechnical test	Quantity
1	Boring	38 points, 20 m to 250m deep, 2,483m exploration in total
2	Humidity measurement	2000 samples
3	Geotechnical classification	2000 samples
4	Apparent density measurement	1000 samples
5	Specific gravity	100 samples
6	Granulometry	100 samples
7	Simple compression test	1000 samples
8	Static triaxial test	170 samples
9	Dynamic triaxial test	100 samples
10	Consolidation test	100 samples
11	Bender element test	40 samples

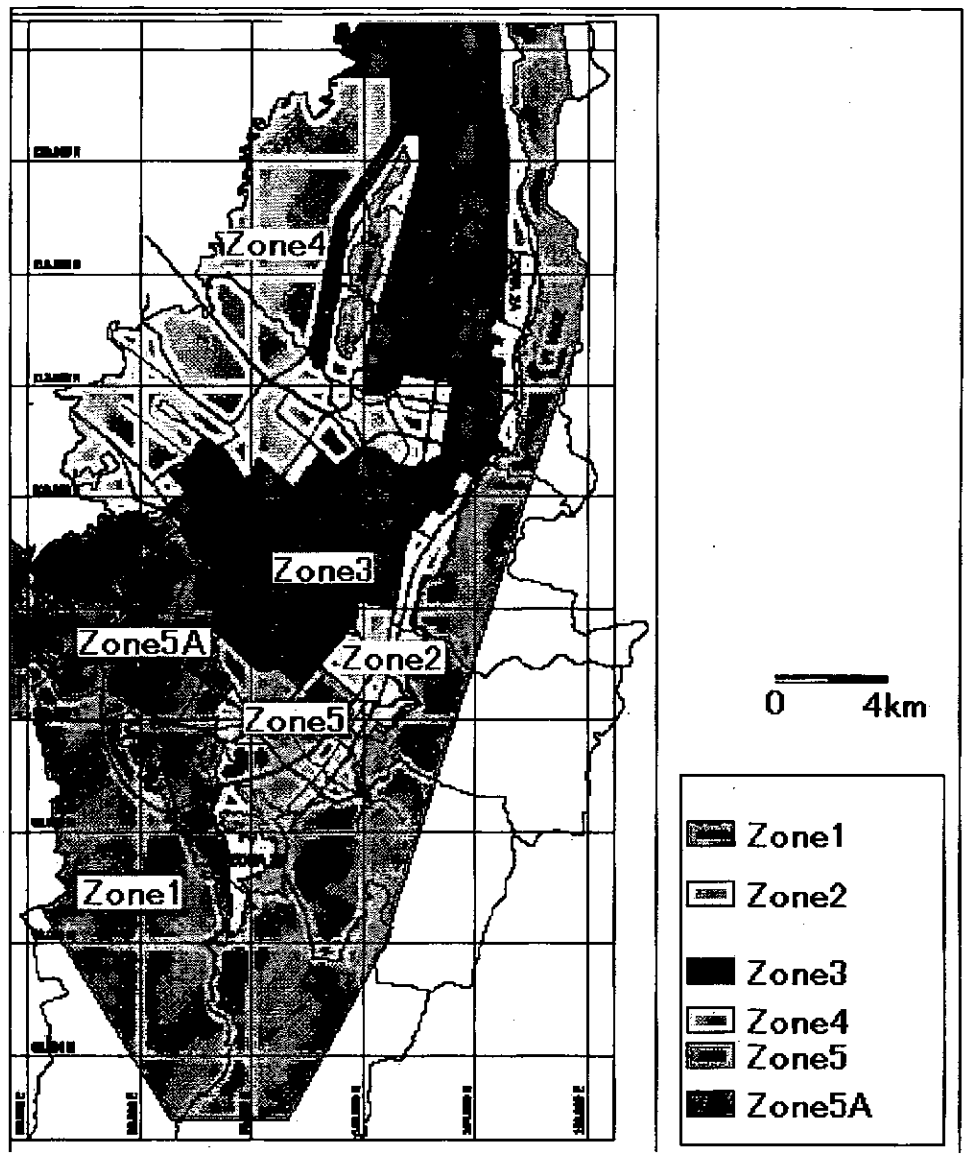
Source: Microzonificación sísmica de Bogotá city, INGEOMINAS 1997

Based on these field studies, the Study classified Bogotá into five geotechnical zones as shown in Table 4.1.5 and Figure 4.1.2.

Table 4.1.5 Geological Microzoning in Bogotá

Zone	Name
1	Mountainous
2	Piedmont
3	Lake deposit A
4	Lake deposit B
5	Terrace and cone
5A	Terrace and cone with liquefaction potential

Source: Microzonificacion sismica de Bogotá city, INGEOMINAS 1997



Source: Microzonificacion sismica de Bogotá city, INGEOMINAS 1997

Figure 4.1.2 Geotechnical Zoning in Bogotá

6) Damage Function

In the previous study on the damage estimation of buildings, the damage function was assumed and adopted in accordance with the definition by Applied Technology Council (ATC) and the building vulnerability was categorized into seven types mainly for residential units.

The damage functions applied in the study are much on the safe side, compared with that obtained from the Quindío earthquake.

7) Seismic Disasters

(1) Bogotá City

According to the seismic microzoning study, seismic damages, i.e., building and lifeline damages and human losses, were estimated based on the acceleration by the three types of scenario earthquakes with daytime and nighttime cases. The daytime and nighttime populations were estimated based on an assumed population by building type.

For estimation of human losses and building damages, Bogotá City was divided into 190 "cells," in which geology, building and administrative divisions are assumed to be homogeneous. The method employed was ATC-13. The total damages due to the three scenario earthquakes are shown in Table 4.1.6.

Table 4.1.6 Results of Total Loss by Scenario Earthquakes

	Daytime		Night		Lost	Destructed	Damage cost
Type	Death	Injured	Death	Injured	house	area(million m2)	(Million USD)
Near	3,500	20,000	4,500	26,000	74,000	33.8	14,000
Medium	1,600	9,000	1,400	7,700	44,000	20.6	8,800
Distant	300	1,600	350	1,900	27,000	12.3	5,100

Source: Microzonificación sísmica de Bogotá city, INGEOMINAS, 1997

The lifeline damages such as aqueduct, electricity and gas were estimated based on ATC-13. Also telephone facility damages dealing with center facilities were estimated based on ATC-13.

(2) Municipalities in Cundinamarca

There has been no seismic microzoning study conducted on the eight municipalities in Cundinamarca.

4.1.2 Landslide

65% of the slope disasters were landslide, and 89% of the slope disasters occurred in Bogotá. In the eight municipalities in Cundinamarca, debris flow and rock fall were relatively high occurrence. One of the major characteristics of the debris flow and rock fall is high probability of human and property damage due to the sudden and quick phenomena, but in Bogotá City possibilities of debris flows are very low.

In Bogotá, debris flow occurred in 1994 and 1995 on the right bank at the elevation of 2,940 m in Quindío, which killed two people and one person respectively. Afterward, gabions were installed in the bank of the river in 1996 and in 1997. At the same time, the width of the river was expanded at the location of the bridges and 63 houses were moved. Moreover, 300 houses near and down the river that were facing to the stream were also moved afterward.

At the site, the riverbed sediments are few, the width of the river is approximately 5m and bank heights are 5m on the left bank and 2m on the right. There is a quarry (Canteras El Zuque, elevation is 3,280m) owned by Bogotá City in the upper reach of the river and it is said to be the source of the debris flow. It is likely that highly dense water stream caused by the outflow of the rock gobs from the quarry ran down bringing the soil mass right below the quarry in it, and pooled at a narrow zone of the river in a densely housed area and from the location of the bridges.

According to the site observation in the quarry, both sides of the main stream were widely dug (especially on the left bank) and large amount of rock gobs exist with a trace of outflow to the stream. Since the dividing ridge is close to the rear side of the quarry, the catchment basin is not large. The amount of the topsoil on the natural slope above the excavated rock wall is little and possibility of outflow is low.

Based on the above-mentioned conditions, it is concluded that the origin of the debris flow at the site is not the top soil on natural slope nor riverbed sediment, but gathered water at the quarry running down with rock gobs. Therefore, the disaster at the site could be prevented by removing the rock gobs and by constructing a slit type dam below or in the quarry. This debris flow is a special case and it is expected that no debris flow would be occurring in other rivers in Bogotá City.

Although many landslides have occurred in Bogotá City, only one person was killed in the past 5 years. It indicates that there is fairly enough time for evacuation or countermeasure before occurrence of the disaster in case of landslides. Also, the signs of landslides can easily be found in the densely populated area. It is one of the factors that reduced the risk of human loss by the landslides.

The earthquake disaster scenario for landslides is taken into consideration by using the lateral ground acceleration in slope stability analysis. However, it is taken into account only in each individual countermeasure design and there is no hazard map presented.

4.1.3 Flooding

Bogotá City has a scenario for flood disasters set based on the flood risk map for Bogotá City, which was prepared based on the flood hazard areas by the probable floods of 100-year and 10-year return periods.

The eight municipalities of Cundinamarca have flood risk maps for flood disasters prepared based on the actual flooding or inundation areas in the past without the assessment from hydrological aspects.

In order to develop an optimum flood risk map for the Bogotá Metropolitan Area, it is necessary to conduct a flood analysis of the Rio Bogotá and to identify flood problems in the Bogotá Metropolitan Area.

4.1.4 Industrial Facilities

A study was conducted by Los Andes University about the potential effect of industrial facilities in the localities of Puente Aranda and Fontibón on the following:

- The life of the district habitants.
- The life of industrial employees.
- The public service infrastructure.
- The urban furniture.
- The activity of the city's productive area.
- Institutions that support the society (schools).
- Massive events installations.
- Health care centers.

Risk generation process might define several failure scenarios. For instance, if an earthquake were taken as a risk generation process, there could be defined scenarios in terms of the most probable earthquake, the most frequent one, etc. However, what Los Andes University studied was fire, explosion, spill and leakage events in normal times, not in an earthquake.

The discussed model should lead to the definition of a certain level of consequences per scenario considered. The results per scenario might represent different levels of evidence that support the final decision. In general, there must be evaluated the consequences in terms of human lives, economic aspects and damages to the physical infrastructure. The consequence should be identifiable based on a parameter or index that supports the decision. Comments by the Study Team about the Los Andes University study are as follows:

- The analysis method used by Los Andes University is nearly the same method (Fire, Leakage, Spill) applied in Japan except explosion blast pressure influence (11,760Pa (=0.12kgf/cm^2), which corresponds to the window glass breakage. This is important because the degree of damage to the public is determined by blast pressure at the residential area.
- For the leakage calculation, amount of chemical substance is assumed; however actual leakage amount assumption in case of real accidents is very difficult to calculate. So worst-case scenario like in the EPA or OSHA risk analysis method should be applied to judge the risk. Worst-case scenario is probable at the time of strong earthquake.

4.2 New Disaster Scenario

4.2.1 Earthquake

1) Basic Concept of Microzoning

(1) Seismic microzoning

In order to mitigate damage due to a possible disaster in the future in a given area, it is important to have knowledge of its disaster history, to understand its current status of disaster prevention and response, and to evaluate possible disasters in the area in future.

In this study, seismic microzoning is defined as hazard and risk evaluation study for a possible future earthquake that would affect the Study Area.

Seismic microzoning is one of several diagnostic studies to evaluate seismic hazard such as ground motion distribution or liquefaction, and landslides in a certain area due to the possible earthquake in future, and then to evaluate associated risks such as human casualties, building damages, infrastructure/lifeline damages. The result of such study will be used as a basic information to make an effective disaster prevention plan. Seismic microzoning study treats the given Study Area as a collection of subdivided small zones called microzones, which are used as a unit for hazard and risk evaluation. Seismic microzoning study should evaluate the possible damage for large quantities of data in the Study Area such as population, building, and infrastructures; it employs basically a statistical approach. The flow of the seismic microzoning in the Study is shown in Figure 4.2.1.

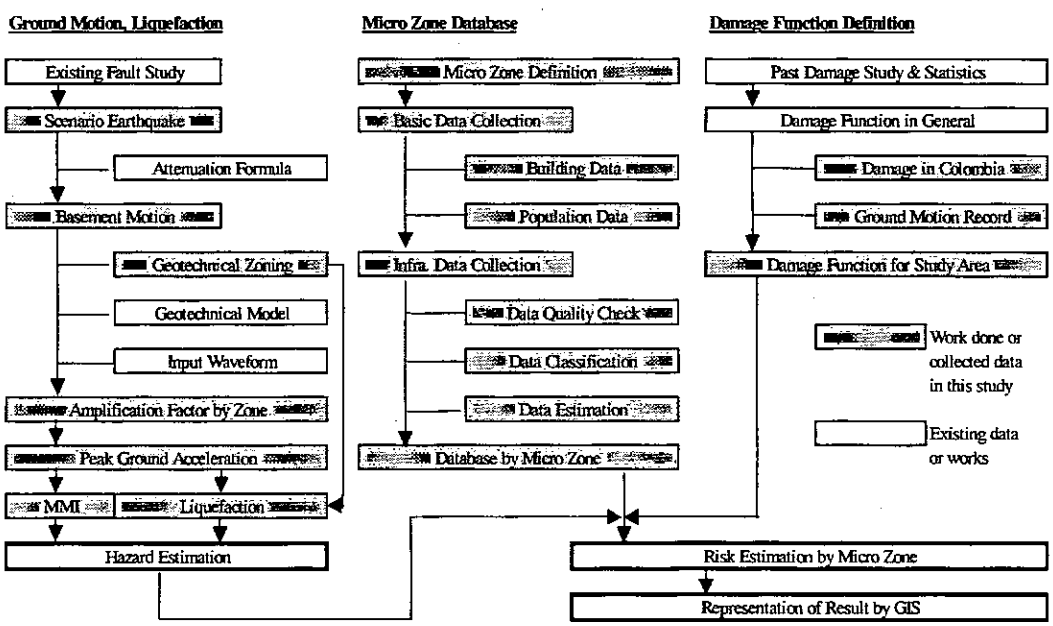


Figure 4.2.1 Flowchart of Seismic Microzoning in this Study

2) Basic Conditions

(1) Scenario earthquake

A. Fault parameter

This Study considers three scenario earthquakes, the same as in the previous microzoning study. They are MZSB97: "Near earthquake," which involves the effect of faults within a radius of 50km from Bogotá, "Regional earthquake," which involves the effect of faults within a radius of 200km from Bogotá, and subduction event in the Pacific coast at a distance of 400km from Bogotá. In MZSB97, uniform distribution of bedrock acceleration was assumed within Bogotá. The scenario earthquakes for the Study are taken as a more specific and realistic approach for the following reasons:

- Non-uniform distribution of bedrock acceleration is taken into account, due to the larger spatial extension of the Study Area; and.
- Most probable and typical earthquakes are considered to simulate realistic situations in a possible event for disaster mitigation planning.

Therefore, among the faults listed in Table 2.1.2 and Table 2.1.3, two faults are selected as scenario earthquakes to evaluate risk analysis, in addition to the subduction event, which is not specified. Criteria of fault selection are as follows:

- Faults classified as "High activity".
- Fault with largest "Maximum Probable Magnitude".
- Fault that satisfies the distance as specified in MZSB97.

Regarding the fault parameters, the magnitudes are taken from MZSB97, estimated by fault characteristics such as fault type. Fault rupture length is taken as a segment length indicated as "Longitude with neotechtonic range" in MZSB97. As the result, scenario earthquakes for the Study are shown in Table 4.2.1. The selection of the scenario earthquake is shown in Appendix 4.2.1.

Table 4.2.1 Faults for Scenario Earthquakes

Case	Fault name	Type	Magnitude	Total fault length (km)	Fault rupture length (km)	Distance (km) *
1	La Cajita	Near	6.4	35	10	20
2	Guayuriba	Regional	7.0	60	29	60
3	Subduction	Subduction	8.3	--	--	400

* Closest distance from INGEOMINAS
Source: Microzonificación sísmica de Santa Fe de Bogotá, INGEOMINAS 1997

B. Attenuation of ground motion at basement

Seismic basement

Seismic waves generated by fault movements spread along the basement as its amplitude decreases with distance, then finally amplified by the effect of surface geology. In order to calculate ground motion at specific site, "seismic basement" is usually defined. Seismic basement is defined as a geological stratum where incident seismic wave can be commonly treated, impedance variation beneath the stratum is negligible, and seismic wave is geologically uniform. Then the ground acceleration can be treated by the difference of surface geological effects.

Attenuation Relation

There are various studies to evaluate attenuation of ground motion. Figure 4.2.2 shows attenuation of ground motions used for the Study, proposed by McGuire (1974) as shown in equation 4.2.1. It is used as it gives almost the same value as the attenuation curve proposed in MZSB97.

$$A=472*e^{0.64M}*(R+25)^{-1.30} \quad \text{(Equation 4.2.1)}$$

Where:

A: Acceleration at basement (gal).

M: Magnitude of earthquake.

R: Distance from fault (km).

The calculation point for each microzone is taken at the center of each microzone. The distance to the fault from each calculation point is taken as minimum distance from the fault for case 1 and case 2. As to the case 3, uniform value at basement is used because the Study Area is 400km from the source so that the difference in distance is negligible.

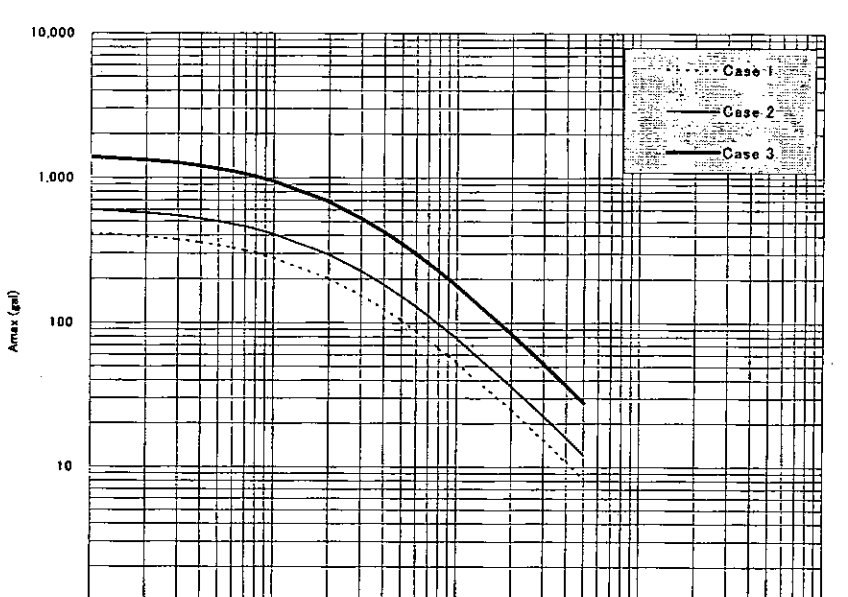


Figure 4.2.2 Attenuation of Ground Motion at Basement

C. Acceleration distribution at basement

Using the magnitude for each fault and distance, acceleration at bedrock is calculated at the center of each microzone.

Case-1: La Cajita Fault

La Cajita Fault locates in south of Soacha, thus base rock acceleration up to 0.5g in the southern part of the Study Area appears due to its proximity to the fault. At the southern part of Bogotá, base rock acceleration varies from 0.2g to 0.3g.

Case-2: Guayuriba Fault

Major part of the Study Area is in the range from 0.1g to 0.2g. In northeastern part of the Study Area, basement acceleration is less than 0.1g due to the attenuation.

Case-3: Subduction

Basement acceleration is the same for the whole Study Area, due to its long distance from the fault.

(2) Evaluation of surface geology

A. Geological zoning

Geological data collection

Based on aerial photo interpretation and site visits to verify an existing geological map, a geological zoning map is prepared for the Study Area. Geological zoning map of 1/50,000 scale was made and served as a basis to make a geotechnical-zoning map later on.

B. Geotechnical zoning

The Study Team collected existing boring data from related organizations such as DPAE, INGEOMINAS, EAAB, CAR, DAMA, IDEAM, INVIAS, Cundinamarca government, planning office in each municipality etc.

Geotechnical boring data collection

Data have been collected on 417 geotechnical boring as shown in Table 4.2.2. Out of them, 254 sites that have coordinates are used for geotechnical zoning. They are distributed in the entire municipalities in the Study Area. These boring data contain some in-situ test result, but maximum depth of exploration is less than 30m outside Bogotá.

Within Bogotá, there are 57 boring sites with geotechnical properties, which enable the performance of seismic response analysis. On the contrary, boring data in municipalities in Cundinamarca do not contain enough information to do such analysis.

Table 4.2.2 Number of Geotechnical Borings with Data Collected

Municipality	No. of study	No. of boring	No. of boring with coordinate	Explorated depth(m)
Bogota	N/A	57	57	20.0 - 250.0
Chia	8	45	15	2.5 - 7.0
Cota	5	15	8	5.0 - 21.0
Facatativa	9	76	50	3.0 - 20.0
Funza	3	17	17	2.0 - 14.0
La Calera	7	43	27	2.5 - 10.0
Madird	4	39	30	4.0 - 12.0
Mosquera	8	83	44	4.3 - 30.0
Soacha	5	42	6	3.0 - 5.0
Total	49	417	254	

Source: JICA Study Team

Groundwater boring data collection

The distribution of boring data collected for groundwater study is shown in Table 4.2.3. In total, data on 59 boring sites were collected. The boring for groundwater study reaches to 530m deep at maximum, but they contain only geological descriptions.

Table 4.2.3 Number of Groundwater Borings with Data Collected

Municipality	No. of boring	Explorated depth(m)
Chia	2	121.0 - 145.0
Cota	9	48.0 - 530.0
Facatativa	12	60.0 - 400.0
Funza	12	173.0 - 510.0
La Calera	0	N/A
Madird	18	140.0 - 400.0
Mosquera	3	202.0 - 500.0
Soacha	3	201.5 - 360.0
Total	59	

Source: JICA Study Team

Geotechnical zoning

Geotechnical zoning map with a scale of 1/50,000 is based on collected boring data, topographic map, and geological zoning map. The classification is described in Table 4.2.4, with correspondence to the zone made in MZSB97.

Table 4.2.4 Geotechnical Classification Defined in this Study

Zone	Zone in MZSB97	Name	Characteristics
1	1	Sedimentary rock predominantly sandy	Sandstone of Guadalupe group, sandstone formation of Regadera, Cachi formation
2	1	Sedimentary rock predominantly clayey	Chipaque, Guaduas and Bogota formation
3	2	Residual soil	Product of meteorization from parental material
4	2	Piedmont soil	Deposit of slope or pending (located preferencially in the base of the hills in the form of cone or fan) Slopes, coluvions, and fluviogracial deposit.
5	5, 5A	Terrace and cone	Preconsolidated clay with intercalation of sandy soils. It can contain layers of peat of thickness less than 4m in the depth deeper than 30m.
6	3	Lake deposit A	Soft clay of high compressibility with thickness more than 50m.
7	4	Lake deposit B	Soft clay of higher compressibility, with thickness from 200m to 400m or more.
8	--	Riverbed and wetland	Clayey deposit of lacustrine origin or of alluvial type innundation. In this zone also exist the body of water such as river, quebrada, wet zone, old lakes and innudation zone.
--	--	Garbage fill	Filled by garbage
--	--	Excavation	Filled excavation

Source: JICA Study Team

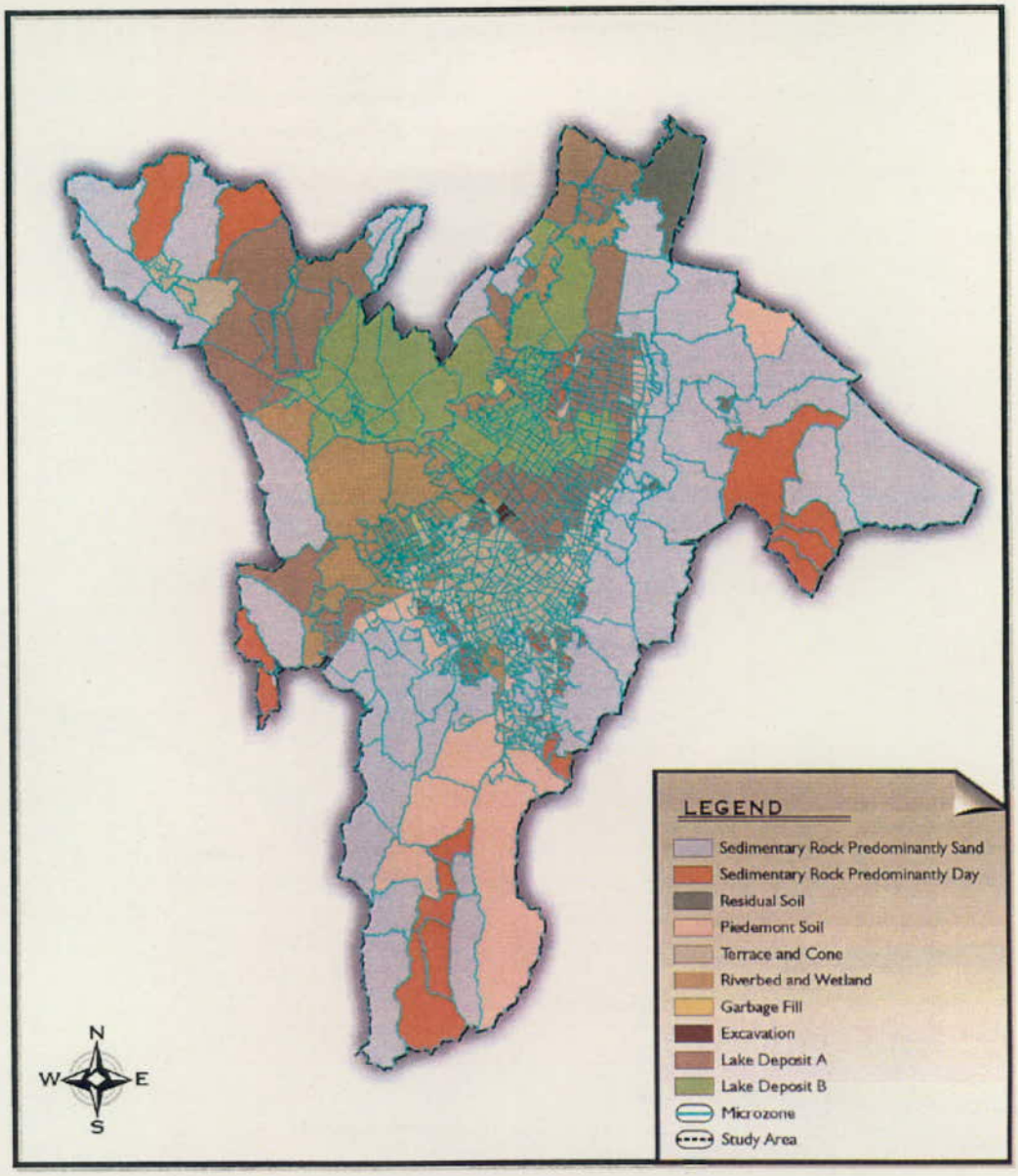
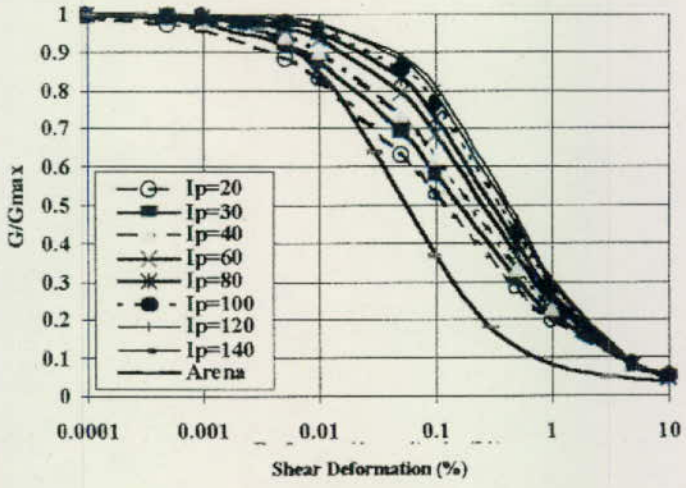


Figure 4.2.3 Geotechnical Classification by Microzone

Source: JICA Study Team

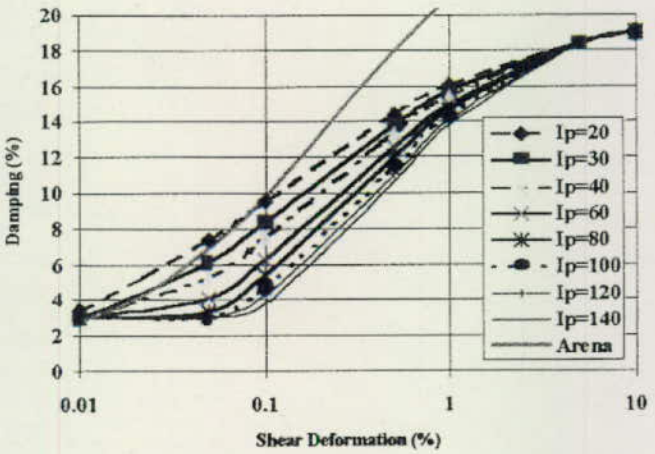
C. Transfer function for surface geology

To evaluate the seismic response, dynamic properties of soil such as variation in shear modulus and damping versus shear deformations are necessary to evaluate a non-linear behavior of soil at greater level of deformation. Such properties for different cohesive soils and granular soils are proposed from laboratory testing and collected geotechnical data using plasticity index (Ip) as an index in MZSB97. Their results are shown in Figure 4.2.4 and Figure 4.2.5.



Source: Microzonificación sísmica de Santa Fe de Bogotá, INGEOMINAS 1997

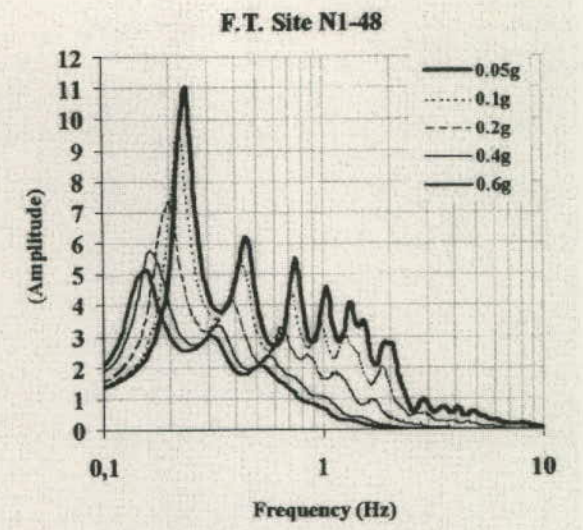
Figure 4.2.4 Shear Modulus Variation of Soil in Bogotá



Source: Microzonificación sísmica de Santa Fe de Bogotá, INGEOMINAS 1997

Figure 4.2.5 Damping Variation of Soil in Bogotá

Using dynamic properties of soil, one dimensional response calculation is made, and resulted transfer function for boring sites in Bogotá are shown in Figure 4.2.6. However, geotechnical boring data collected for municipalities in Cundinamarca lacks dynamic properties to calculate transfer function. Therefore, to estimate the transfer function for the municipalities in Cundinamarca, the following steps are taken:

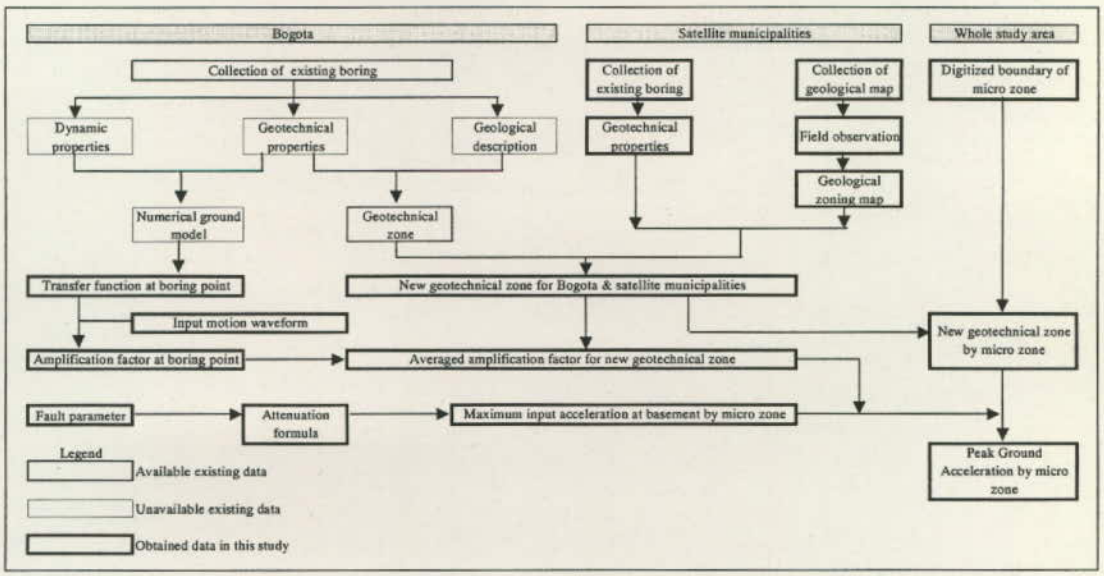


Source: JICA Study Team

Figure 4.2.6 Amplification Factors in this Study

- Calculate PGA at 57 points for 3 input waveforms.
- Calculate amplification factor (PGA/input level) for each calculation.
- Calculate average amplification factor for each geotechnical zone.
- Calculate PGA multiplying basement acceleration by amplification factor for whole area.

The process of this application is shown in diagram in Figure 4.2.7. The procedures and limitation in the evaluation of amplification by subsoil is shown in Appendix 4.2.2.



Source: JICA Study Team

Figure 4.2.7 Flowchart for Calculation of Peak Ground Acceleration

(3) Strong motion calculation

A. Input ground motion records

The input waveform records used in this study to calculate ground acceleration are the same records used in MZSB97 as shown in Table 4.2.5. These waveforms are shown in Figure 4.2.8.

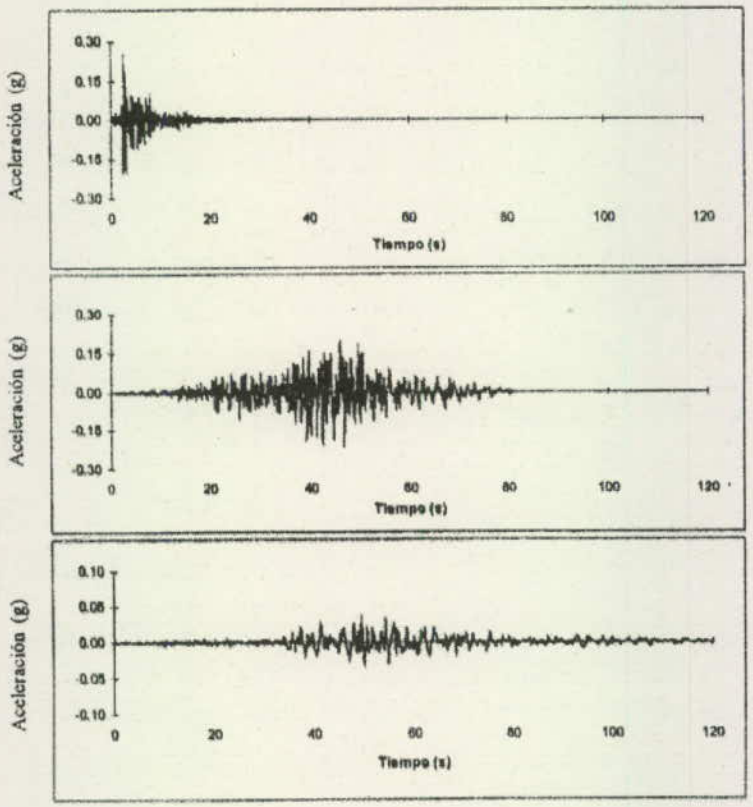
Table 4.2.5 Input Waveforms

Case	Site name	Earthquake name	Date	Magnitude	Distance (km)	Input level (g)**
1	Corralitos	Loma Prieta, USA	198910/17	Ms=7.0	10	0.20
2	El Rosal	Tauramena, Colombia	1995/1/19	Ms=7.2*	60	0.12
3	Ciudad Universitaria	Michoacan, Mexico	1985/8/19	Ms=8.1	400	0.038

* Synthesized from original record

** Input level at INGEOMINAS

Source: Microzonificación sísmica de Santa Fe de Bogotá, INGEOMINAS 1997

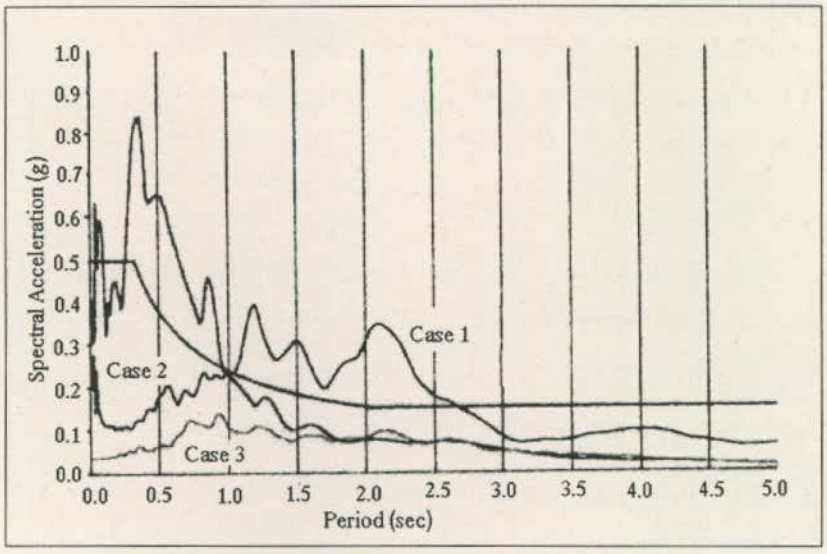


Source: Microzonificación sísmica de Santa Fe de Bogotá, INGEOMINAS 1997

Figure 4.2.8 Input Waveforms (Top:Case 1, Middle:Case 2, Bottom:Case 3)

The records used for case 1 and case 3 are the records obtained during significant damaging earthquakes at similar distance respectively. The record used for case 2 is a synthetic record calculated by Empirical Green's Function method from a small earthquake.

Each record demonstrates different frequency components and spectral amplitude as shown in Figure 4.2.9, as they are obtained from different types of seismic event at different distances from the epicenter. The record for case 1 has a sharp peak at 0.4 second, while the record for case 2 has various peaks at 0.6 second, 1.1 second and 2 seconds. The record for case 3 has a smooth spectrum, with a small peak at around 0.6 second.



Source: Microzonificación sísmica de Santa Fe de Bogotá, INGEOMINAS 1997

Figure 4.2.9 Response Spectrum of Input Waveform Records

The peak acceleration of input waveform at each point of calculation is adjusted to match the bedrock acceleration as calculated by attenuation formula, under period of time. The basement acceleration is shown in Appendix 4.2.3.

B. Peak ground acceleration

Peak ground acceleration (PGA) is calculated using input motion record and transfer function. The results of calculation is shown in Appendix 4.2.4.

Case-1: La Cajita fault

PGA is from 0.7g to 1g in microzones where fault is included. Microzones with PGA between 0.3g and 0.5g are mostly observed in the southern half of Bogotá; however, they are also observed in some microzones in the northern part of Bogotá and some part of La Calera, due to the site amplification. In a major part of the northern part of the Study Area, PGA varies from 0.1g to 0.2g.

Case-2: Guayuriba fault

PGA varies from 0.3g to 0.5g in the center of Bogotá and southern part of the Study Area, but PGA decays from 0.2g to 0.3g in the northwestern part of the Study Area due to the attenuation. PGA in most of the suburb of the Study Area falls in the range of 0.1g to 0.2g.

Case-3: Subduction

PGA is less than 0.1g in more than half of the Study Area. In the central part of Bogotá and northwestern part of the Study Area, PGA is between 0.1g and 0.2g, due to the amplification of the thick lake deposit.

C. Seismic intensity

PGA is converted to Modified Mercalli Intensity (MMI) using empirical relationship proposed by Trifunac & Brady shown below as Equation 4.2.2, to evaluate various risks. MMI scale description is given in Appendix 4.2.5.

MMI=(Log(PGA)-0.014)/0.3 (4.2.2)

Figure 4.2.10 shows distribution of MMI for three cases.

Case-1: La Cajita Fault

In the southern end of the Study Area, which is close to the fault, MMI varies from IX to X. While MMI is VII in most part of the Study Area, some distant zones from the fault are in MMI VIII due to the amplification by site condition.

Case-2: Guayuriba Fault

MMI in majority of the Study Area, most part of Bogotá and northwestern part of the Study Area appear to be VIII. The rest of the area is in MMI VII, with exception of northwestern end of the Study Area with MMI V and one microzone in southeastern edge that appears to be in scale of MMI IX.

Case-3: Subduction

Microzones with MMI VII are found in the center of Bogotá and northwestern part of the Study Area, due to the amplification by thick lake deposit. MMI for mountainous area in the suburb of the Study Area remains at V.

D. Liquefaction evaluation

In general, liquefaction occurs where loose fine sand and high water table exists, together with intensive ground motion. Liquefaction is known to repeat at the same site for different earthquakes, thus historical record of liquefaction serves as a good reference to identify the possible area of liquefaction due to a possible earthquake in the future.

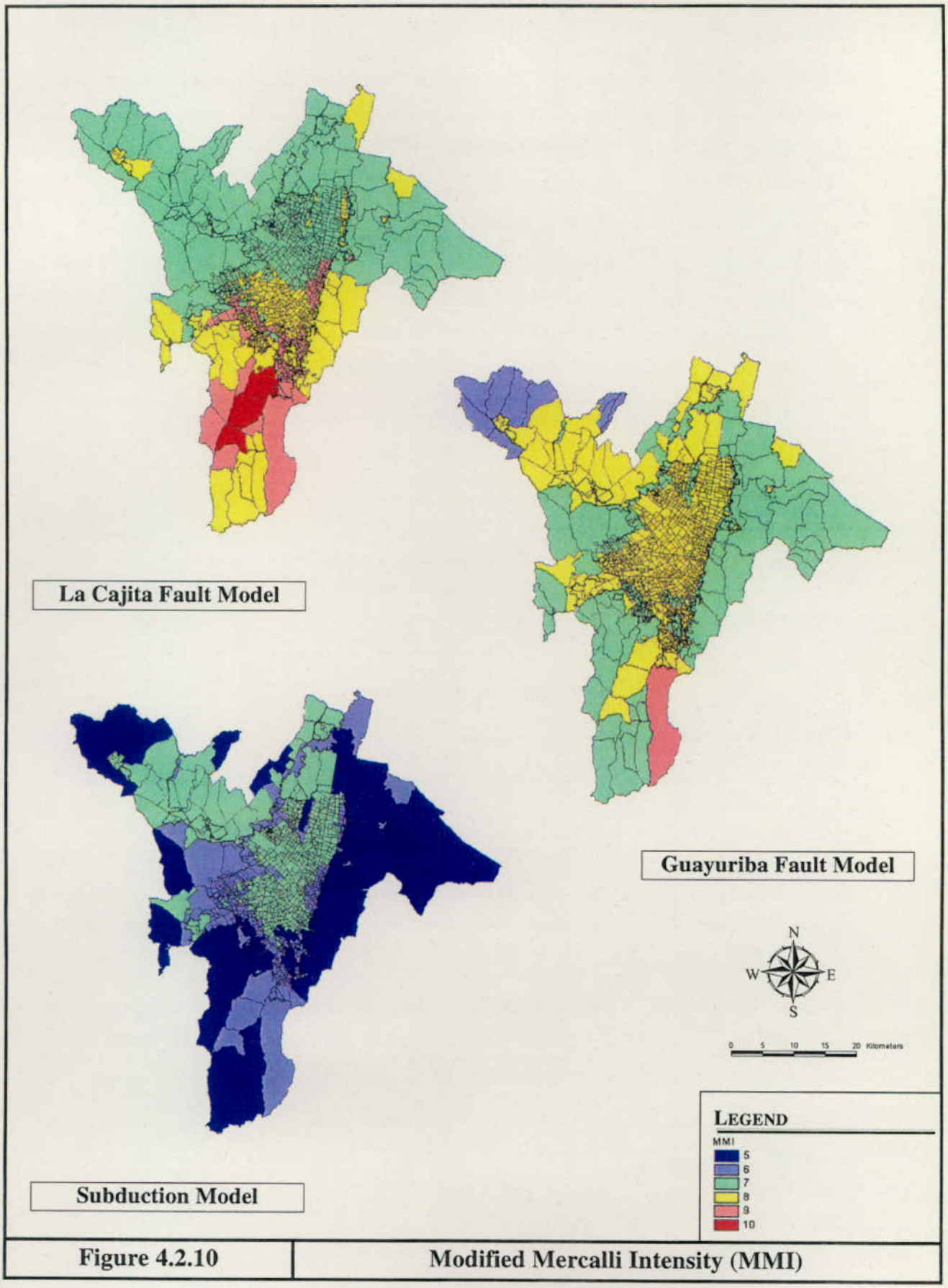


Figure 4.2.10 **Modified Mercalli Intensity (MMI)**

Japanese method

In Japan, liquefaction has been a subject of study in the field of earthquake engineering since the experience of the 1964 Niigata earthquake, when liquefaction caused significant damage to buildings, bridges and an oil refinery built in a newly developed area on reclaimed land which was part of a riverbed.

Following method is proposed as a grade-1 method by the International Society of Soil Mechanics and Geotechnical Engineering:

- In terms of seismic intensity, significant liquefaction is expected to occur where ground is Alluvium soil and MM Intensity is greater than VIII.
- In terms of topography, liquefaction possibility is expected as shown in Table 4.2.6.

Table 4.2.6 Liquefaction Possibility Evaluated by Topography

Rank	Topography	Liquefaction possibility
A	Existing river bed, Old river bed, Wet land, Reclaimed land, lowland between dune	High
B	Fan, Natural bank, Sand dune, Flood plain, Sea shore, other lowland	Possible
C	Plateau, Hill, Mountain	Low

Source: "Manual for zonation on seismic geotechnical hazards,"
Technical Committee for Earthquake Geotechnical Engineering, TC4 ISSMGE 1998

Method Used in this Study

The area having liquefaction potential in Bogotá was mentioned in an existing study based on the description in historical documents.

In this study, new boring data in Bogotá are obtained and used to revise the liquefiable area from a geotechnical point of view. In general, the deposit in the Rio Tunjuelito contains fine sand, while the deposit along the Rio Bogotá is made up from mostly clayey material, which has less possibility of liquefaction.

However, due to the lack of sufficient quantitative data such as soil grain size destitution, standard penetration testing N-values, and water table, detailed evaluation of liquefaction in this study is not possible. Therefore, rough evaluation method is employed using existing information.

In this study, the area subjected to liquefaction evaluation is the above-mentioned revised liquefiable area and zone 5. Together with seismic intensity estimated in this study and geotechnical condition, liquefaction possibility is evaluated by the criteria as shown in Table 4.2.7.

Table 4.2.7 Criteria for Liquefaction Evaluation used in this Study

	Area		
Seismic Intensity (MMI)	Liquefiable area defined by boring data	Zone 5	Others
VIII or more	Highly Probable	Probable	None

Source: JICA Study Team

The result of the evaluation is as follows and is presented in Figure 4.2.11.

Case-1: La Cajita Fault

Probable liquefiable area appears to be in the newly defined liquefiable area, and possible liquefiable area appears to be in zone 5.

Case-2: Guayuriba Fault

Probable liquefiable area appears to be in most of the newly defined liquefiable area, and possible liquefiable area appears to be in zone 5.

Case-3: Subduction event

No possible liquefaction area is defined due to the low seismic intensity in the area for liquefaction area.

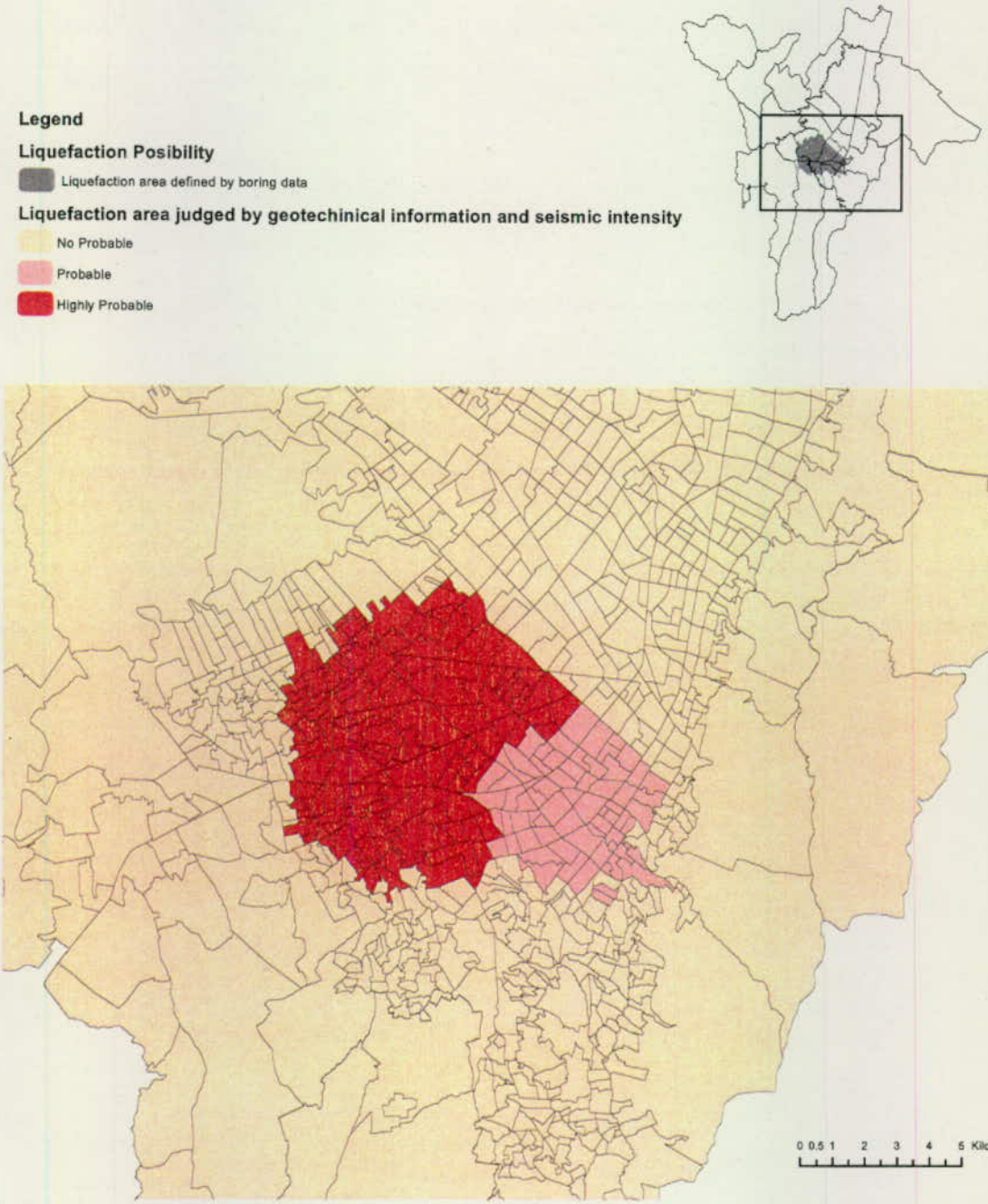


Figure 4.2.11 **Liquefaction Potential Area**

(4) Collected data for estimation

A. Building data

In this study, the building inventory database was prepared based on 2000 cadastral data. In Bogotá City, cadastral data are collected at the Bogotá cadastral office, while Cundinamarca data are prepared by IGAC office, which is the agency responsible for cadastral data collection in Cundinamarca. The flow chart of database preparation is shown in the following Figure 4.2.12.

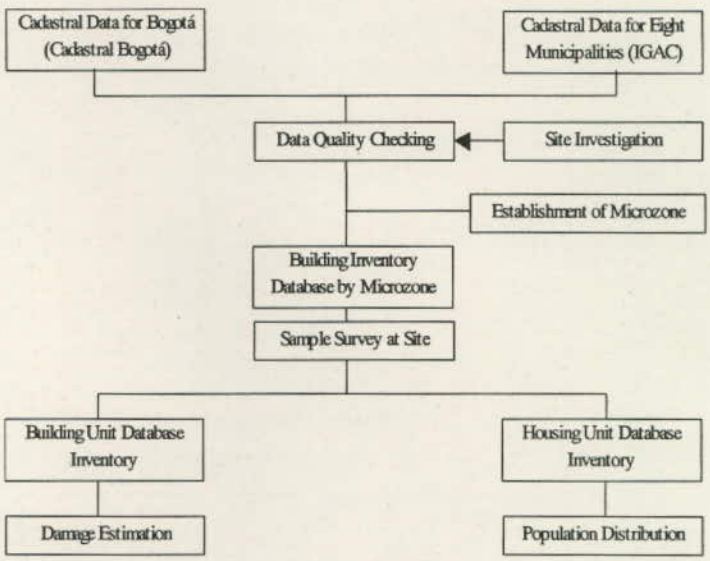


Figure 4.2.12 Building and Housing Unit Database Construction Process

The cadastral data of Bogotá City contain two types of information:

- Non-horizontal property data, which pertain to normal buildings.
- Horizontal property data, which are high-rise building data.

The non-horizontal property data (NHP) have 901,600 records, which include houses, lots and other establishments. Similarly, the horizontal property (PH) data has 49,901 representing units which represents 858,464 apartments units.

The horizontal property data are represented as follows:

- Representative and Representing apartment per building.
- Data of the summary of building complex.

For non-horizontal property, the number of houses is counted for each *manzana* and the number of housing units and number of buildings in each *manzana* are counted.

Cadastral data of Cundinamarca are collected from IGAC office. Their data comprise horizontal property and non-horizontal property of all eight municipalities. Similar analysis is carried out for the Cundinamarca data.

Table 4.2.8 Original Distribution of Records in the Database

Area	NPH records	PH records
Bogotá	901,600	49,901 Representing
		858,464 Represented
Eight Municipalities	148,610	6,000

In order to verify the reliability of the cadastral data, the Study Team carried out field surveys to match cadastral data and exact housing units at site. The Study Team selected randomly more than 300 samples from the whole Study Area. The field survey found that the cadastral data is reliable, except for the year of construction and number of stories in Bogotá. Cadastral data in Bogotá City shows that more than 90% has the year of construction as 1999 and the number of stories as a negative figure and huge figures like more than 70 stories. The Study Team could not use this data for analysis.

The Study Team found that there are few building units without data for the structure. This oversight was corrected based on the *manzana* data.

The number of buildings in each locality and municipality is shown as follows:

Table 4.2.9 Summary of Buildings in the Study Area

Area	Number of Buildings
Bogotá	752,063
Eight Municipalities	127,561
Total	**879,624**

B. Population data

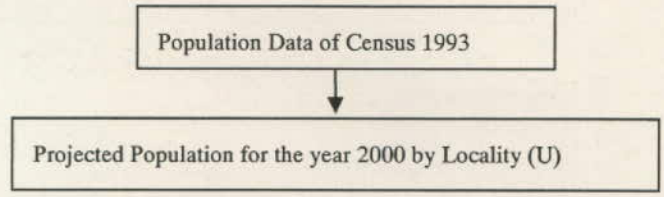
Population distributions for Bogotá and the other municipalities were done separately because of the availability of data in each area.

The population data for Bogotá are established based on the projection of the population for locality for the year 2000. This is done in three stages:

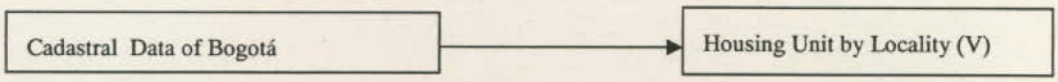
- Population Projection: The population of census 1993 by locality of Bogotá is projected for the year 2000 by the planning department of Bogotá. In the present study, these data are used.
- Housing Units Estimation: Using the cadastral data of Bogotá, housing units in microzones were estimated. These data were later grouped for each locality in Bogotá.
- Distribution of Population in Microzone: Once housing units were determined for each locality, number of residents in each housing unit was established for each locality.

This factor was used to determine the population in each microzone. The process is schematically shown in the next page.

1. Population Projection



2. Housing Units Estimation



3. Population Estimation by Microzone

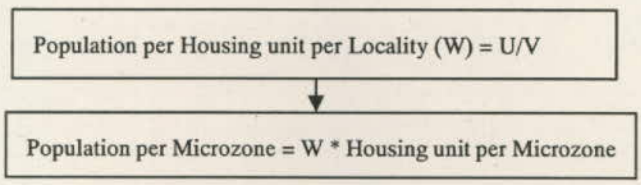


Figure 4.2.13 Population Projection Procedure

For eight municipalities, DANE data was obtained for rural and urban areas. For each microzone, housing units are estimated based on IGAC cadastral data. The total population was distributed in these microzones based on the number of residents living in each housing unit, a factor estimated previously for each municipality.

Based on the above method, the population obtained is as follows.

Table 4.2.10 Summary of Population

Area	Population
Bogotá	6,378,928
Eight Municipalities	606,581
Total	**6,985,509**

C. Establishment of microzone

The microzoning system was established in the Study Area by observing two factors:

- The possibility of aggregating data from the existing spatial division; and
- The homogeneous behaviour of a seismic event.

Based on the above, the microzoning system was established as follows:

Table 4.2.11 Summary of Microzoning System

Area	Rural	Urban
Bogotá	Village Boundary	Cadastral Barrio
Eight Municipalities	Village Boundary	Urbanized area of IGAC cadastral data divided in DANE Sector

The number of micorozones in the Study Area is shown as follows:

Table 4.2.12 Summary of Microzones

Area	Number of Microzones
Bogotá	950
Eight Municipalities	110
Total	**1,060**

In each microzone, collected data are distributed and a database for microzones is established. The databases are used as a unit of analysis.

3) Damage Estimation

(1) Building

A. Collected data

The building database was established based on the cadastral data in 2000. Main structures of the buildings are categorized into several types such as adobe, stone, wood, bahareque, prefabrication, masonry and concrete. Bahareque is a vernacular for mixed structure of adobe and wooden timber. Prefabrication means manufactured structural elements of thin concrete panels. The thickness of the panel is so small, more or less 10 cm that the structural reliability is almost equal to the adobe structure. Masonry is clay-brick walled structure and has two types: non-reinforced masonry and confined or reinforced masonry. Non-reinforced masonry has only mortar and/or mud as adhesive for bricks without any reinforcing steel bars. Confined masonry denominates both reinforced brick wall structure with reinforcing steel bars and masonry filled slender RC (reinforced concrete) frame structure. Concrete structure is classified into two types, that is, the concrete structure with 3 stories or less and the concrete structure with more than 4 stories.

The database contains various information for property tax collection purpose. For this study, following data are utilized for the building damage estimation:

- Type of building.
- Number of stories.
- *Estrato.*

The characteristics of the buildings in the Study Area can be summarized as follows:

- Cadastral data indicates that the total number of buildings in Bogotá city is approximately 752 thousand while the masonry buildings are approximately 666 thousand occupying

almost 88% of the total. In the 8 municipalities, the total number of buildings is roughly 128 thousand while the masonry buildings are approximately 111 thousand occupying 88% of the total. Therefore, in the whole Study Area, the number of buildings in total is approximately 880 thousand and that of masonry buildings is around 777 thousand. Masonry buildings share approximately 88% in the Study Area.

- Masonry structures are mainly used for residential buildings in various scale such as independent housing units as well as apartment houses. Other public buildings such as hospitals, schools, hotels, offices and many other varied facilities have adopted masonry structures as well. Among these masonry buildings, especially old ones, the non-reinforced masonry type occupies large percentages.
- Other structural types, such as adobe, stone, wood and prefabrication, collectively share merely 6%, while concrete structure occupies approximately 6% of all the building types. Concrete structures were used for rather large-scale government and/or private office buildings. They are either massive structures or extremely slender and tall structures mainly located in the downtown area in Bogotá City.
- There are so many non-engineered building constructions in the Study Area that the vulnerability of the buildings is seriously increased. Especially, in the lower staged region, *estrato* 1 and 2, ratio of the number of non-engineered buildings looks very large. As results of non-skilled labor works, structural elements are not properly placed.

B. Methods and procedure

Procedure

Flowchart of the building damage estimation is shown in Figure 4.2.14.

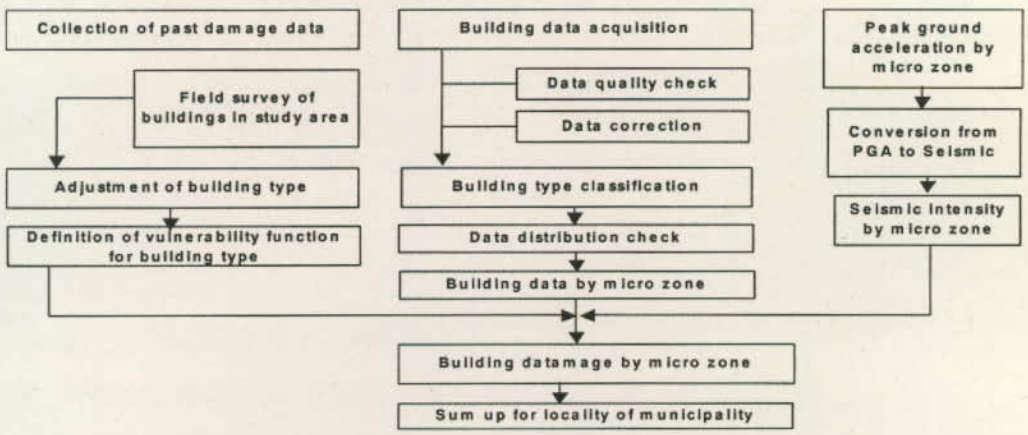


Figure 4.2.14 Flowchart of Building Damage Estimation

Damage Functions for Building Collapse

In order to establish a damage function for a seismic risk study in a given area, it is most desirable to study similar earthquake damage in a similar area, if any. This kind of study is important to incorporate building type and social situation in the similar area into the risk analysis in the given area.

In the case of Quindío Earthquake, monetary loss, defined as repair cost per building value, is calculated for each seismic intensity according to the ATC-13. In the ATC-13, damage state and each damage factor is specified as shown in Table 4.2.13.

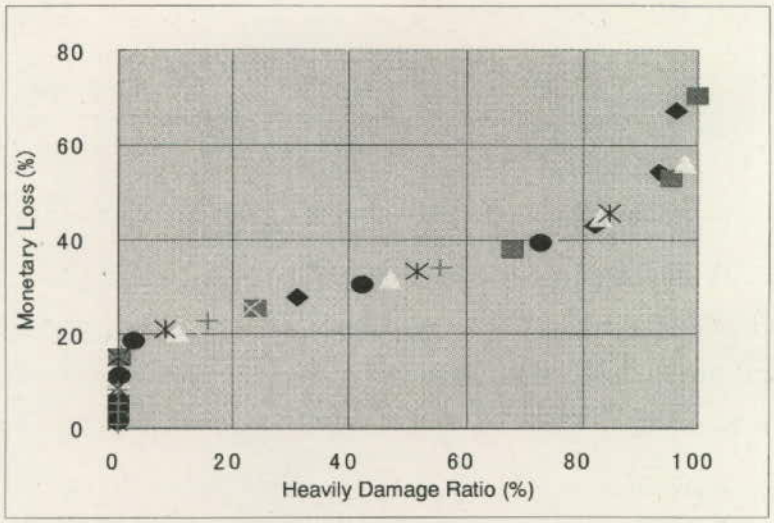
Table 4.2.13 Damage State and Central Damage Factor in Monetary Loss

Damage State	Central Damage Factor
Light	2.5%
Moderate	20%
Serious	45%
Severe	80%
Destructive	100%

Source: ATC-13

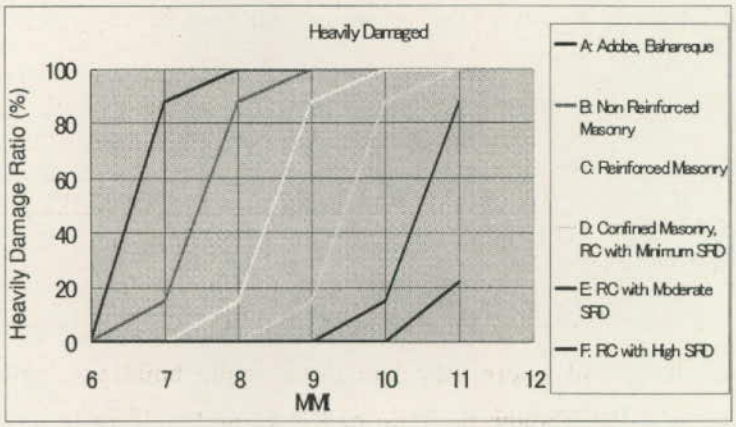
In general, damaged building is demolished at the state of monetary loss over 50%. Empirically, such buildings have damaged floor area exceeding 50%, and are considered extremely unsafe, thus not usable even as an emergency shelter as such. For example, the Turkish government recommended demolishing damaged buildings of monetary loss over 40% after the Kocaeri Earthquake in 1999.

Therefore, this study defines "heavily damaged building" as a building with a state of damage severer than "Serious," i.e. damaged building to be demolished rather than to be repaired. Monetary loss as defined in ATC-13 and physical damage can be converted as shown in Figure 4.2.15. "Heavily (severely) damaged ratio" versus seismic intensity of the building is defined as shown Figure 4.2.16.



Source: JICA Study Team

Figure 4.2.15 Relation between Masonry and Heavily Damaged Ratio



Source: JICA Study Team

Figure 4.2.16 Heavily Damaged Structures in Quindío Earthquake referred from Figure 3.2.4

The building classification used in this study is shown in Table 4.2.14.

Table 4.2.14 Building Classification used in this Study

Type	Structure Type	Estrato
1	Wood, Prefablicated	1,2,3,4,5,6
2	Masonry	1,2
3	Masonry	3,4
4	Masonry	5,6
5	Reinforced Concrete Frame less than 3 floors	1,2,3,4,5,6
6	Reinforced Concrete Frame more than 4 floors	1,2,3,4,5,6

Source: JICA Study Team

All the structural types in cadastral data are supposed to correspond to the structural types depicted in Figure 4.2.16 and briefly explained below.

Wood

Type 1 should correspond to type A in the case of Quindío Earthquake shown in Figure 4.2.16.

Masonry

Type 2, 3 and 4 should correspond to type B, C and D in Figure 4.2.16.

Through field observation of the buildings in Bogotá, low quality RC frame structure was categorized as masonry structure in cadastral data, while masonry structure was not classified as RC frame structure. Therefore, it is conjectured that type 2, 3 and 4 should include low quality RC frame structures.

Through field observation in Bogotá conducted by the Study Team, correspondence and contribution of each type of masonry is defined as shown in Table 4.2.15. Notice that the difference of the buildings' seismic quality caused by the difference of *estrato* is considered as well.

Table 4.2.15 Contribution of Structural Type to Classification of Masonry

	B	C	D
Type 2	80%	20%	0%
Type 3	40%	50%	10%
Type 4	20%	40%	40%

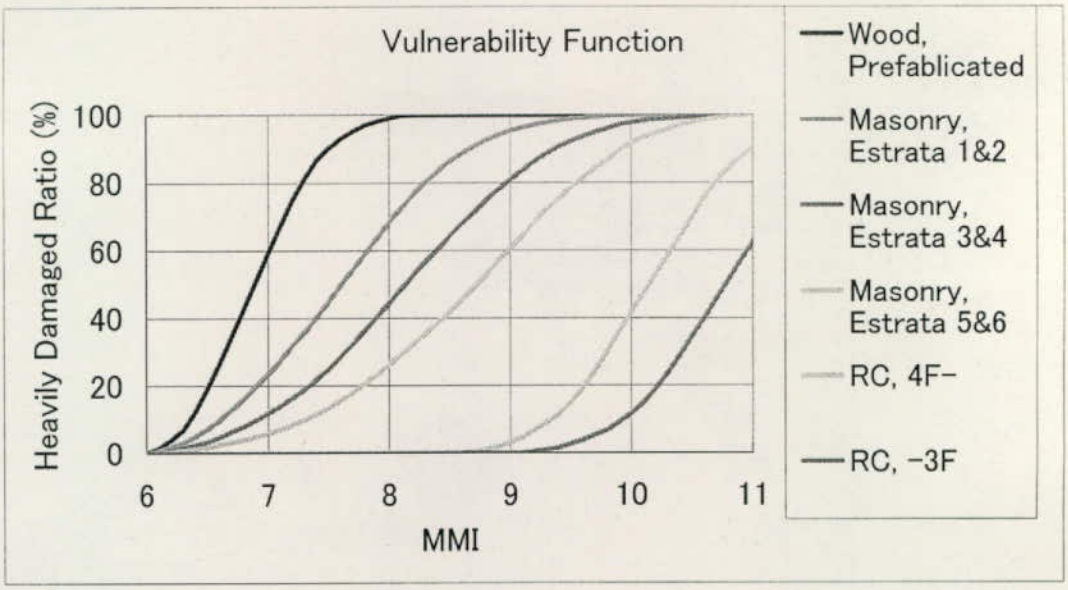
RC Frame

Among the heavily damaged buildings for all the types of structures in the 1999 Quindío earthquake, 84% had floors less than three, while buildings higher than 10 floors have a percentage of 0.4%. Though the ratio of RC frame buildings in this statistics is unknown, the damage ratio for type E and type F in Figure 4.2.16 would show the damages of RC buildings with lower stories.

The damage ratio for type F as shown in Figure 4.2.16 is almost the same as that for RC frame structures in general in California. However, few buildings would exist in affected areas having equal quality as that in California. Therefore, type E is taken for setting standard damage function.

In cadastral data, RC frame building is classified into two categories: 3 stories and up and under 3 stories. In general, higher storied buildings are more likely to suffer damage. Damage function for type E shows average damage ratio for RC frame structures. Damage function for type F is defined so that damage ratio is 30% higher on the average, since the difference in damage ratio between E and F is 20% at MMI X and 60% at MMI XI.

Damage function defined for each MMI as a discrete value is finally smoothed out as shown in Figure 4.2.17, because damage ratio should vary continuously according to the seismic intensity that varies continuously as well.



Source: JICA Study Team

Figure 4.2.17 Proposed Heavily Damaged Ratio of Buildings

C. Results of estimation

As shown in the table and figures below, the ratio of whole building collapse is between 45% and 48% in case of near and medium distance earthquakes, a range much higher than the results of the previous study. The results are shown in Table 4.2.16 and Figure 4.2.18 (1) and 18 (2).

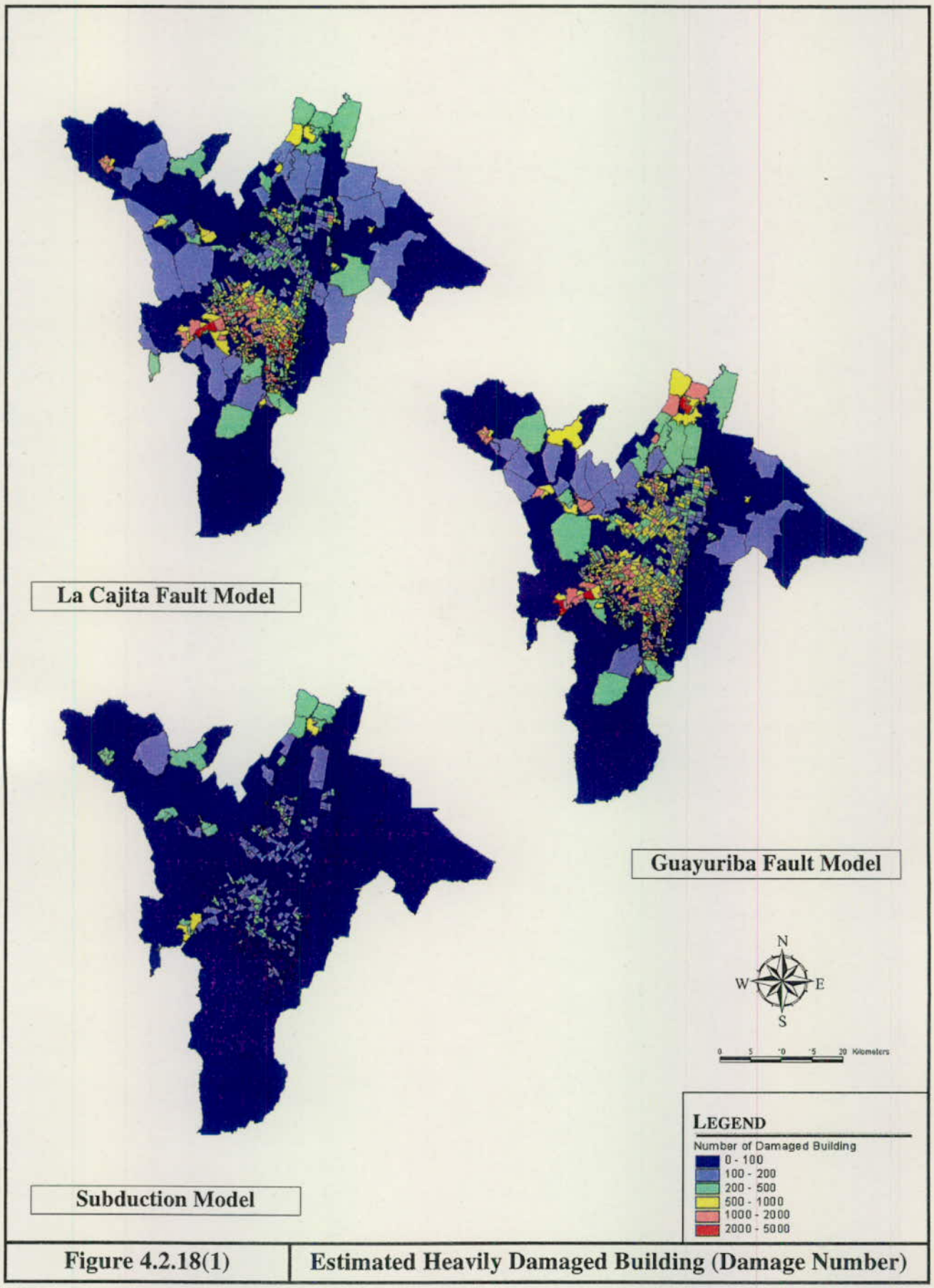


Figure 4.2.18(1) **Estimated Heavily Damaged Building (Damage Number)**

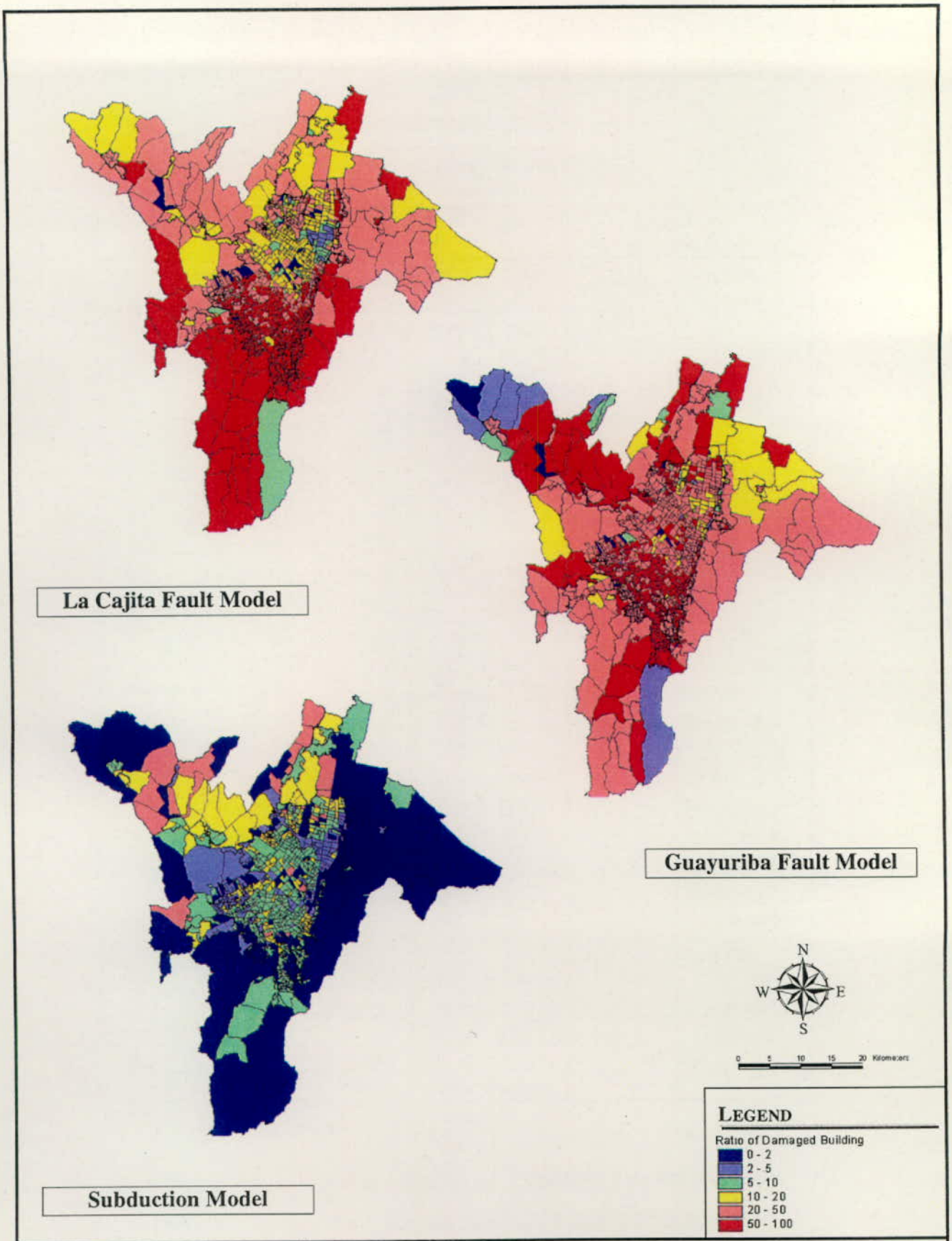


Figure 4.2.18(2)	Estimated Heavily Damaged Building (Damage Ratio)

Table 4.2.16 Summary of Building Damage

		Case 1		Case 2		Case 3	
		Heavily Damaged Building		Heavily Damaged Building		Heavily Damaged Building	
	Locality or Municipality	Number (nos)	Ratio (%)	Number (nos)	Ratio (%)	Number (nos)	Ratio (%)
Bogotá	Usaquén	11,070	2.8%	14,697	3.5%	2,404	3.9%
	Chapinero	5,771	1.4%	5,158	1.2%	481	0.8%
	Santa Fe	10,418	2.6%	8,232	2.0%	1,035	1.7%
	San Cristobal	43,281	10.8%	30,561	7.2%	2,506	4.1%
	Usme	33,740	8.4%	27,135	6.4%	2,305	3.7%
	Tunjuelito	13,959	3.5%	12,995	3.1%	2,144	3.5%
	Bosa	25,666	6.4%	28,442	6.7%	3,466	5.6%
	Kennedy	46,229	11.6%	49,964	11.8%	7,387	11.9%
	Fontibón	4,153	1.0%	11,269	2.7%	2,217	3.6%
	Engativá	11,873	3.0%	35,197	8.3%	6,796	11.0%
	Suba	16,786	4.2%	37,336	8.8%	7,628	12.3%
	Barrios Unidos	4,854	1.2%	13,242	3.1%	2,642	4.3%
	Teusaquillo	4,089	1.0%	7,365	1.7%	1,144	1.9%
	Mártires	7,500	1.9%	7,285	1.7%	937	1.5%
	Antonio Nariño	7,273	1.8%	7,153	1.7%	932	1.5%
	Puente Aranda	18,575	4.7%	18,697	4.4%	2,493	4.0%
	La_Candelaria	2,122	0.5%	1,925	0.5%	287	0.5%
	Rafael Uribe	38,244	9.6%	29,062	6.9%	3,066	5.0%
	Ciudad Bolívar	55,569	13.9%	31,870	7.6%	2,038	3.3%
	Sub Total	**362,072**	**90.7%**	**377,585**	**89.5%**	**51,908**	**84.0%**
Cundinamarca	Chia	3,725	0.9%	8,014	1.9%	2,370	3.8%
	Cota	1,460	0.4%	2,447	0.6%	722	1.2%
	Facatativa	5,078	1.3%	5,325	1.3%	1,372	2.2%
	Funza	1,555	0.4%	3,329	0.8%	897	1.5%
	La Calera	1,746	0.4%	1,435	0.3%	71	0.1%
	Madrid	2,089	0.5%	4,069	1.0%	1,240	2.0%
	Mosquera	1,329	0.3%	2,436	0.6%	486	0.8%
	Soacha	20,330	5.1%	17,349	4.1%	2,763	4.5%
	Sub Total	**37,312**	**9.3%**	**44,404**	**10.5%**	**9,921**	**16.0%**
	Total	**399,384**	**100.0%**	**421,989**	**100.0%**	**61,829**	**100.0%**

D. Discussion

a) Heavily damaged buildings

Due to the estimated damages, the ratios of the heavily damaged buildings are between 45% and 48% in the case of near and medium distance earthquakes, of which the building damage ratio is much higher than the results of the previous study.

In the case of near earthquake, the damage ratio is rather high in the southern part of the Bogotá City Area. These are both attributed to the higher earthquake intensity and lower seismic performance defined in this Study than those by the previous study.

(2) Human casualty

A. Collected data

As mentioned in (4) collected data for estimation, human casualties have been calculated based on the building data and population data.

B. Methods and procedure

a) Procedure

The human casualties are estimated based on the flowchart shown in Figure 4.2.19.

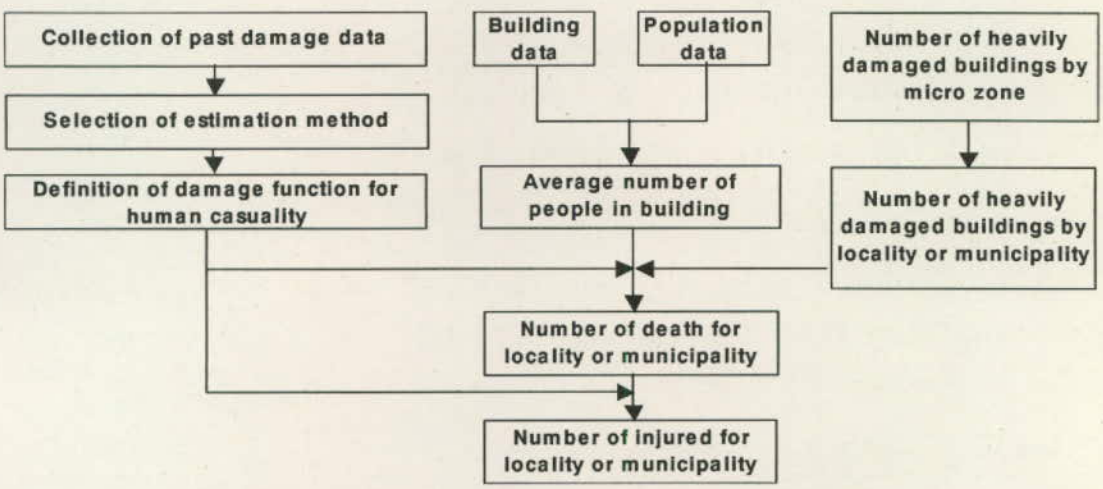


Figure 4.2.19 Flowchart of Human Casualty Estimation

b) Human deaths

This Study defines human deaths in an earthquake as number of victims by building damages.

The relation between the number of deaths and the number of heavily damaged buildings is based on the study by DANE on the 1999 Quindio earthquake. These numbers are in good correlation as shown in Figure 4.2.20. Therefore, following equation is proposed to estimate the human deaths due to the building damages in the Study Area.

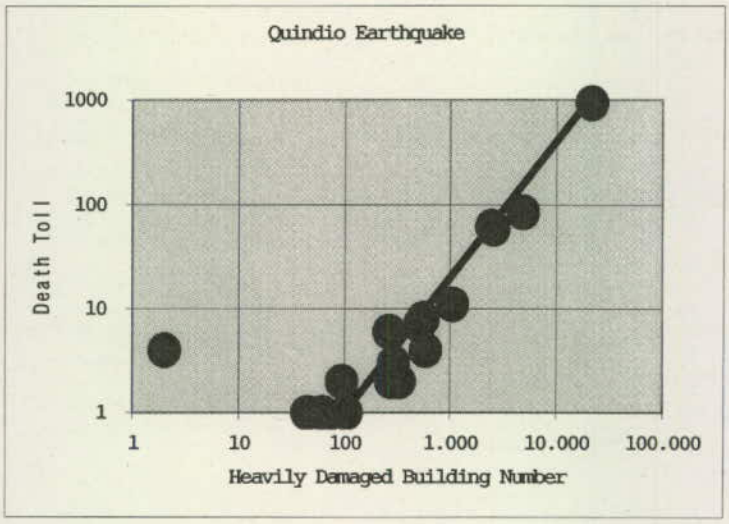


Figure 4.2.20 Heavily Damaged Buildings and Death Toll Relationship

Log Y = 1.3029 log X – 2.6039.

Where Y: Number of Deaths.

X: Number of Heavily Damaged Buildings.

c) Humans Injured

The relationship between number of Deaths and Injured is also obtained from Figure 4.2.20, and expressed in the Figure 4.2.21. Referring to the figure, the relationship between deaths and casualties is formulated by the following equation:

Log Y = 0.9824 log X + 0.9031.

Where Y: Number of Injured.

X: Number of Deaths by heavily damaged buildings.

In this study, the relationship above is adopted for estimation of the number of human casualties due to the building damages.

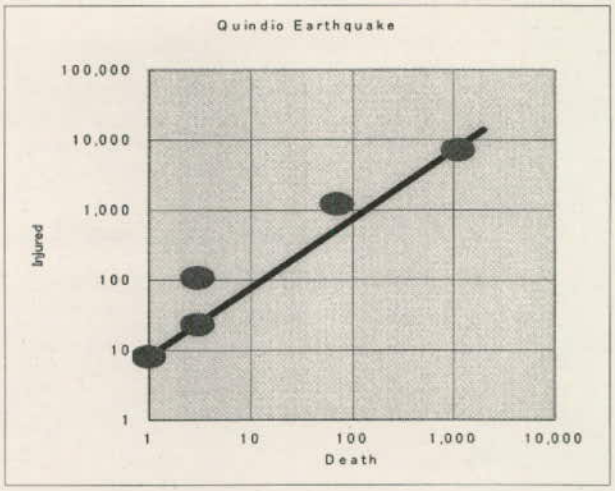


Figure 4.2.21 Relationship between Number of Deaths and Injured

C. Results of estimation

Following table and figure shows the results of estimation.

Table 4.2.17 Results of Estimation

		Case 1				Case 2				Case 3			
		Human Death		Human Injury		Human Death		Human Injury		Human Death		Human Injury	
	Locarity or Municipality	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)	Number (persons)	Ratio (%)
Bogota	Usaquen	1.081	2.8%	7.651	2.8%	1.564	3.9%	10.996	3.9%	148	4.5%	1.083	4.4%
	Chaniner0	336	0.9%	2.426	0.9%	290	0.7%	2.101	0.7%	13	0.4%	101	0.4%
	Santa Fe	642	1.6%	4.580	1.7%	472	1.2%	3.388	1.2%	32	1.0%	238	1.0%
	San Cristobal	5.104	13.0%	35.136	12.9%	3.243	8.0%	22.507	8.0%	125	3.8%	916	3.8%
	Usme	3.027	7.7%	21.028	7.7%	2.279	5.6%	15.911	5.7%	92	2.8%	678	2.8%
	Tuniuelito	1.544	3.9%	10.854	4.0%	1.406	3.5%	9.904	3.5%	134	4.1%	987	4.1%
	Bosa	2.529	6.4%	17.629	6.5%	2.892	7.2%	20.106	7.1%	186	5.7%	1.359	5.6%
	Kennedy	6.564	16.7%	44.985	16.5%	7.263	18.0%	49.688	17.6%	602	18.4%	4.302	17.7%
	Fontibón	299	0.8%	2.162	0.8%	1.097	2.7%	7.757	2.8%	132	4.0%	968	4.0%
	Engativá	1.014	2.6%	7.181	2.6%	4.177	10.3%	28.859	10.2%	490	15.0%	3.516	14.4%
	Suba	1.460	3.7%	10.273	3.8%	4.134	10.2%	28.582	10.2%	522	16.0%	3.743	15.4%
	Barrios Unidos	213	0.5%	1.552	0.6%	788	1.9%	5.608	2.0%	97	3.0%	713	2.9%
	Teusaquillo	269	0.7%	1.947	0.7%	446	1.1%	3.205	1.1%	39	1.2%	296	1.2%
	Mártires	378	1.0%	2.727	1.0%	364	0.9%	2.627	0.9%	25	0.8%	190	0.8%
	Antonio Nariño	428	1.1%	3.076	1.1%	419	1.0%	3.011	1.1%	29	0.9%	222	0.9%
	Puente Aranda	1.497	3.8%	10.529	3.9%	1.510	3.7%	10.617	3.8%	109	3.3%	805	3.3%
	La Candelaria	115	0.3%	843	0.3%	101	0.2%	744	0.3%	8	0.3%	65	0.3%
	Rafael Uribe	3.848	9.8%	26.622	9.8%	2.691	6.7%	18.733	6.7%	144	4.4%	1.053	4.3%
	Ciudad Bolívar	7.280	18.5%	49.806	18.3%	3.528	8.7%	24.448	8.7%	98	3.0%	724	3.0%
	Sub Total	**37,627**	**95.9%**	**261,005**	**95.7%**	**38,667**	**95.6%**	**268,792**	**95.5%**	**3,026**	**92.7%**	**21,959**	**90.2%**
Cundinamarca	Chia	85	0.2%	628	0.2%	230	0.6%	1.674	0.6%	47	1.4%	352	1.4%
	Cota	23	0.1%	177	0.1%	46	0.1%	343	0.1%	9	0.3%	72	0.3%
	Facatativá	227	0.6%	1.650	0.6%	241	0.6%	1.753	0.6%	41	1.3%	309	1.3%
	Funza	45	0.1%	334	0.1%	120	0.3%	885	0.3%	22	0.7%	165	0.7%
	La Calera	47	0.1%	349	0.1%	36	0.1%	272	0.1%	1	0.0%	6	0.0%
	Madrid	60	0.2%	443	0.2%	142	0.4%	1.040	0.4%	30	0.9%	227	0.9%
	Mosquera	23	0.1%	175	0.1%	51	0.1%	381	0.1%	6	0.2%	48	0.2%
	Soacha	1.112	2.8%	7.865	2.9%	905	2.2%	6.420	2.3%	83	2.5%	611	2.5%
	Sub Total	**1,622**	**4.1%**	**11,621**	**4.3%**	**1,771**	**4.4%**	**12,768**	**4.5%**	**239**	**7.3%**	**1,790**	**7.4%**
	Total	**39,249**	**100.0%**	**272,626**	**100.0%**	**40,438**	**100.0%**	**281,560**	**100.0%**	**3,265**	**100.0%**	**24,349**	**100.0%**

D. Discussion

Approximately forty thousand would be killed by the heavy damage of the buildings in the cases of near and medium distance earthquakes. In the case of near earthquake, high death percentages are in the southern localities.

However, in the case of medium distance earthquake, the casualties are distributed in the whole Study Area, that necessitates urgent countermeasures against earthquake disasters.

(3) Lifeline

The following 4 types of lifelines are to be estimated:

- Water supply pipelines.
- Gas pipelines.
- Electric power supply cables.
- Telecommunications cables.

The lifeline facilities are to be classified into two major categories, namely, nodes and links. Nodes include facilities such as purification plants and substations. Links include facilities such as pipes or lines for supply and distribution purposes.

A. Water supply pipeline

a) Collected data

Water pipeline GIS or CAD data for the whole area in Bogotá and urban area in the eight municipalities in Cundinamarca are provided from EAAB. Rural area in Cundinamarca was not studied because the data was not available.

Provided data includes information on service network, mostly including pipe diameter between 1 and 78 inches, and pipe material. However, the data excludes pipelines to individual buildings.

The collected data is classified by material as shown in Table 4.2.18, and by diameter as shown in Table 4.2.19. Details of the data compilation procedure are described in Appendix 4.2.6.

Note that proportion of pipe material type is different between Bogotá and municipalities in Cundinamarca. This difference would come from the pipeline installation age, because Cundinamarca has installed later than Bogotá.

Table 4.2.18 Distribution of Water Pipeline by Material

	Locarity or Municipality	Asbest-cement pipe (ACP)	Cast Iron (CIP)	Galvanized Iron (SP)	Polyvinyl-chloride pipe (VP)	Reinforced Concrete (ACP)	Steel (SP)	Steel Iron (SP)	Unknown	Sum (m)	Sum (%)
Bogota	Usaquen	369,002	2,209	377	75,457	11,008	5,224	0	24,977	488,253	7.2
	Chapinero	159,138	6,623	25,257	47,119	1,557	4,482	1,780	7,648	253,606	3.7
	Santa Fe	134,311	1,245	9,866	5,566	28,998	407	0	3,511	183,903	2.7
	San Cristobal	278,913	3,670	15,463	64,001	26,501	418	619	4,758	394,344	5.8
	Usme	126,166	227	168	29,536	5,481	0	1,932	919	164,430	2.4
	Tunjuelito	145,691	1,431	4,173	6,134	6,974	0	3,596	41	168,040	2.5
	Bosa	198,614	0	802	46,226	13,993	0	0	1,019	260,657	3.8
	Kennedy	510,429	580	2,127	115,990	34,077	0	2,499	3,020	668,722	9.8
	Fontibón	233,865	1,196	6,378	15,979	19,433	0	0	3,570	280,423	4.1
	Engativá	509,134	1,894	8,693	61,036	27,984	0	0	6,919	615,661	9.1
	Suba	357,034	17	524	301,663	21,966	5,820	0	29,889	716,915	10.6
	Barrios Unidos	192,104	8,211	34,615	27,986	3,907	3,639	13	2,062	272,517	4.0
	Teusaquillo	181,891	7,465	32,110	17,084	17,409	939	205	12,714	269,816	4.0
	Mártires	140,094	4,535	34,341	478	9,223	299	0	395	189,365	2.8
	Antonio Nariño	95,520	5,066	20,829	5,365	5,658	0	2,374	291	135,302	2.0
	Puente Aranda	345,323	9,098	15,980	23,727	21,969	0	11	1,902	418,009	6.2
	La Candelaria	42,089	142	2,703	399	8,852	15	0	1,431	55,631	0.8
	Rafael Uribe	233,398	4,962	34,195	40,226	10,676	0	9,715	518	333,689	4.9
	Ciudad Bolivar	293,808	0	3,842	61,351	16,669	0	689	7,803	384,162	5.7
	Sub-total (m)	4,546,525	58,371	252,443	945,522	292,340	21,222	23,432	113,388	6,253,444	92.1
	(%)	72.7	0.9	4.0	15.1	4.7	0.3	0.4	1.8	100.0	
Cundinamarca	Chía	0	0	0	141,785	0	0	0	576	142,361	2.1
	Cota	0	0	0	0	0	0	0	15,903	15,903	0.2
	Facatativá	0	0	0	0	0	0	0	25,697	25,697	0.4
	Funza	26,736	172	0	38,614	0	0	0	1,436	66,958	1.0
	La Calera	0	0	0	18,661	0	0	0	0	18,661	0.3
	Madrid	31,438	244	0	17,564	0	0	0	623	49,869	0.7
	Mosquera	16,559	0	0	22,406	1,723	0	0	2,830	43,519	0.6
	Soacha	119,580	0	7,478	33,505	11,234	0	0	1,282	173,080	2.5
	Sub-total (m)	194,314	415	7,478	272,535	12,957	0	0	48,349	536,048	7.9
	(%)	36.2	0.1	1.4	50.8	2.4	0.0	0.0	9.0	100.0	
	Total (m)	4,740,839	58,987	259,921	1,218,057	305,296	21,222	23,432	161,736	6,789,491	100.0
	(%)	69.8	0.9	3.8	17.9	4.5	0.3	0.3	2.4	100.0	

Source: EAAB

Table 4.2.19 Distribution of Water Pipeline by Diameter

	Locarity or Municipality	D is bigger than 500mm	D is 200 - 500mm	D is 100 - 200mm	D is smaller than 100mm	Sum (m)	Sum (%)
Bogota	Usaquén	42,264	58,205	189,153	198,632	488,253	7.2
	Chapinero	10,341	45,813	128,944	68,508	253,606	3.7
	Santa Fe	25,220	34,762	64,126	59,795	183,903	2.7
	San Cristobal	28,343	56,720	90,834	218,447	394,344	5.8
	Usme	10,015	9,340	42,237	102,838	164,430	2.4
	Tunjuelito	6,577	21,796	52,390	87,277	168,040	2.5
	Bosa	11,666	21,715	78,534	148,741	260,657	3.8
	Kennedy	23,227	79,513	215,692	350,290	668,722	9.8
	Fontibón	15,423	50,962	101,517	112,521	280,423	4.1
	Engativá	25,328	91,809	237,891	260,632	615,661	9.1
	Suba	46,249	114,783	261,025	295,108	717,165	10.6
	Barrios Unidos	12,138	32,640	108,317	119,421	272,517	4.0
	Teusaquillo	19,745	34,947	123,246	91,878	269,816	4.0
	Mártires	7,023	28,746	64,545	89,051	189,365	2.8
	Antonio Nariño	5,093	20,849	40,878	68,482	135,302	2.0
	Puente Aranda	20,721	72,159	163,084	162,045	418,009	6.2
	La Candelaria	6,598	13,803	23,129	12,101	55,631	0.8
	Rafael Uribe	10,708	37,804	114,064	171,114	333,689	4.9
	Ciudad Bolivar	21,362	47,111	112,504	203,185	384,162	5.7
	Sub-total (m)	348,041	873,475	2,212,110	2,820,066	6,253,693	92.1
	(%)	5.6	14.0	35.4	45.1	100.0	
Cundinamarca	Chía	963	10,775	31,482	99,141	142,361	2.1
	Cota	0	0	822	15,081	15,903	0.2
	Facatativá	0	13,453	10,753	1,492	25,697	0.4
	Funza	1,436	8,139	13,497	43,885	66,958	1.0
	La Calera	0	554	2,907	15,201	18,661	0.3
	Madrid	623	6,814	15,047	27,384	49,869	0.7
	Mosquera	4,553	3,779	11,425	23,762	43,519	0.6
	Soacha	8,964	18,213	55,208	90,695	173,080	2.5
	Sub-total (m)	16,540	61,727	141,140	316,640	536,048	7.9
	(%)	3.1	11.5	26.3	59.1	100.0	
	Total (m)	364,581	935,202	2,353,251	3,136,706	6,789,741	100.0
	(%)	5.4	13.8	34.7	46.2	100.0	

Source: EAAB

b) Methods and procedures

Assumptions

Following are the basic assumptions applied for estimation of water supply pipelines and gas pipelines.

A statistical approach for damage estimation of links, i.e. distribution pipes and lines, is applicable only when information on their structures and lengths is available in any given area. This approach was used in the Study.

- Node facilities are not included for damage estimation, such as water purification plant, gas tank, electric power generator, transformer station, telephone station. Individual diagnosis should be made on such node facilities to evaluate safety against earthquakes.
- Damage due to the direct result of ground motion is estimated, such as breakage or disjoint of pipelines. Secondary damages such as the damages caused by landslides or building collapses are not included.
- Results are considered as a statistical representation in a given area.
- Damage estimation method is in principle based on the past damage experiences.
- In cases when proper data is not available, input data are set based on reasonable assumptions. Thus precision of the results is dependent on the quality of the input data.

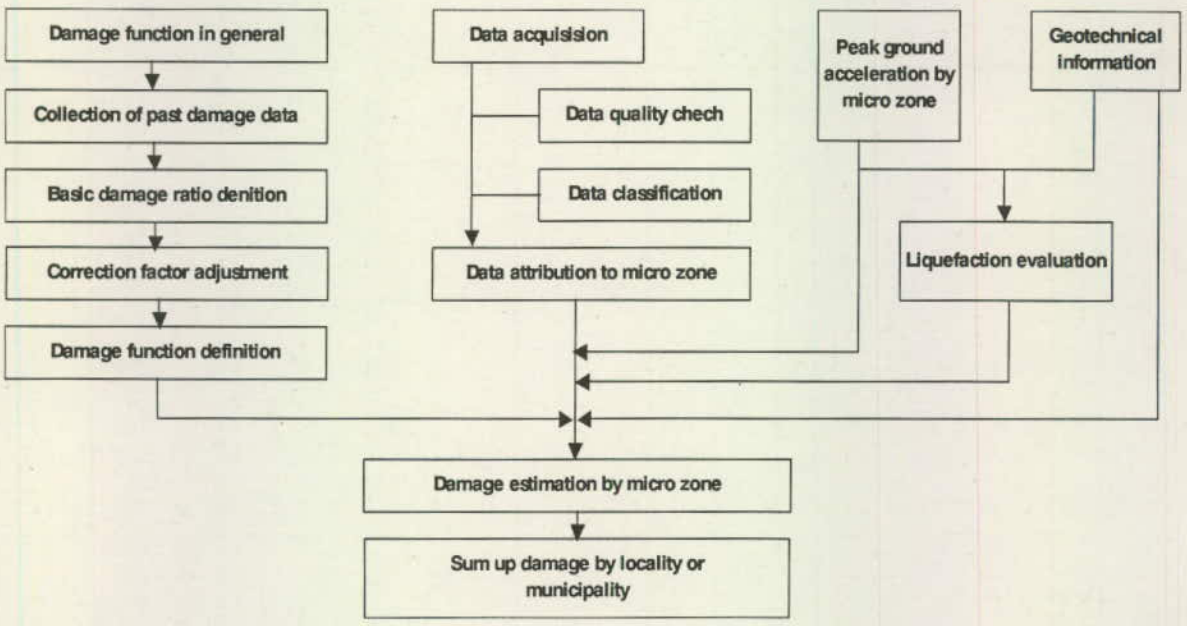


Figure 4.2.22 Flowchart of Damage Estimation for Water and Gas Pipelines

c) Damage function

Except for a few quantitative studies, no quantitative studies on seismic damages for lifeline facilities were available in the Study Area.

The characteristics of water supply networks and pipeline structures are considered similar to those of Japan. Although the strength of the pipeline materials is not much different from that of Japan, it is considered that the quality of construction of the joints always leads to problems. Therefore, an analysis method for the damage estimation of water pipelines as well as gas pipelines proposed by Japan Waterworks Association, which is widely used in Japan, was applied to the Study, taking account of the experience in Armenia earthquakes. However, it is considered that the damages will be more serious than those estimated.

In Japan, the standard damage ratio R(a) for water pipeline proposed by Kubo and Katayama (1975)[4-2-1] has been commonly used to evaluate seismic damages of water pipelines. The damage ratio for pipeline $R_m(a)$ is defined as follows:

$$R_m(a) = C_p \times C_d \times C_g \times C_l \times R(a).$$

Where,

R(a) : standard damage ratio (damaged points/km).

Cp : correction factor for pipe material.

Cd : correction factor for pipe diameter.

Cg : correction factor for topography and ground.

Cl : correction factor for liquefaction.

A : peak ground acceleration (gal).

Japan Waterworks Association[4-2-2] (1996) compiled relationship between damage ratio of pipelines and PGA value based upon actual observation of damage for the 1995 Kobe earthquake. They applied average damage ratio, especially in cases of larger PGA. There is a significant difference in damage ratio between the above two procedures, especially for the case of acceleration range from 300gal to 800gal.

Kawakami's (1996)[4-2-3], study shows that 1) service interruption rate after two days from the main shock is about 60%, and 2) service interruption rate is 87% in the case of 2 damaged points/km.

[4-2-1] Japan Water works Association (Nov. 1998 Damage estimation of water supply pipeline due to earthquake).

[4-2-2] K. Kubo & T. Katayama (1975 Damage estimation of underground water supply pipeline).

[42-3] E. KAWAKAMI (1996 Relation between shape of road traffic system and establishment of connection)

According to the damage study on the 1999 Quindío earthquake, the situations are noted as follows:

- In Armenia, recorded PGA was 589 gal, and almost no service was available after two days from the main shock.
- In Pereira, recorded PGA was 291 gal, and almost all services were available after two days from the main shock.

Standard Damage Ratio Proposed for this Study

If PGA of 589 gal in Armenia earthquake is applied to Japan Waterworks Association's damage curve, damage ratio is estimated at about 0.6 points/km. However, almost all service interruption after two days indicates that damage ratio would be higher than 0.6 points/km based on Kawakami's work. In addition, it is noted that installation situation is different than that in Japan from the site observation.

Therefore, a higher damage ratio than Japan Waterworks Association's damage curve is proposed and this is shown in Figure 4.2.23.

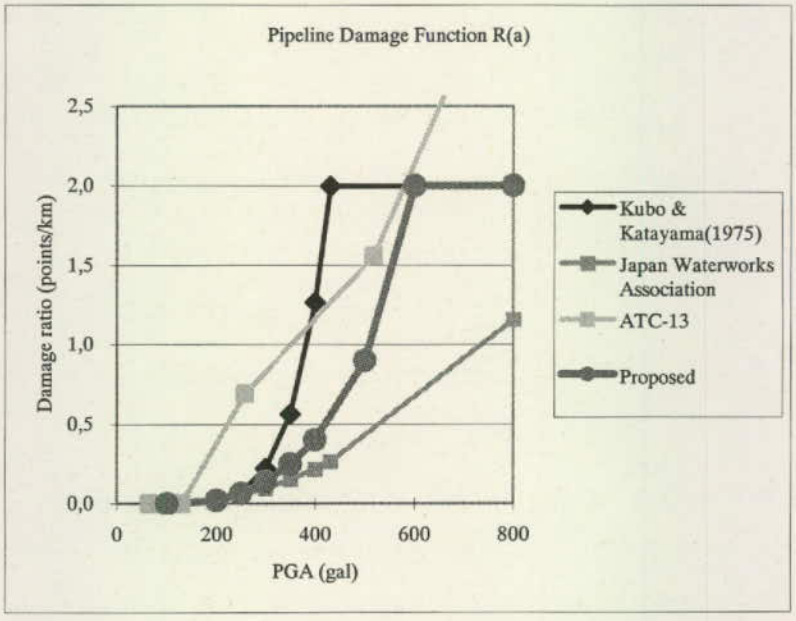


Figure 4.2.23 **Standard Damage Ratio for Pipelines**

In the method of Kubo and Katayama, various correction factors are included such as pipe material, pipe diameter, ground, and liquefaction. In this study, these values are maintained, while classifications of pipe materials, pipe diameters, and ground conditions are adjusted to Colombian situation. They are shown in Table 4.2.20 to Table 4.2.23.

Table 4.2.20 Correction Factor for Pipe Materials (Cp)

Pipe material	Correction factor Cp
Asbest-cement, Reinforced concrete〔ACP〕	1.2
Cast iron〔CIP〕	1
Polyvinyl-chloride〔VP〕	1
Steel, Steel Iron , Galvanized iron〔SP〕	0.3
Unknown	1

Table 4.2.21 Correction Factor for Pipe Diameters (Cd)

Diameter	Correction factor Cd
ϕ 100mm or smaller	1.6
ϕ 100mm - 200mm	1
ϕ 200mm - 500mm	0.8
ϕ 500 or bigger	0.5

Table 4.2.22 Correction Factor for Ground Conditions (Cg)

Ground	Correction factor Cg
Geotechnical Zone 1,2: good ground	0.4
Geotechnical Zone 3,4: good ground	1.1
Geotechnical Zone 5: alluvial plane	1
Geotechnical Zone 6: soft soil	1
Geotechnical Zone 7,8: other than above	1

Table 4.2.23 Correction Factor for Liquefaction (Cc)

Liquefaction potential	Correction factor Cl
None	1
Possible	2
Probable	2.4

d) Results of Estimation

Case 1: La Cajita

The results of damage estimation by the scenario earthquakes are shown in Table 4.2.24 and in Figure 4.2.24. Damages are concentrated in the southern part of the Study Area, due to the high ground acceleration and liquefaction phenomena, which would enhance the extent of damages. In Bogotá, damage ratio in Usme and Ciudad Bolivar exceeds 2.0 points per km. During the 1999 Quindío earthquake, water service was totally out of service immediately after the earthquake in

the area where damage ratio exceeded 2.0 points per km. The damage ratio in San Cristobal and Soacha is also as high as 1.3 points per km and 1.4 points per km respectively.

Case 2: Guayuriba

The results are shown in Table 4.2.24 and in Figure 4.2.24. The damaged area spreads widely in the Bogotá City Area, though total amount of damage is smaller than that of Case 1. The damage extends in liquefied areas. The area with a high damage ratio is at Tunjuelito, where the value is 0.5 points per km. Total disruption of water service in this case is not likely in any locality in Bogotá or municipality in Cundinamarca.

Case 3: Subduction

The results are shown in Table 4.2.24 and in Figure 4.2.24. Almost no damage is estimated for this case.

Remarks

- Damage will be extensive due to the liquefaction areas, where the localities of Kennedy, Puente Aranda, Rafael Uribe and Ciudad Bolivar are located.
- Regarding the pipe material, asbestos cement suffers most, because of the fragility of the material and also the widespread use of the material, whose proportion is about 70%.

Table 4.2.24 Estimated Damage of Water Pipelines (Cases 1, 2, and 3)

			(Case 1)														(Case 2)												(Case 3)											
			By Material								By Diameter				Total		By Material								By Diameter				Total		By Material								By Diameter				Total	
	Locality or Municipality	Status (m)	Asbest-cement pipe (ACP)	Cast Iron (CIP)	Galvanized Iron (SP)	Polyvinyl-chloride pipe (VP)	Reinforced Concrete (ACP)	Steel (SP)	Steel Iron (SP)	Unknown	D is bigger than 500mm	D is 200 - 500mm	D is 100 - 200mm	D is samller than 100mm	Sum (Points)	Damage ratio (Points/km)	Asbest-cement pipe (ACP)	Cast Iron (CIP)	Galvanized Iron (SP)	Polyvinyl-chloride pipe (VP)	Reinforced Concrete (ACP)	Steel (SP)	Steel Iron (SP)	Unknown	D is bigger than 500mm	D is 200 - 500mm	D is 100 - 200mm	D is samller than 100mm	Sum (Points)	Damage ratio (Points/km)	Asbest-cement pipe (ACP)	Cast Iron (CIP)	Galvanized Iron (SP)	Polyvinyl-chloride pipe (VP)	Reinforced Concrete (ACP)	Steel (SP)	Steel Iron (SP)	Unknown	D is bigger than 500mm	D is 200 - 500mm	D is 100 - 200mm	D is samller than 100mm	Sum (Points)	Damage ratio (Points/km)
Bogotá	Usaquen	488,253	47	0	0	6	1	0	0	1	1	4	17	32	55	0.1	58	0	0	9	1	0	0	1	2	6	23	38	69	0.1	1	0	0	0	0	0	0	0	0	0	1	1	2	4.5
	Chapinero	253,606	66	2	4	7	1	0	0	1	1	13	44	23	81	0.3	28	1	2	8	0	0	0	1	0	6	20	14	40	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Santa Fe	183,903	84	1	3	1	9	0	0	1	7	17	39	35	98	0.5	36	0	1	1	3	0	0	0	2	5	14	19	41	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	San Cristobal	394,344	409	1	3	97	8	0	0	1	9	44	87	379	519	1.3	81	1	2	12	3	0	0	0	3	10	21	65	100	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Usme	164,430	419	1	0	90	7	0	1	1	11	18	98	391	517	3.1	47	0	0	9	1	0	0	0	1	2	11	43	57	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Tunjuelito	168,040	121	0	1	4	2	0	1	0	2	9	34	84	129	0.8	80	0	1	3	2	0	0	0	1	6	22	56	85	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Bosa	260,657	175	0	0	11	7	0	0	0	5	13	47	127	194	0.7	35	0	0	2	1	0	0	0	1	2	11	24	39	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Kennedy	668,722	271	0	0	31	8	0	0	1	5	23	78	206	312	0.5	255	0	0	26	7	0	0	1	5	22	72	191	290	0.4	1	0	0	0	0	0	0	0	0	0	0	1	2	0.0
	Fontibon	280,423	3	0	0	0	0	0	0	0	0	0	1	2	3	0.0	28	0	0	1	1	0	0	0	1	4	10	15	31	0.1	1	0	0	0	0	0	0	0	0	0	0	1	1	0.0
	Engativa	615,661	5	0	0	0	0	0	0	0	0	1	2	3	6	0.0	48	0	0	4	1	0	0	0	1	5	18	30	55	0.1	2	0	0	0	0	0	0	0	0	0	1	1	2	0.0
	Suba	716,915	8	0	0	6	0	0	0	0	0	2	4	8	14	0.0	41	0	0	24	1	0	0	1	2	7	22	37	68	0.1	1	0	0	1	0	0	0	0	0	0	1	1	2	0.0
	Barrios Unidos	272,517	3	0	0	0	0	0	0	0	0	0	1	2	4	0.0	38	1	2	5	0	0	0	0	1	4	18	24	47	0.2	1	0	0	0	0	0	0	0	0	0	1	1	1	0.0
	Teusaquillo.	269,816	52	0	7	0	2	0	0	1	2	5	23	32	62	0.2	40	1	2	3	2	0	0	2	2	5	23	21	51	0.2	1	0	0	0	0	0	0	0	0	0	1	0	1	0.0
	Martires	189,365	78	1	6	0	3	0	0	0	2	10	29	48	88	0.5	62	2	5	0	2	0	0	0	1	8	22	39	71	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Antonio Nariño	135,302	60	2	4	3	2	0	0	0	1	8	19	42	71	0.5	55	2	4	3	1	0	0	0	1	8	18	39	65	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Puente Aranda	418,009	164	1	2	7	4	0	0	0	3	20	51	105	178	0.4	172	3	2	9	5	0	0	0	4	22	61	104	191	0.5	1	0	0	0	0	0	0	0	0	0	0	1	1	0.0
	La Candelaria	55,631	34	0	1	0	4	0	0	1	3	8	18	11	41	0.7	15	0	0	0	2	0	0	0	1	4	7	6	17	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Rafael Uribe	333,689	278	3	8	47	4	0	2	0	4	21	93	225	342	1.0	85	2	6	11	2	0	2	0	1	11	31	64	107	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Ciudad Bolivar	384,162	687	0	9	68	20	0	1	3	19	79	229	462	789	2.1	56	0	1	6	2	0	0	0	2	6	18	38	64	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Sub-total (points)	6,253,444	2,964	13	49	379	83	0	5	11	76	296	914	2,217	3,504	0.6	1,260	14	28	138	37	0	3	8	32	146	444	867	1,488	0.2	12	0	0	2	0	0	0	0	0	2	5	8	15	0.0
Cundinamarca	Chia	142,361	0	0	0	1	0	0	0	0	0	0	0	1	1	0.0	0	0	0	14	0	0	0	0	0	1	2	12	14	0.1	0	0	0	1	0	0	0	0	0	0	0	1	1	0.0
	Cota	15,903	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	0	0	2	0	2	2	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Facatativa	25,697	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Funza	66,958	0	0	0	0	0	0	0	0	0	0	0	1	1	0.0	2	0	0	2	0	0	0	0	0	0	1	3	4	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	La Calera	18,661	0	0	0	6	0	0	0	0	0	0	1	5	6	0.3	0	0	0	4	0	0	0	0	0	0	0	3	4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Madrid	49,869	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	2	0	0	1	0	0	0	0	0	0	1	2	3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Mosquera	43,519	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	1	0	0	1	0	0	0	0	0	0	0	1	2	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Soacha	173,080	199	0	1	33	6	0	0	1	4	13	65	158	240	1.4	21	0	0	5	1	0	0	0	0	2	8	17	27	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	Sub-total (points)	536,048	200	0	1	41	6	0	0	2	4	14	67	165	249	0.5	25	0	0	28	1	0	0	3	0	4	12	40	57	0.1	0	0	0	1	0	0	0	0	0	0	0	1	2	0.0
	Total (points)	6,789,491	3,163	13	50	420	89	0	5	12	80	310	981	2,383	3,753	0.6	1,284	14	29	165	38	0	3	11	32	150	456	907	1,545	0.2	12	0	0	3	0	0	0	0	0	2	5	9	16	0.0

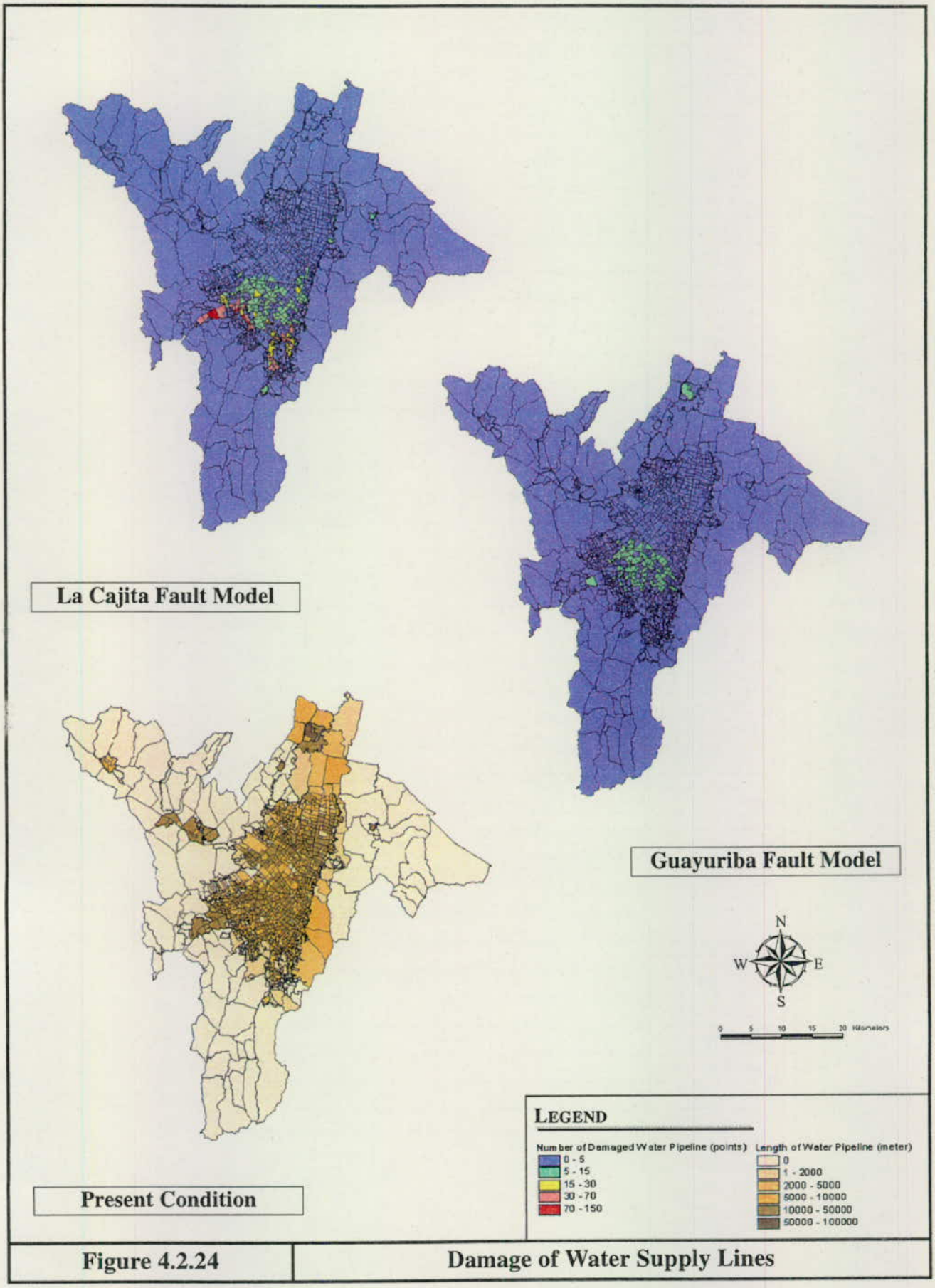


Figure 4.2.24 | **Damage of Water Supply Lines**

B. Damage estimation of gas pipelines

a) Collected data

The gas pipeline for low-pressure (60 psi) distribution for Bogotá, Chia and Soacha excluding the pipeline to individual buildings is provided by Natural Gas Company. Other municipalities in Cundinamarca do not have gas pipelines. The distribution of gas pipelines in the Study Area is shown in Appendix 4.2.7.

b) Damage ratio definition

Basic damage ratio for gas pipelines is the same as that of the water supply pipelines. Correction factors for ground type and liquefaction effect are also the same. Regarding pipe material and pipe diameter, the following values currently used in Japan are adopted.

$C_p \times C_d$: Polyethylene pipes (60 psi) 0.1

c) Result of estimation

Table 4.2.25 shows status and damage points for each locality and municipality due to the three scenario earthquakes.

Case 1: La Cajita

Most damage is estimated at the southern part of the Study Area, especially in the localities of Ciudad Bolivar, Usme and San Cristobal in Bogotá and the municipality of Soacha in Cundinamarca as shown in Appendix 4.2.7. This is because of high seismic intensity and liquefaction in the area close to the fault. Mid west to northern part of the Study Area will suffer a little damage, but there will not be damage in Chia.

Case 2: Guayuriba

Damaged area spreads widely in Bogotá, especially in Kennedy, Puente Aranda, Rafael Uribe, Ciudad Bolívar. Damage of at least one point is expected in every locality in Bogotá. Damage is also expected in Chia and Cota in Cundinamarca.

Case 3: Subduction

Almost no damage is expected as liquefaction is not expected in this case.

Table 4.2.25 Estimated Length and Damage of Gas Pipelines

	Locaridad	Length (m)	Damage (points)			Damage ratio (points/km)		
			Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Bogotá	Usaquen	432,656	3	4	0	0.01	0.01	0.00
	Chapinero	171,736	5	2	0	0.03	0.01	0.00
	Santa Fe	168,985	7	3	0	0.04	0.02	0.00
	San Cristobal	577,386	53	9	0	0.09	0.02	0.00
	Usme	377,866	71	8	0	0.19	0.02	0.00
	Tuenjuelito	196,268	10	7	0	0.05	0.03	0.00
	Bosa	531,520	21	5	0	0.04	0.01	0.00
	Kennedy	981,395	28	25	0	0.03	0.03	0.00
	Fontibón	285,122	0	2	0	0.00	0.01	0.00
	Engativá	887,072	1	5	0	0.00	0.01	0.00
	Suba	912,479	1	5	0	0.00	0.01	0.00
	Barrios Unidos	310,006	0	4	0	0.00	0.01	0.00
	Teusaquillo	182,259	4	3	0	0.02	0.02	0.00
	Mártires	166,661	7	5	0	0.04	0.03	0.00
	Antonio Nariño	145,818	6	6	0	0.04	0.04	0.00
	Puente Aranda	406,013	15	15	0	0.04	0.04	0.00
	La Candelaria	30,535	2	1	0	0.07	0.03	0.00
	Rafael Uribe	550,978	48	13	0	0.09	0.02	0.00
	Ciudad Bolivar	709,046	107	9	0	0.15	0.01	0.00
	Sub Total	8,023,800	388	132	1	0.05	0.02	0.00
Cundinamarca	Chía	182,544	0	1	0	0.00	0.01	0.00
	Cota	0	0	0	0	0.00	0.01	0.00
	Facatativá	0	0	0	0	0.00	0.01	0.00
	Funza	0	0	0	0	0.00	0.01	0.00
	La Calera	0	0	0	0	0.00	0.01	0.00
	Madrid	0	0	0	0	0.00	0.01	0.00
	Mosquera	0	0	0	0	0.00	0.01	0.00
	Soacha	584,113	39	6	0	0.07	0.01	0.00
	Sub Total	766,657	39	7	0	0.05	0.01	0.00
	Total	8,790,457	428	139	1	0.05	0.02	0.00

C. Damage estimation of electric power supply cables

a) Collected data

Printed materials of the cable network and tables for 11kV intermediate voltage for Bogotá, Cota, Funza, Mosquera and Soacha is provided from CODENSA. Data include overhead and underground cables.

Three different methods according to the network density were used to estimate the cable length distribution for the Study Area. Thus data accuracy varies for each municipality. Details of the collected data and the process of distribution estimation are described in Appendix 4.2.6. Distribution of estimated cable length is shown in Table 4.2.26 and Appendix 4.2.8.

Table 4.2.26 Distribution of Estimated Electric Power Supply Cable Length

	Locarity or Municipality	Over Head (m)	Under Ground (m)	Total (m)
Bogotá	Usaquen	129,791	360,202	489,993
	Chapinero	28,028	125,621	153,649
	Santa Fe	73,894	48,649	122,543
	San Cristobal	108,035	658	108,693
	Usme	214,413	5,345	219,758
	Tuenjuelito	89,990	12,765	102,755
	Bosa	111,414	7,715	119,129
	Kennedy	414,611	66,868	481,478
	Fontibón	211,000	175,084	386,083
	Engativá	312,980	218,286	531,266
	Suba	510,471	373,249	883,720
	Barrios Unidos	48,743	206,178	254,921
	Teusaquillo	55,797	249,038	304,835
	Mártires	73,346	29,797	103,143
	Antonio Nariño	61,944	5,176	67,120
	Puente Aranda	195,646	46,907	242,553
	La Candelaria	9,410	4,541	13,951
	Rafael Uribe	173,190	5,556	178,746
	Ciudad Bolívar	143,950	12,930	156,880
	Sub Total	2,966,653	1,954,565	4,921,217
Cundinamarca	Chía	52,280	2,202	54,482
	Cota	90,491	0	90,491
	Facatativá	68,155	0	68,155
	Funza	141,510	0	141,510
	La Calera	94,364	0	94,364
	Madrid	45,499	0	45,499
	Mosquera	143,033	0	143,033
	Soacha	206,195	0	206,195
	Sub Total	841,528	2,202	843,730
	Total	3,808,180	1,956,767	5,764,947

Source: CODENSA

b) Methods and procedures

Overhead

Damage to the electric poles due to the 1995 Kobe Earthquake in Japan is as follows:

- No damage was observed in areas where PGA is less than 380 gal.
- 0.55% was broken or collapsed in areas where PGA is greater than 380 gal.

Damage to the electric facilities during the 1999 Quindío earthquake is as follows:

- In Armenia where PGA of 589 gal was observed, 50% of the damage was recovered in two days after the main shock.
- In Pereira where PGA of 291gal was observed, almost all damages were recovered in two days after the main shock.
- In Manizales where PGA of 102 gal was observed, no damage was recorded.

The strength of electric poles in the Study Area is assumed to be the same as those in Japan. In this study, damage function is proposed as shown in Figure 4.2.25 in the following manner:

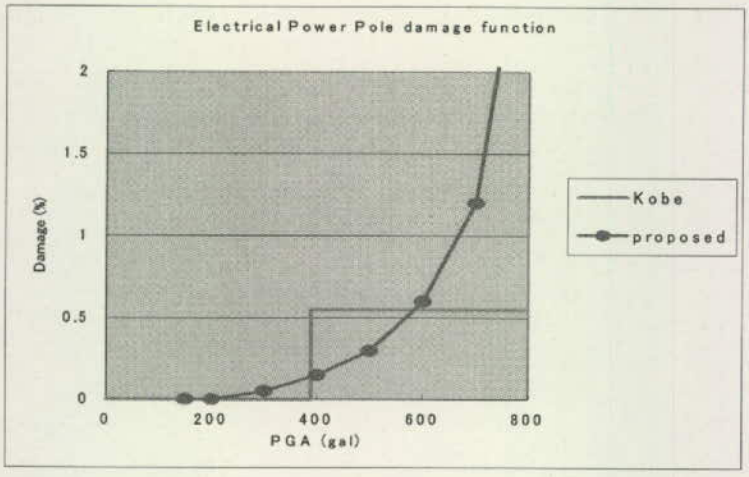


Figure 4.2.25 Damage Function for Electrical Power Pole

- Damage appears where PGA is greater than 300 gal.
- Same damage as that in Kobe occurs at PGA of 600 gal.

The damage to a pole causes damage to the cable between the poles of the broken pole, that is, half span of the cable is cut at each damaged pole.

Underground

Damages to underground cables during the 1995 Kobe earthquake in Japan were as follows:

- No damage occurred in areas where PGA is less than 380 gal.
- 0.3% was damaged in areas where PGA is over 380 gal.

No damage data for underground cable during the Quindío earthquake is available. The underground cables in the Bogotá City Area are assumed to have the same strength as that of Japan. The damage function is proposed based on the experiences in Japan earthquakes and this is shown in Figure 4.2.26.

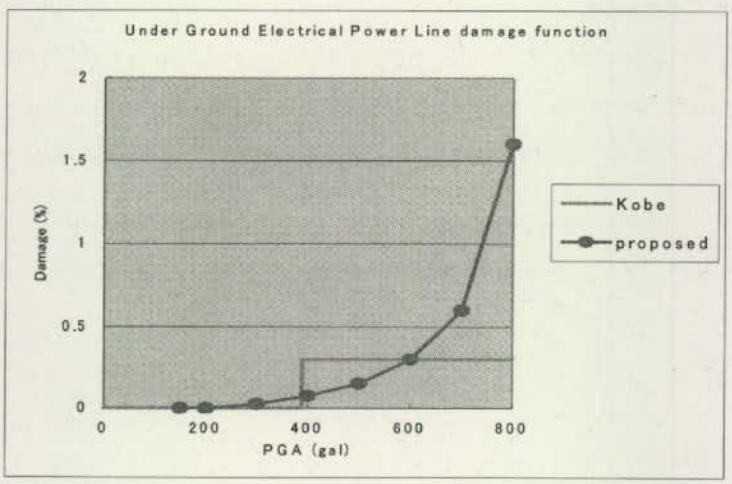


Figure 4.2.26 Damage Function for Underground Electrical Power Line

- Damage occurs at PGA higher than 300 gal.
- Damage ratio is 0.3% at PGA of around 600 gal.
- Damage ratio increases as PGA increases.

c) Results

The estimated damages for overhead cables, underground cables, and cables in total are shown in Table 4.2.27.

Case 1: La Cajita

The damage ratio for the whole area is 0.04%. The damages are estimated at the southern part of the Study Area, especially in Usme as shown in Appendix 4.2.8. This is because of high seismic intensity. The peak ground acceleration higher than 500 gal is estimated in some part of Usme, Ciudad Bolívar, San Cristobal, Rafael Uribe, Bosa and Soacha. During the 1999 Quindio earthquake, about 50% of electricity was cut-off during two days after the main shock in Armenia where 589 gal of peak ground acceleration was recorded. Therefore, service of electricity is very likely to be suspended in above-mentioned areas.

In the northern part of the Study Area except for Soacha, the damage ratio is less than 0.01%, due to the relatively low ground acceleration.

Case 2: Guayuriba

Damage ratio in the Study Area is 0.02%. Within Bogotá, areas with a damage ratio between 0.01% and 0.04% are widely distributed as shown in Appendix 4.2.8; the difference in damage ratios between areas is smaller compared to that in Case 1. Maximum damage ratio of 0.04% is estimated for Usme and Antonio Nariño.

Case 3: Subduction

Expected PGA is less than the threshold value of damage occurrence; therefore no damage is expected.

Table 4.2.27 Estimated Damage of Electric Overhead Cables

	Locarity or Municipality	Overhead Cable							Underground Cable							Cable in Total						
		Length (m)	Damage (m)			Damage ratio (%)			Length (m)	Damage (m)			Damage ratio (%)			Length (m)	Damage (m)			Damage ratio (%)		
			Case 1	Case 2	Case 3	Case 1	Case 2	Case 3		Case 1	Case 2	Case 3	Case 1	Case 2	Case 3		Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Bogota	Usaquen	129,791	17	22	0	0.01	0.02	0.00	360,202	47	62	0	0.01	0.02	0.00	489,993	64	84	0	0.01	0.02	0.00
	Chapinero	28,028	14	6	0	0.05	0.02	0.00	125,621	61	28	0	0.05	0.02	0.00	153,649	75	34	0	0.05	0.02	0.00
	Santa Fe	73,894	40	16	0	0.05	0.02	0.00	48,649	28	11	0	0.06	0.02	0.00	122,543	68	28	0	0.06	0.02	0.00
	San Cristobal	108,035	138	25	0	0.13	0.02	0.00	658	1	0	0	0.13	0.02	0.00	108,693	139	25	0	0.13	0.02	0.00
	Usme	214,413	1,013	88	0	0.47	0.04	0.00	5,345	26	2	0	0.48	0.04	0.00	219,758	1,038	91	0	0.47	0.04	0.00
	Tunjuelito	89,990	50	31	0	0.06	0.03	0.00	12,765	7	4	0	0.06	0.03	0.00	102,755	57	36	0	0.06	0.03	0.00
	Bosa	111,414	46	10	0	0.04	0.01	0.00	7,715	3	1	0	0.04	0.01	0.00	119,129	49	11	0	0.04	0.01	0.00
	Kennedy	414,611	95	81	0	0.02	0.02	0.00	66,868	15	13	0	0.02	0.02	0.00	481,478	110	94	0	0.02	0.02	0.00
	Fontibon	211,000	0	25	0	0.00	0.01	0.00	175,084	0	21	0	0.00	0.01	0.00	386,083	0	47	0	0.00	0.01	0.00
	Engativa	312,980	0	32	0	0.00	0.01	0.00	218,286	0	23	0	0.00	0.01	0.00	531,266	0	55	0	0.00	0.01	0.00
	Suba	510,471	2	47	0	0.00	0.01	0.00	373,249	2	35	0	0.00	0.01	0.00	883,720	4	82	0	0.00	0.01	0.00
	Barrios Unidos	48,743	0	13	0	0.00	0.03	0.00	206,178	0	54	0	0.00	0.03	0.00	254,921	0	67	0	0.00	0.03	0.00
	Teusaquillo	55,797	18	16	0	0.03	0.03	0.00	249,038	82	73	0	0.03	0.03	0.00	304,835	100	89	0	0.03	0.03	0.00
	Martires	73,346	34	25	0	0.05	0.03	0.00	29,797	14	10	0	0.05	0.03	0.00	103,143	47	35	0	0.05	0.03	0.00
	Antonio Nariño	61,944	25	23	0	0.04	0.04	0.00	5,176	2	2	0	0.04	0.04	0.00	67,120	27	25	0	0.04	0.04	0.00
	Puente Aranda	195,646	61	61	0	0.03	0.03	0.00	46,907	15	15	0	0.03	0.03	0.00	242,553	76	76	0	0.03	0.03	0.00
	La Candelaria	9,410	9	3	0	0.10	0.03	0.00	4,541	4	2	0	0.10	0.03	0.00	13,951	14	5	0	0.10	0.03	0.00
	Rafael Uribe	173,190	206	48	0	0.12	0.03	0.00	5,556	7	2	0	0.12	0.03	0.00	178,746	212	50	0	0.12	0.03	0.00
	Ciudad Bolivar	143,950	219	16	0	0.15	0.01	0.00	12,930	20	1	0	0.15	0.01	0.00	156,880	238	17	0	0.15	0.01	0.00
	Sub-total (points)	2,966,653	1,986	591	0	0.07	0.02	0.00	1,954,565	332	358	0	0.02	0.02	0.00	4,921,217	2,319	950	0	0.05	0.02	0.00
Cundinamarca	Chia	52,280	1	7	0	0.00	0.01	0.00	2,202	0	0	0	0.00	0.02	0.00	54,482	1	7	0	0.00	0.01	0.00
	Cota	90,491	0	5	0	0.00	0.01	0.00	0	0	0	0	0.00	0.00	0.00	90,491	0	5	0	0.00	0.01	0.00
	Facatativa	68,155	0	2	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	68,155	0	2	0	0.00	0.00	0.00
	Funza	141,510	0	6	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	141,510	0	6	0	0.00	0.00	0.00
	La Calera	94,364	2	2	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	94,364	2	2	0	0.00	0.00	0.00
	Madrid	45,499	0	4	0	0.00	0.01	0.00	0	0	0	0	0.00	0.00	0.00	45,499	0	4	0	0.00	0.01	0.00
	Mosquera	143,033	0	2	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	143,033	0	2	0	0.00	0.00	0.00
	Soacha	206,195	86	23	0	0.04	0.01	0.00	0	0	0	0	0.00	0.00	0.00	206,195	86	23	0	0.04	0.01	0.00
	Sub-total (points)	841,528	90	51	0	0.01	0.01	0.00	2,202	0	0	0	0.00	0.02	0.00	843,730	90	51	0	0.01	0.01	0.00
	Total (points)	3,808,180	2,077	642	0	0.05	0.02	0.00	1,956,767	332	359	0	0.02	0.02	0.00	5,764,947	2,409	1,001	0	0.04	0.02	0.00

Source: JICA Study Team

D. Damage estimation for telecommunication cable

a) Collected data

Summary of collected data is shown as follows:

Table 4.2.28 Summary of Collected Data

Institutions	Content of Data	Data Form
ETB	Location of local control stations and cabinets	GIS
	6 examples of primary network length of ETB central station	Printed table
	The total pole number in Bogotá plant of Soacha	Interview
	Radio link between overhead cable and underground cable	Interview
CAPITEL	Overhead cable network	GIS
	Underground cable network	GIS
	Location of poles	GIS
EPM BOGOTÁ	No information	

Data process

From the interview with ETB, the Study Team assumed that 99% and 51% of the primary network and the secondary network respectively is underground in the Study Area. An average distance between two adjacent electric poles is assumed to be 30m, according to CAPITEL.

Three estimation methods to estimate cable length for ETB are used according to the characteristics of data and that of area. The procedure of acquired data process is described in the Appendix 4.2.6. The estimated distribution of cable length is shown in Table 4.2.29 and in Appendix 4.2.9.

Table 4.2.29 Estimated Distribution of Telephone Cables

	Locarity or Municipality	Over Head (m)	Under Ground (m)	Total (m)
Bogotá	Usaquen	384,412	524,997	909,409
	Chapinero	251,764	372,311	624,075
	Santa Fe	126,244	147,694	273,938
	San Cristobal	236,409	219,587	455,996
	Usme	164,301	154,945	319,246
	Tuenjuelito	114,149	105,321	219,470
	Bosa	221,592	239,404	460,995
	Kennedy	429,220	483,137	912,358
	Fontibón	209,536	252,172	461,707
	Engativá	570,882	553,568	1,124,449
	Suba	558,514	641,483	1,199,997
	Barrios Unidos	298,584	326,643	625,227
	Teusaquillo	175,541	205,770	381,311
	Mártires	188,367	198,766	387,133
	Antonio Nariño	116,377	106,859	223,236
	Puente Aranda	374,512	382,335	756,847
	La Candelaria	36,793	59,389	96,182
	Rafael Uribe	277,146	256,321	533,466
	Ciudad Bolivar	263,122	275,081	538,203
	Sub Total	4,997,464	5,505,781	10,503,245
Cundinamarca	Chía	48,536	16,373	64,909
	Cota	90,491	0	90,491
	Facatativá	68,155	0	68,155
	Funza	141,510	0	141,510
	La Calera	94,364	0	94,364
	Madrid	45,499	0	45,499
	Mosquera	143,033	3,853	146,886
	Soacha	326,444	218,265	544,710
	Sub Total	958,033	238,491	1,196,524
	Total	5,955,497	5,744,273	11,699,770

Source: ETB and CAPITEL

b) Damage function definition

Same procedure is applied as that of the electric power supply cables for the estimation of overhead and underground telecommunications cables.

c) Result of estimation

The damage to telephone overhead cables, underground cables, and cables in total is shown in Table 4.2.30. The damage distribution of telephone cables in total for case 1 and case 2 is shown in Appendix 4.2.9.

Table 4.2.30 Estimated Damage of Telephone Overhead Cable

	Locality or Municipality	Overhead Cable							Underground Cable							Cable in Total						
		Length (m)	Damage (m)			Damage ratio (%)			Length (m)	Damage (m)			Damage ratio (%)			Length (m)	Damage (m)			Damage ratio (%)		
			Case 1	Case 2	Case 3	Case 1	Case 2	Case 3		Case 1	Case 2	Case 3	Case 1	Case 2	Case 3		Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Bogota	Usaquen	384,412	40	64	0	0.01	0.02	0.00	524,997	51	92	0	0.01	0.02	0.00	909,409	91	156	0	0.01	0.02	0.00
	Chapinero	251,764	104	57	0	0.04	0.02	0.00	372,311	145	89	0	0.06	0.04	0.00	624,075	249	146	0	0.04	0.02	0.00
	Santa Fe	126,244	93	31	0	0.07	0.02	0.00	147,694	126	37	0	0.10	0.03	0.00	273,938	219	68	0	0.08	0.02	0.00
	San Cristobal	236,409	254	55	0	0.11	0.02	0.00	219,587	244	52	0	0.10	0.02	0.00	455,996	498	107	0	0.11	0.02	0.00
	Usme	164,301	746	60	0	0.45	0.04	0.00	154,945	726	58	0	0.44	0.04	0.00	319,246	1,471	118	0	0.46	0.04	0.00
	Tunjuelito	114,149	58	35	0	0.05	0.03	0.00	105,321	54	33	0	0.05	0.03	0.00	219,470	112	68	0	0.05	0.03	0.00
	Bosa	221,592	105	20	0	0.05	0.01	0.00	239,404	136	23	0	0.06	0.01	0.00	460,995	241	43	0	0.05	0.01	0.00
	Kennedy	429,220	96	84	0	0.02	0.02	0.00	483,137	110	97	0	0.03	0.02	0.00	912,358	206	181	0	0.02	0.02	0.00
	Fontibon	209,536	0	24	0	0.00	0.01	0.00	252,172	0	32	0	0.00	0.02	0.00	461,707	1	56	0	0.00	0.01	0.00
	Engativa	570,882	0	54	0	0.00	0.01	0.00	553,568	0	53	0	0.00	0.01	0.00	1,124,449	0	108	0	0.00	0.01	0.00
	Suba	558,514	3	57	0	0.00	0.01	0.00	641,483	4	74	0	0.00	0.01	0.00	1,199,997	7	131	0	0.00	0.01	0.00
	Barrios Unidos	298,584	0	70	0	0.00	0.02	0.00	326,643	0	77	0	0.00	0.03	0.00	625,227	0	148	0	0.00	0.02	0.00
	Teusaquillo	175,541	57	48	0	0.03	0.03	0.00	205,770	70	56	0	0.04	0.03	0.00	381,311	127	104	0	0.03	0.03	0.00
	Martires	188,367	77	60	0	0.04	0.03	0.00	198,766	79	62	0	0.04	0.03	0.00	387,133	156	122	0	0.04	0.03	0.00
	Antonio Nariño	116,377	45	40	0	0.04	0.03	0.00	106,859	41	37	0	0.04	0.03	0.00	223,236	86	77	0	0.04	0.03	0.00
	Puente Aranda	374,512	100	109	0	0.03	0.03	0.00	382,335	98	111	0	0.03	0.03	0.00	756,847	198	220	0	0.03	0.03	0.00
	La Candelaria	36,793	36	12	0	0.10	0.03	0.00	59,389	57	19	0	0.16	0.05	0.00	96,182	93	30	0	0.10	0.03	0.00
	Rafael Uribe	277,146	303	74	0	0.11	0.03	0.00	256,321	281	69	0	0.10	0.02	0.00	533,466	584	143	0	0.11	0.03	0.00
	Ciudad Bolivar	263,122	371	28	0	0.14	0.01	0.00	275,081	377	31	0	0.14	0.01	0.00	538,203	747	58	0	0.14	0.01	0.00
	Sub-total (m)	4,997,464	2,489	982	0	0.05	0.02	0.00	5,505,781	2,999	1,101	0	0.05	0.02	0.00	10,503,245	5,088	2,083	0	0.05	0.02	0.00
Cundinamarca	Chia	48,536	1	6	0	0.00	0.01	0.00	16,373	0	2	0	0.00	0.00	0.00	64,909	1	8	0	0.00	0.01	0.00
	Cota	90,491	0	4	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	90,491	0	4	0	0.00	0.00	0.00
	Facatativa	68,155	0	2	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	68,155	0	2	0	0.00	0.00	0.00
	Funza	141,510	0	5	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	141,510	0	5	0	0.00	0.00	0.00
	La Calera	94,364	2	1	0	0.00	0.00	0.00	0	0	0	0	0.00	0.00	0.00	94,364	2	1	0	0.00	0.00	0.00
	Madrid	45,499	0	4	0	0.00	0.01	0.00	0	0	0	0	0.00	0.00	0.00	45,499	0	4	0	0.00	0.01	0.00
	Mosquera	143,033	0	2	0	0.00	0.00	0.00	3,853	0	0	0	0.00	0.00	0.00	146,886	0	2	0	0.00	0.00	0.00
	Soacha	326,444	278	43	0	0.09	0.01	0.00	218,265	213	37	0	0.07	0.01	0.00	544,710	492	80	0	0.09	0.01	0.00
	Sub-total (m)	958,033	282	67	0	0.03	0.01	0.00	238,491	213	39	0	0.02	0.00	0.00	1,196,524	495	106	0	0.04	0.01	0.00
	Total (points)	5,955,497	2,771	1,049	0	0.05	0.02	0.00	5,744,273	2,813	1,140	0	0.05	0.02	0.00	11,699,770	5,583	2,189	0	0.05	0.02	0.00

Case 1

The damage ratio for the Study Area is 0.05%. The damage is expected to concentrate in the southern part of the Study Area, especially in Usme. This is because of a high seismic intensity. The peak ground acceleration higher than 500 gal exists in some part of the localities of Usme, Ciudad Bolívar, San Cristóbal, Rafael Uribe, Bosa and Soacha.

In the northern part of Bogotá and municipalities in Cundinamarca except for Soacha, the damage ratios are less than 0.01%, due to the relatively low ground acceleration.

Case 2

The damage ratio in the whole Study Area is 0.02%. Within Bogotá, areas with a damage ratio between 0.01% and 0.04% are widely distributed; the difference in damage ratios between areas is smaller compared to that in case 1. The maximum damage ratio of 0.04 % is estimated at the locality of Usme.

Case 3

The estimated PGA is less than the threshold value of damage to be incurred; therefore no damage is estimated.

(4) Damage estimation for bridges

A. Collected data

The vehicular bridges on the main roads in the map "PLANO DE LA CIUDAD DE BOGOTÁ, D.C," IGAC, 2001, and the national roads in the eight municipalities are investigated by the Study Team.

The number of bridges investigated is shown in Table 4.2.31. Figure 4.2.27 shows the location of bridges.

Table 4.2.31 Number of Bridges Investigated by JICA Study Team

	Pedestrian bridges	Vehicular bridges		
		Flyover	River	Total
Bogotá	146	108	69	323
8 cities	19	6	11	36
Total	**165**	**114**	**80**	**359**

Source: JICA Study Team

The following characteristics are observed about the bridges in the Bogotá City Area:

- Almost all the bridges are made of concrete structures.
- Of the 194 of the total number of bridges, 80 of them, or about 40%, go across rivers. While the number of bridges across roads is 114, or 60%, and most of them are flyover bridges.
- Most of the bearings on piers and abutments are of neoprene material. Those are designed based upon the concept that the fixed or movable bearings are not distinguishable.
- 80% of the river-cross bridges are one-span simple girder type. While rigid frame, one-span simple girder, continuous girder, and simple girder of multi-span are distributed almost evenly in road-cross bridges.

The following characteristic are seen from the design viewpoint:

- It is considered that bridges were designed based on the AASHTO standard (USA design code) with modification from time to time before 1995 when Colombian bridge design code (CCP-200) was stipulated. Seismic design was performed in accordance with the AASHTO standard.
- Bridge design is performed based on the CCP-200 after 1995 and seismic coefficient of 0.2 is adopted in Bogotá City.
- Bridge design, however, is performed based on the CCP-200 after 1997 when the Microzonation Study was completed. Seismic coefficient is set in accordance with the study result. (Seismic coefficient is in accordance to the response spectrum.)
- Liquefaction is generally not considered in the design but only in a specific project when required.

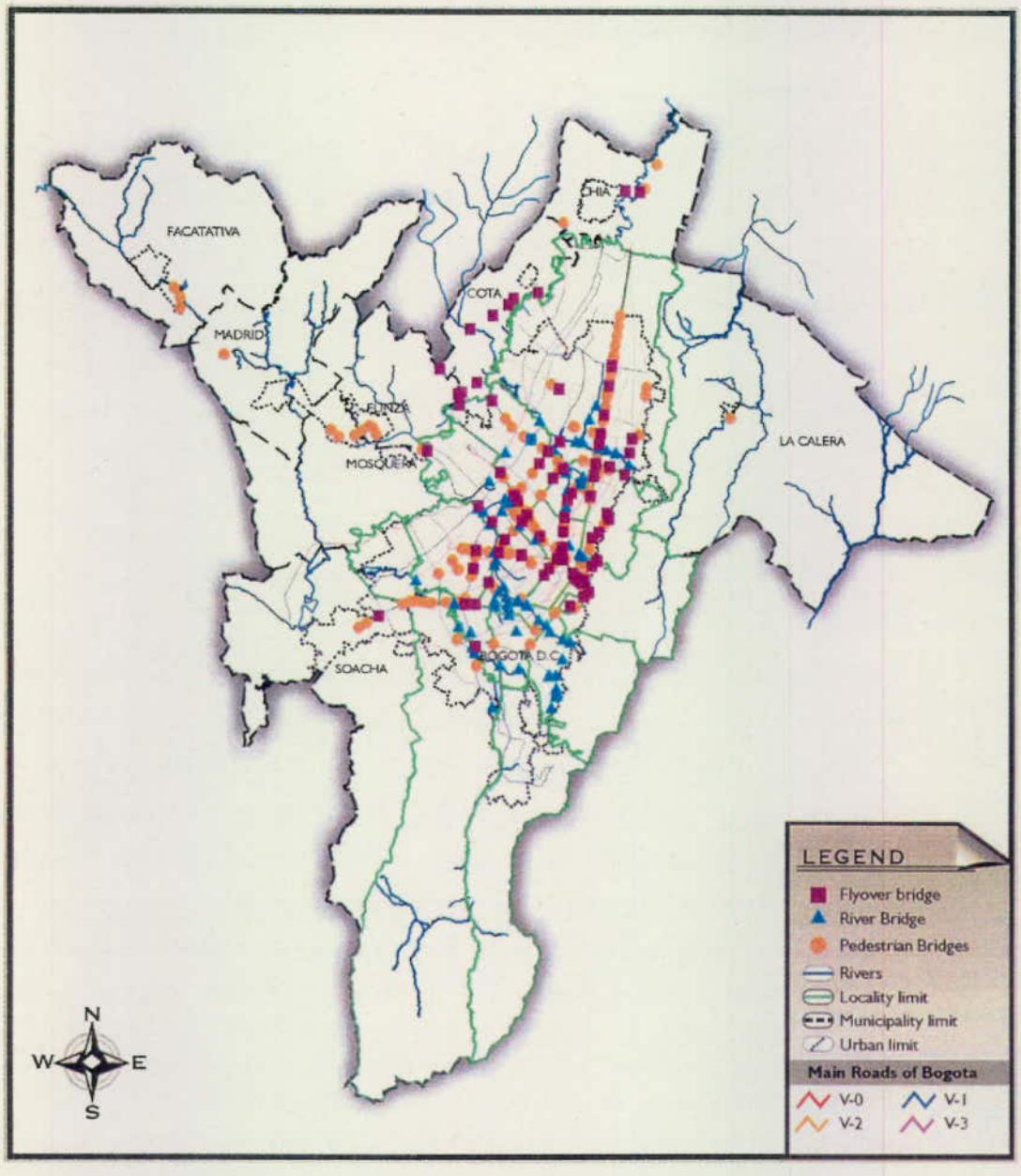


Figure 4.2.27 Locations of Bridges

Assumptions

A statistical method based on Japanese experiences is adopted, since information on collapse of bridges in Colombia is not available. The "point evaluation procedure", i.e. the multi-dimensional quantification theory, was adopted. The results obtained from the 'point evaluation procedure' describe what amount of damage may be expected to bridges at the time of an earthquake. It is crucial that once some bridges are judged to collapse then a detailed seismic analysis should be undertaken as precise as the original design.

B. Methods and procedures

Procedures

There are vehicular and pedestrian bridges in the Study Area. In this study, seismic risk of vehicular bridges is evaluated. Basic concept of seismic risk estimation for bridges is shown in Figure 4.2.28.

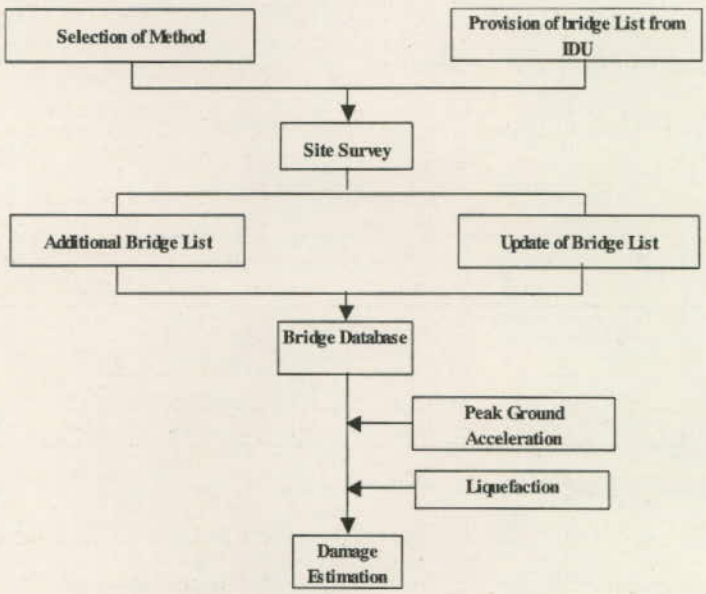


Figure 4.2.28 Basic Concept of Damage Estimation for Bridges

Methods

The criteria for seismic damage of the bridge is based on the method proposed by Tsuneo Katayama, which has been adopted in the Disaster Prevention Council of Tokyo Metropolitan Area (1978) and is widely used in Japan for practical purpose. This method only evaluates collapse of beam, and breaking of piers or foundations etc. are not evaluated. The following factors are taken into account for evaluation:

- Ground type, Liquefaction, Girder type, Number of individual girders.
- Bearing type (shoe type), Minimum bridge seat width.
- Maximum height of abutment and pier, Earthquake intensity scale.
- Foundation type, Material of abutment and pier.

Estimated seismic risk is expressed as a total score. Stability judgment of bridges is defined as follows:

- Total score is above 30: "High Seismic Risk".
- Total score is from 26 to 30: "Medium Seismic Risk".
- Total score is below 26: "Low Seismic Risk".

Pedestrian Bridge

In this study, pedestrian bridges are evaluated only with respect to liquefaction potential area. This is partly because collapsed pedestrian bridges will not pose major obstacles after an earthquake, since it is relatively easy to remove the wreckage. Another reason is that there was no collapse of pedestrian bridges in earthquakes in Japan. Furthermore, no information on collapse of pedestrian bridges during earthquakes in Colombia was available.

C. Results of damage estimation

The estimated risks of bridge are shown in Table 4.2.32 and Figure 4.2.29.

Table 4.2.32 Summary of Estimated Seismic Risk

Seismic Risk	Case 1: La Cajita		Case 2:Guayuriba		Case 3: Subduction	
	Nom.	%	Nom.	%	Nom.	%
High	53	27.3	58	29.9	0	0.0
Medium	1	0.5	0	0.0	0	0.0
Low	140	72.2	136	70.1	194	100.0
Total	**194**	**100.0**	**194**	**100.0**	**194**	**100.0**

The damages of case 1 are almost the same as that of Case 2. Seismic damages for one-third of the bridges are "High". No damage is expected in Case 3. All the bridges in municipalities in Cundinamarca are expected as "low" risk for the three cases.

The estimated seismic damages of bridges by structural type are shown in Figure 4.2.30 and Tables 4.2.33 and 4.2.34.

Regarding structural type of bridges, all Rahamen type bridges are of low seismic risk for the three cases. Most bridges with more than 1 simple beam are at high risk in cases 1 and 2.

The estimated seismic risk of bridges by liquefaction effect is shown as Figure 4.2.31 and Tables 4.2.35 and 4.2.36.

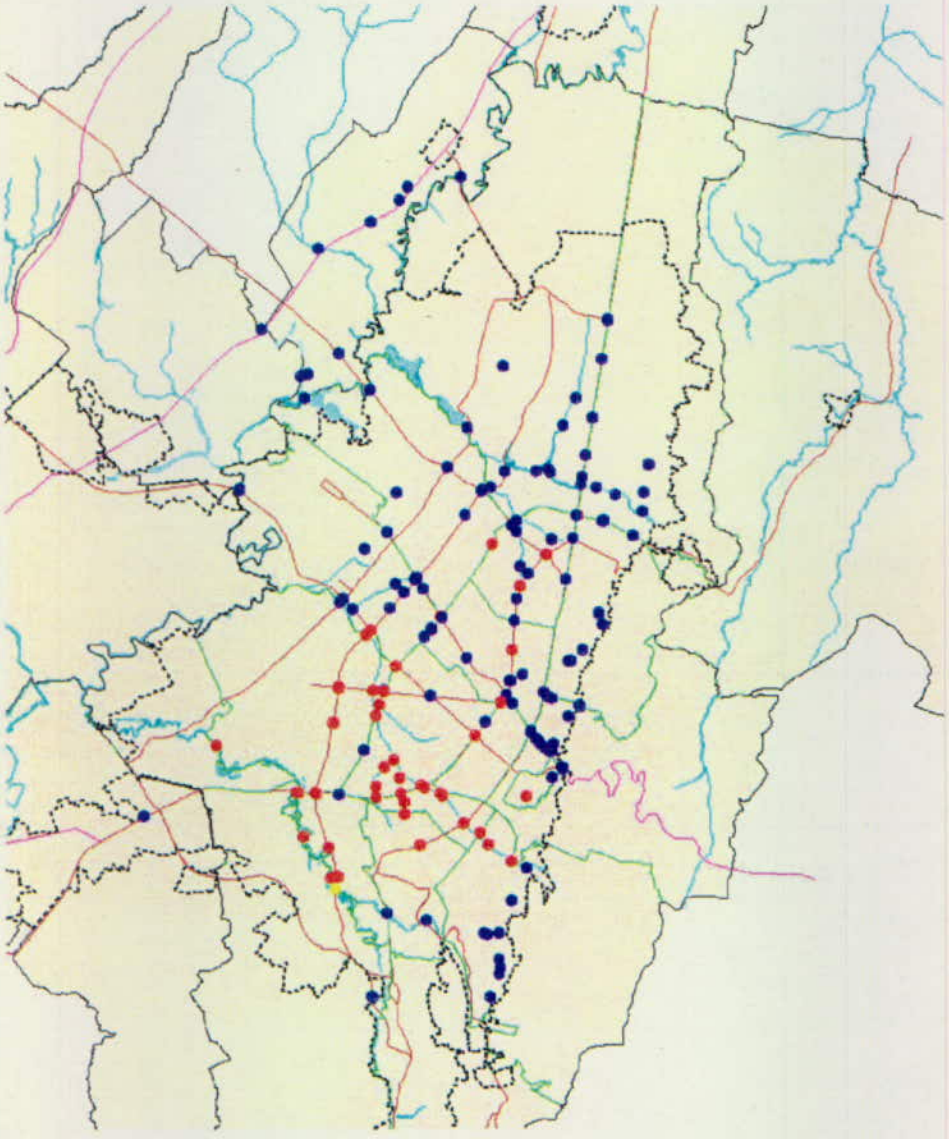
Regarding liquefaction effects, more than 70% of high-risk bridges are affected by liquefaction.

Table 4.2.33 Estimated Seismic Risk of Bridges by Structural Type (Case 1)

					Case 1: La Cajita fault					
					Number			(%)		
Area	Type	Structure	Num.	%	High	Medium	Low	High	Medium	Low
Bogotá	River	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	64	33.0	25	1	38	12.9	0.5	19.6
		more than 1 Simple beam	2	1.0	2	0	0	1.0	0.0	0.0
		Sub-total	**69**	**35.6**	**27**	**1**	**41**	**13.9**	**0.5**	**21.1**
	Vehicle	Rahamen	26	13.4	0	0	26	0.0	0.0	13.4
		Continuous	7	3.6	0	0	7	0.0	0.0	3.6
		Simple beam	27	13.9	1	0	26	0.5	0.0	13.4
		more than 1 Continuous	22	11.3	7	0	15	3.6	0.0	7.7
		more than 1 Simple beam	26	13.4	18	0	8	9.3	0.0	4.1
		Sub-total	**108**	**55.7**	**26**	**0**	**82**	**13.4**	**0.0**	**42.3**
	River + Vehicle		177	91.2	53	1	123	27.3	0.5	63.4
8 Municipalities	River	Simple beam	11	5.7	0	0	11	0.0	0.0	5.7
	Vehicle	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	1	0.5	0	0	1	0.0	0.0	0.5
		more than 1 Continuous	2	1.0	0	0	2	0.0	0.0	1.0
		Sub-total	**6**	**3.1**	**0**	**0**	**6**	**0.0**	**0.0**	**3.1**
	River + Vehicle		17	8.8	0	0	17	0.0	0.0	8.8
Total	River	Bogotá + Cundinamarca	80	41.2	27	1	52	13.9	0.5	26.8
	Vehicle	Bogotá + Cundinamarca	114	58.8	26	0	88	13.4	0.0	45.4
	Total	**Bogotá + Cundinamarca**	**194**	**100.0**	**53**	**1**	**140**	**27.3**	**0.5**	**72.2**

Table 4.2.34 Estimated Seismic Risk of Bridges by Structural Type (Case 2)

					Case 2: Guayuriba fault					
					Number			(%)		
Area	Type	Structure	Num.	%	High	Medium	Low	High	Medium	Low
Bogotá	River	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	64	33.0	25	0	39	12.9	0.0	20.1
		more than 1 Simple beam	2	1.0	2	0	0	1.0	0.0	0.0
		Sub-total	**69**	**35.6**	**27**	**0**	**42**	**13.9**	**0.0**	**21.6**
	Vehicle	Rahamen	26	13.4	0	0	26	0.0	0.0	13.4
		Continuous	7	3.6	0	0	7	0.0	0.0	3.6
		Simple beam	27	13.9	1	0	26	0.5	0.0	13.4
		more than 1 Continuous	22	11.3	7	0	15	3.6	0.0	7.7
		more than 1 Simple beam	26	13.4	23	0	3	11.9	0.0	1.5
		Sub-total	**108**	**55.7**	**31**	**0**	**77**	**16.0**	**0.0**	**39.7**
	River + Vehicle		177	91.2	58	0	119	29.9	0.0	61.3
8 Municipalities	River	Simple beam	11	5.7	0	0	11	0.0	0.0	5.7
	Vehicle	Rahamen	3	1.5	0	0	3	0.0	0.0	1.5
		Simple beam	1	0.5	0	0	1	0.0	0.0	0.5
		more than 1 Continuous	2	1.0	0	0	2	0.0	0.0	1.0
		Sub-total	**6**	**3.1**	**0**	**0**	**6**	**0.0**	**0.0**	**3.1**
	River + Vehicle		17	8.8	0	0	17	0.0	0.0	8.8
Total	River	Bogotá + Cundinamarca	80	41.2	27	0	53	13.9	0.0	27.3
	Vehicle	Bogotá + Cundinamarca	114	58.8	31	0	83	16.0	0.0	42.8
	Total	**Bogotá + Cundinamarca**	**194**	**100.0**	**58**	**0**	**136**	**29.9**	**0.0**	**70.1**



La Cajita Fault Model

0 5 10 Kilometers

N
W E
S

LEGEND

Seismic Risk of Bridges
- High
- Medium
- Low

Figure 4.2.29	Estimated Seismic Risk of Bridges

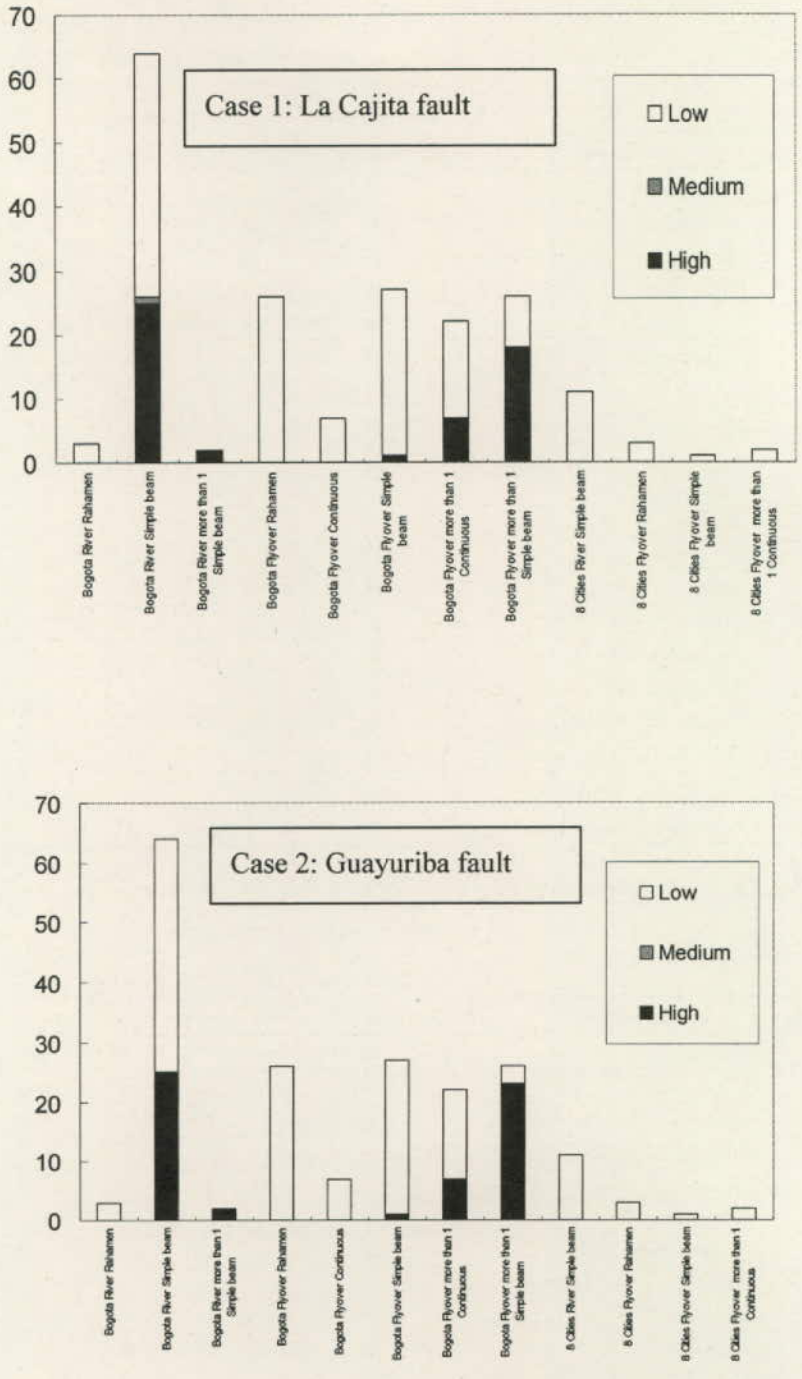


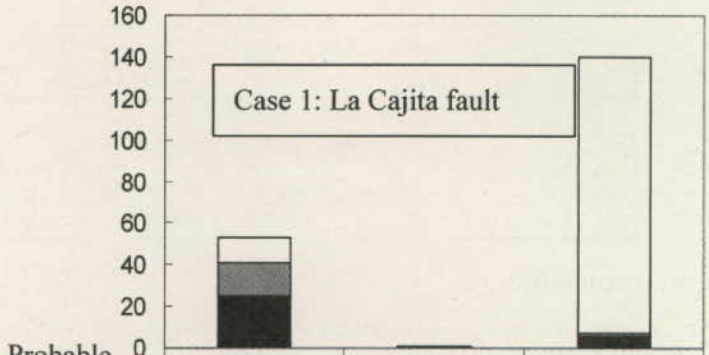
Figure 4.2.30 Estimated Seismic Risk of Bridges by Structural Type

Table 4.2.35 Estimated Seismic Risk of Bridges by Liquefaction Effect (Case 1)

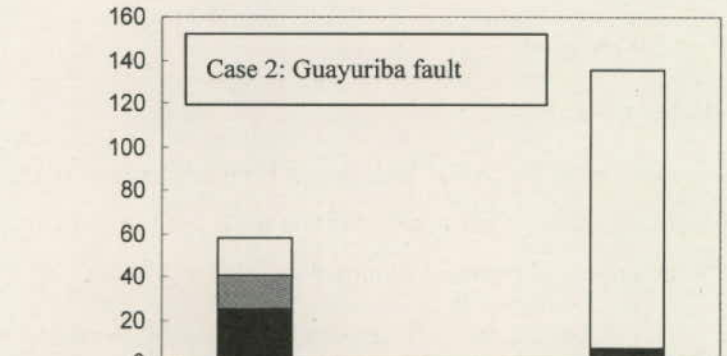
			Liquéfaction								
			Probable			Possible			None		
Area	Type	Structure	High	Medium	Low	High	Medium	Low	High	Medium	Low
Bogotá	River	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	11	0	0	14	0	1	0	0	38
		more than 1 Simple beam	2	0	0	0	0	0	0	0	0
		Sub-total	**13**	**0**	**0**	**14**	**0**	**1**	**0**	**0**	**41**
	Vehicle	Rahamen	0	0	6	0	0	0	0	0	20
		Continuous		0	0	0	0	0	0	0	7
		Simple beam	0	0	0	1	0	0	0	0	26
		more than 1 Continuous	6	0	0	1	0	0	0	0	15
		more than 1 Simple beam	6	0	0	0	0	0	17	0	3
		Sub-total	**12**	**0**	**6**	**2**	**0**	**0**	**17**	**0**	**71**
	River + Vehicle		25	0	6	16	0	1	17	0	112
8 Municipalities	River	Simple beam	0	0	0	0	0	0	0	0	11
	Vehicle	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	0	0	0	0	0	0	0	0	1
		more than 1 Continuous	0	0	0	0	0	0	0	0	2
		Sub-total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
	River + Vehicle		0	0	0	0	0	0	0	0	17
Total	River	Bogotá + Cundinamarca	13	0	0	14	0	1	0	0	52
	Vehicle	Bogotá + Cundinamarca	12	0	6	2	0	0	17	0	77
	Total	**Bogotá + Cundinamarca**	**25**	**0**	**6**	**16**	**0**	**1**	**17**	**0**	**129**

Table 4.2.36 Estimated Seismic Risk of Bridges by Liquefaction Effect (Case 2)

			Liquefaction								
			Probable			Possible			None		
Area	Type	Structure	High	Medium	Low	High	Medium	Low	High	Medium	Low
Bogotá	River	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	11	0	0	14	0	1	0	1	37
		more than 1 Simple beam	2	0	0	0	0	0	0	0	0
		Sub-total	**13**	**0**	**0**	**14**	**0**	**1**	**0**	**1**	**40**
	Vehicle	Rahamen	0	0	6	0	0	0	0	0	20
		Continuous	0	0	0	0	0	0	0	0	7
		Simple beam	0	0	0	1	0	0	0	0	26
		more than 1 Continuous	6	0	0	1	0	0	0	0	15
		more than 1 Simple beam	6	0	0	0	0	0	12	0	8
		Sub-total	**12**	**0**	**6**	**2**	**0**	**0**	**12**	**0**	**76**
	River + Vehicle		25	0	6	16	0	1	12	1	116
8 Municipalities	River	Simple beam	0	0	0	0	0	0	0	0	11
	Vehicle	Rahamen	0	0	0	0	0	0	0	0	3
		Simple beam	0	0	0	0	0	0	0	0	1
		more than 1 Continuous	0	0	0	0	0	0	0	0	2
		Sub-total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
	River + Vehicle		0	0	0	0	0	0	0	0	17
Total	River	Bogotá + Cundinamarca	13	0	0	14	0	1	0	1	51
	Vehicle	Bogotá + Cundinamarca	12	0	6	2	0	0	12	0	82
	Total	**Bogotá + Cundinamarca**	**25**	**0**	**6**	**16**	**0**	**1**	**12**	**1**	**133**



Probable	High	Medium	Low
None	12	1	133
Possible	16	0	1
Occurrence	25	0	6



Probable	High	Medium	Low
None	17	0	129
Possible	16	0	1
Occurrence	25	0	6

Figure 4.2.31 Estimated Seismic Risk of Bridges by Liquefaction Effect

C. Pedestrian bridges in liquefaction potential area

Liquefaction during earthquakes would cause serious damage to bridges. In this Study, locations of pedestrian bridges are examined from the viewpoint of potentially liquefiable area for two scenario earthquakes. As a result, almost 20% of the pedestrian bridges are found to be located in liquefaction potential area as shown in Table 4.2.37.

Table 4.2.37 Number of Pedestrian Bridges in Potentially Liquefiable Area

	Number of bridges		Ratio (%)	
Liquefaction	Case 1	Case 2	Case 1	Case 2
None	134	133	81.2	80.6
Possible	4	4	2.4	2.4
Probable	27	28	16.4	17.0
Total	**165**	**165**	**100.0**	**100.0**

D. Recommendations

- Seismic diagnosis is recommended for all the bridges in the Study Area, except for bridges examined in second step by IDU's study in 1998.
- Among them, bridges of simple beam or more than one simple beam type is high priority for seismic diagnosis.
- Bridges in potential area of liquefaction is high priority for seismic diagnosis.
- Installation of preventive measures for beam collapse is recommended.

Detailed investigation on liquefaction effect is recommended.

(5) Industrial facilities

A. Collected data

The investigation on the industrial facilities in Bogotá City was made by DPAE in 1999 and the industrial facilities of the eight municipalities have been investigated by the Study Team. The summary of the industrial facilities is shown in Table 4.2.38.

Table 4.2.38 Industrial Facilities Database

Area	CCS data base (Surveyed year)	DPAE GIS database As of 2001	Data used for seismic risk analysis
Bogotá	1,747 (1999)	1,206	1,582
8 Municipalities	392(2001)	-	392
Total	**2,286**	**1,206**	**1,974**

Source: JICA Study Team

The Study Team made some corrections on the locations of industrial facilities because some 319 companies were not included in DPAE's database.

These data on industrial facilities are classified and distributed as presented in Table 4.2.31.

Table 4.2.39 Number of the Industrial Facilities Classified according to Locality and Municipality

Locality	Number of Industrial Facilities								
	TYPE								Sum
	1	2	3	4	5	6	7	8	
Usaquén	2	0	3	12	24	12	11	33	97
Chapinero	1	0	0	6	13	2	6	20	48
Santa Fe	1	0	1	16	5	0	0	5	28
San Cristobal	2	0	0	0	4	0	0	5	11
Usme	0	0	0	0	0	0	0	1	1
Tunjuelito	2	0	0	19	5	0	1	32	59
Bosa	1	0	1	2	5	1	1	5	16
Kennedy	6	1	8	27	42	3	5	43	135
Fontibón	8	2	5	54	58	6	6	46	185
Engativá	1	1	9	39	27	13	4	43	137
Suba	0	0	4	17	14	8	11	39	93
Barrios Unidos	3	2	7	29	20	14	9	38	122
Teusaquillo	1	1	3	23	9	15	3	18	73
Mártires	2	1	2	21	33	7	4	34	104
Antonio Nariño	0	0	0	6	27	3	1	14	51
Puente Aranda	6	2	15	78	122	29	16	102	370
La Candelaria	1	0	2	1	3	0	0	4	11
Rafael Uribe	0	0	2	3	12	0	0	17	34
Ciudad Bolívar	0	0	0	2	1	1	0	3	7
Sub-total	**37**	**10**	**62**	**355**	**424**	**114**	**78**	**502**	**1,582**
Chía	0	0	7	0	13	1	7	21	49
Cota	0	0	2	8	7	0	2	4	23
Facatativa	0	0	5	3	14	0	4	3	29
Funza	1	4	4	7	20	2	11	34	83
La Calera	0	0	0	4	3	0	0	10	17
Madrid	0	1	4	10	7	0	9	17	48
Mosquera	2	1	0	7	5	0	3	2	20
Soacha	2	1	29	23	43	1	3	21	123
Sub-total	**5**	**7**	**51**	**62**	**112**	**4**	**39**	**112**	**392**
Total	**42**	**17**	**113**	**417**	**536**	**118**	**117**	**614**	**1,974**

Type 1: Oil & fat, Type 2: Pulp & Paper, Type 3: Soap, detergent & paint, Type 4: Inorganic chemical products, Type 5: Organic chemical products, Type 6: Medicine & drugs, Type 7: Other chemical, Type 8: Other industry

B. Method of analysis

In Japan, seismic risk analysis for industrial facilities is made by statistical approach, so the same kind of method is used. Flowchart is shown in Figure 4.2.32.

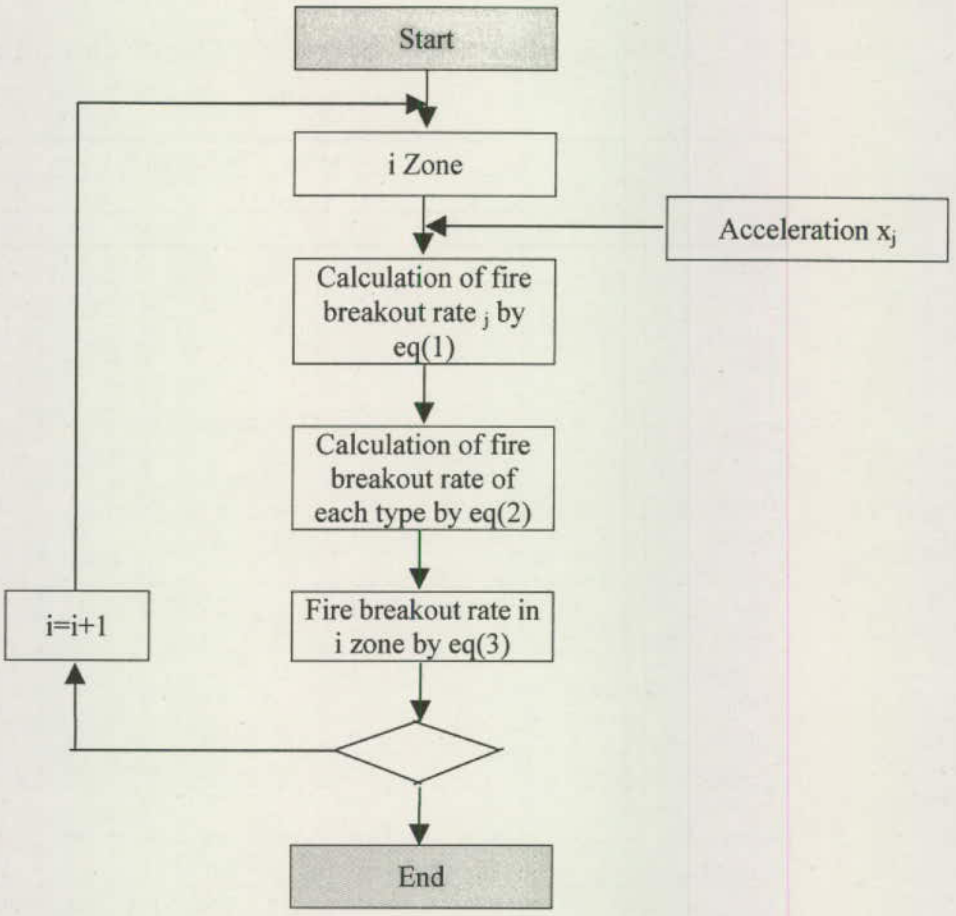


Figure 4.2.32 Flowchart of Fire Break Out Calculation

Assumptions

Tokyo Fire Department investigated the fire break out rate after an earthquake based on the past damage results and various experiments and research. These figures show the fire break out rate at the peak ground acceleration of 350 gal. Also, Tokyo Fire Department classified the industrial facilities into 8 types according to the dangerousness, that is, the degree of risk they presented (see Table 4.2.40).

Table 4.2.40 Fire Break Out Rate After an Earthquake

Type	Type of industrial facility	350gal
1	Oil and fat manufacturing from animals and plants	0.0168
2	Pulp, paper manufacturing	0.0056
3	Soap and detergent, paint manufacturing	0.0098
4	Inorganic chemical products manufacturing	0.0172
5	Organic chemical products manufacturing	0.0255
6	Medicine & drugs manufacturing	0.0467
7	Other chemical company	0.0111
8	Other industry (No use of hazardous materials)	0.0

Source: Tokyo Fire Department (1987)

On the other hand, Kanagawa Prefecture came up with an equation to estimate other acceleration as follows:

- Change rate in fire break out rate = $4.0\times10^{-4}\times$(Acceleration) +0.16.
- Combining this equation and fire break out rate at 350 gal, the fire break out rate at the other acceleration is calculated by the equation as shown in (1).

Since this estimation method uses a statistical approach, absolute values of calculation results are not so meaningful; however, relative value is important. High value indicates high risk of fire break out rate, which corresponds to the relative damage of the industrial facilities.

Calculation method

$$A_{ij} = A_j \times (1.333\times10^{-3}\ \alpha_i + 0.533) \quad (1)$$

$$D_{ij} = A_{ij} \times N_{ij} \quad (2)$$

$$D_i = \Sigma D_{ij} \quad (3)$$

i : Zone number i

j : Type of industrial facilities

α i : Peak ground acceleration in i-the zone

Nij : Total number of j type industrial facilities in i zone

Aij : Fire break out rate of j-the type industrial facilities in i-the zone

Aj : j-the type of fire out break rate at 350 gal

Dij : Damage or fire break out number of j-the type industry in i-the zone

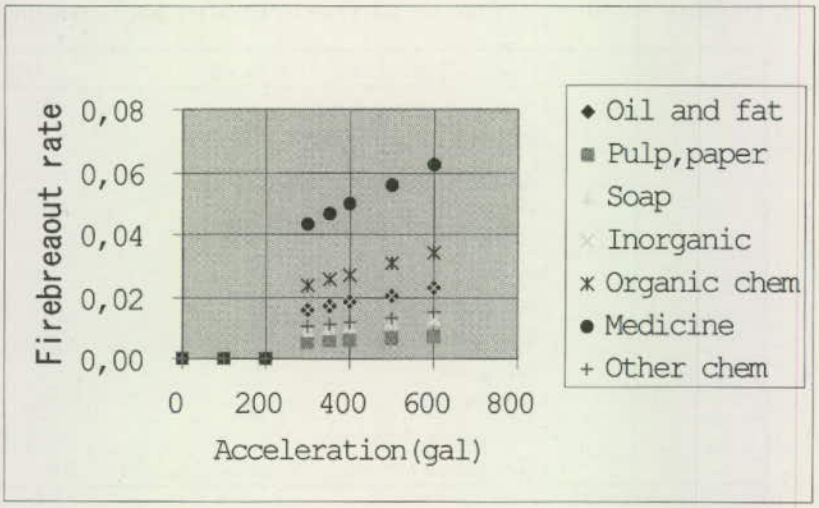


Figure 4.2.33 Fire Break Out Rate by Facility Type

Note 1) 350 gal data is shown on the basis of Tokyo Fire Department data. Other outbreak rate can be estimated by Kawasaki City's estimation method depending on acceleration experiment results.

$A_{ij} = A_j \times (1.333 \times 10^{-3} \alpha_i + 0.533)$ where A_j is at 350gal value above

2) There is no fire break out in case acceleration is less than 300 gal.

3) Gas station is classified into type 8 despite handling gasoline. Japanese experience showed no fire break out, because gasoline is stored in the underground tank.

C. Calculation results and evaluation

Risk by earthquake ground motions

Estimated seismic risks and number of the industrial facilities classified by locality and municipality is shown in Table 4.2.41. Estimated seismic damages for industrial facilities for Case 1 scenario earthquake (La Cajita Fault Model) is shown in Appendix 4.2.10. Estimated seismic risks for industrial facilities for Case 2 scenario earthquake (Guayuriba Fault model) is shown in Table 4.2.41 and Appendix 4.2.10.

These results indicate the following:

- High risk area are Puente Aranda and Los Mártires in both cases, because the number of industrial facilities that handles hazardous materials is high and peak ground acceleration is rather high.
- Soacha is medium risk area in both cases, because the number of industrial facilities is rather high and peak ground acceleration is rather high.

Table 4.2.41 Estimated Seismic Risk by Locality and Municipality

Locality	Seismic Risk Evaluation		
	Case 1	Case 2	Case 3
Usaquén	Low	Medium	Low
Chapinero	Low	Low	Low
Santa Fe	Low	Low	Low
San Cristóbal	Low	Low	Low
Usme	Low	Low	Low
Tunjuelito	Low	Low	Low
Bosa	Low	Low	Low
Kennedy	High	Medium	Low
Fontibón	Low	Medium	Low
Engativá	Low	Medium	Low
Suba	Low	Low	Low
Barrios Unidos	Low	High	Low
Teusaquillo	Low	Medium	Low
Mártires	High	High	Low
Antonio Nariño	Low	Low	Low
Puente Aranda	High	High	Low
La Candelaria	Low	Low	Low
Rafael Uribe	Low	Low	Low
Ciudad Bolívar	Low	Low	Low
Chía	Low	Low	Low
Cota	Low	Low	Low
Facatativá	Low	Low	Low
Funza	Low	Low	Low
La Calera	Low	Low	Low
Madrid	Low	Low	Low
Mosquera	Low	Low	Low
Soacha	Medium	Medium	Low

D. Risk by liquefaction

La Cajita case covers an area a bit smaller than the Guayuriba case. The total number of industrial facilities located in the liquefaction area is 474.

E. Risk analysis for gasoline tanks

The Study Team carried out a case study on the seismic influence to the gasoline tanks based on the data from TEXACO. The detailed analysis is shown in tank calculation.

F. Recommendation

- The gasoline tanks are located at Puente Aranda. The Seismic influence to the gasoline tanks must be assessed, because their holding amounts are so huge that catastrophic

disaster may occur if the tanks are destroyed. And also the toxic substances such as Cl_2 and NH_3 must be assessed, because these are very dangerous substances: TLV (Threshold Limit Value) is 1 vol. ppm for chlorine and 25 vol. ppm for ammonia.

- The big companies, which handle hazardous materials, are listed in Table 4.2.42. These companies should make the risk assessment of liquefaction influence.

Table 4.2.42 Big Companies Handling Hazardous Materials in Liquefaction Area

Name	Locality	Activity Description	Hazard Resource	Hazard
Cyquim De Colombia S.A	Puente Aranda	Production of basic industrial chemical substances except fertilizer	Dangerous substances management and dangerous process	D, F, I, E
Novartis De Colombia S.A.	Puente Aranda	Manufacturing and mixture of insecticides, pesticides, fungicides and herbicides	Dangerous substances management and dangerous process	D, F, I, E
Emp De Licores De Cundinamarrca	Puente Aranda	Distillation of ethyl alcohol, for any use	Alcohol management, combustible storage and caldron use	D, I, E
Merck Colombia S.A.	Puente Aranda	Fabrication of pharmaceutical products and medicine	Dangerous substances management	D,I
Boehringer Ingelheim S.A.	Puente Aranda	Fabrication of pharmaceutical products and medicines	Dangerous substances management and dangerous process	D, I
Fabrica Nacional De Muñecos S.A.	Puente Aranda	Fabrication of basic shape plastics, lamina, film, sticks, pipes and similar products	Management of combustible materials	I
Aga Fano Fabrica Nacional De Oxigeno S.A.	Kennedy	Manufacturing of industrial gases except chlorine and other halogens, natural gas and raw hydrocarbons	Dangerous substances management and dangerous process	D, F, I, E
Quimica Comercial Andina S.A.	Kennedy	Chemical products fabrication	Dangerous materials management, dangerous operations	D, F, I, E
Ico Pinturas S.A	Kennedy	Paint and varnish production for industrial and general use	Inflammable and volatile substances management. Dangerous reactions	D, I, E
Bayer S.A.	Kennedy	Fabrication of pharmaceutical products and medicines	Dangerous substances management and dangerous process	D, I
Gaseosas Lux S.A.	Kennedy	Manufacturing of nonalcoholic drinks or noncarbonated fruit drinks	Use of ammonia as refrigerant gas	F
Filmtex S.A.	Ciudad Bolivar	Plastic production fabrication	Dangerous substances management	I

Legend: D: Spillage F: Leakage I: Fire E: Explosion

(6) Slope

In order to evaluate the landslide possibility in an earthquake, slope stability is calculated based on the maximum horizontal acceleration in each zone by three scenario earthquakes. Thus the distribution of the possible landslide disaster area is presented.

A. Data

The slope data used in this analysis is based on maps obtained from IGAC, which was digitized and converted to grid data by the Study Team. The size of grid is 50m by 50m within basin area, or 25m by 25m within mountainous area. Slope angles (θ ') were calculated for each mesh.

B. Method

The method assumes that the area of the landslide disasters should be estimated by the distribution of the area with a critical slope angle, decided by the average of the critical slope angles in the following three slope failure modes.

$$F_S = \frac{\tan\varphi(\cos\theta - k_H \sin\theta) + c\ell}{\sin\theta + k_H \cos\theta} < 1$$

Where:

F_s: safety factor.

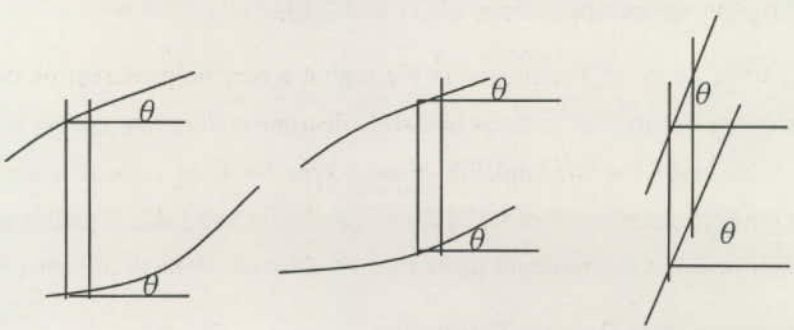
ϕ : internal friction angle of slip surface (degree).

θ : angle of slip surface (degree).

k_H: horizontal acceleration (gal).

c: cohesion (tf/m^2).

ℓ : length of slip surface per unit width (m) $\ell = 1/\cos\theta$.



Landslide Flow Fall

Table 4.2.43 Adopted Values for Slope Stability Analysis During Earthquake

Mode	c tf/m^2	ϕ °	θ
Flow	0.5	20	$\theta = \theta$ ' Slope angle θ ' is equal to the angle of the slip surface
Landslide	0.2	25	$\theta = 2/3 \cdot \theta$ ' Slip surface just under the slice is equal to 2/3 of θ '
Fall	0.0	35	Slope angle is assumed parallel to the slip surface.

The equation used here to calculate slope stability is a simplified Bishop method, added with horizontal seismic intensity. Weight of sliced volume is assumed as unit weight of 1tf. Pore pressure changes during earthquake is not included here.

The area in which Fs in each failure mode is less than 1.0 is regarded unstable. Strength of the slip surface is assumed from the results of laboratory test as follows:

- Though cohesion of the soil varies from 0 to 1, mean value is adopted in case of Flow, 0.2 (roughly half of the mean value) is adopted in case of Landslide, and 0 is adopted while in case of Fall, because the slip surface is separated.
- Internal friction angle shows 20° to 30°, and 25° is adopted in case of Landslide. The lower limit, 20° is adopted for the case of Flow. In case of Fall, 35° is adopted because 40° is the upper limit. The slope begins to move under the condition of the Fs below 1.0. If the Fs is less than 0.95, it is certain that the slope slides.

C. Result

The resulted figures are as Appendices 4.2.11 to 4.2.13.

The unstable slope areas are recognized in the region where no preservation object exists. The possibility of slope failure that induces landslide disaster is very low except for Case 1 scenario earthquake. With respect to the landslide disaster type for Case 1 scenario earthquake, possible disaster area tends to decrease in order of Flow, Landslide and Fall. For all types, unstable areas are mainly distributed in the southern part of the Study Area close to the epicenter.

4) Estimated Damage from Damage Estimation

(1) Implication of the results

Summary of status in the Study Area is shown in Tables 4.2.44 and 4.2.45. Summary of estimated damage for cases 1, 2 and 3 is shown in Tables 4.2.46, 4.2.47 and 4.2.48.

Table 4.2.44 Summary of Estimated Damage by Earthquake Scenario

Items		Earthquake Scenario		
		Case 1 (La Cajita)	Case 2 (Guayuriba)	Case 3 (Subduction)
Seismic Intensity		Maximum peak ground acceleration reaches to 0.908g. All the area will suffer seismic intensity higher than VII (strong), and southern part of study area has seismic intensity of XI (very violent) to X (violent).	Maximum peak ground acceleration is 0.361g, lower than that of case 1 due to the long distance to the fault. Major area will suffer seismic intensity of VIII (very strong) or VII (strong).	Due to the long distance to the fault, maximum peak ground acceleration is 0.125g. Central part of study area will suffer seismic intensity of VII (strong) to VI (moderate).
Direct Effects	Building	Heavily damaged: 399,384 Building damage:$ 17,316,160 Million Peso More than 50 % of the building damage is expected in the following localities. Usme, Ciudad Bolivar San Cristobal ,Tunjuelito La Candelaria, Rafael Uribe Santa Fe, Antonio Narino, Bosa	Heavily damaged:421,989 Building damage:$ 22,198,638 Million Peso 50 % of building damage is expected in the following localities. Usme, Tunjuelito, La Candelaria, Bosa San Cristobal , Rafael Uribe Kennedy , Santa Fe Antonio Narino	Heavily damaged: 61,829 Building damage:$ 4,056,774 Million Peso Building damage is expected in the study area, yet the number of affected building is mostly less than 10 % in Bogotá. Among the eight municipalities, Cota, Chia, Funza and Madrid are more than 10% of damage ratio.
	Human Casualty	It is expected more than 250 thousands injured person whole study area. The following localities have more than 10,000 injury. Ciudad Bolivar Kennedy San Cristobal Rafael Uribe Usme Bosa Tunjuuelito Puente Aranda	Following localities would have more than 10,000 injured person. Kennedy Egativa Suba Ciudad Bolivar San Cristobal Bosa Rafael Uribe Usme Usaquen Puente Aranda	Injured person also small comparing to other two cases. The highest locality is Kennedy of more than 4,000 persons.
	Infrastructure	Damage: $ 378,683 Million Peso. Bridge damage: 53 bridges Water and Gas pipeline Ciudad Bolivar, San Cristobal Usme, Kennedy, Bosa Puente Aranda Electricity and telephone cable Usme,Ciudad Bolivar, San Cristobal, Rafael Uribe	Damage: $ 408,921 Million Peso. Bridge damage: 58 bridges Water and Gas pipeline Kennedy, Puente Aranda Rafael Uribe, Usme Electricity and telephone cable damage is expected in the study area, especially most of liquefaction area.	No infrastructure damage is expected.
Secondly Effects	Industrial Facility	Seismic risk to industrial facilities is high in Puenta Aranda and Martires localities in Bogotá, medium in Kennedy locality, and in Soach municipality in Cundinamarca.	Seismic risk to industrial facilities is high in Puente Aranda and Martires in Bogotá, and medium in Usaquen, Kennedy, Fontibon, Barrios Unidos and Teusaquillo localities and Soacha municipality in Cundinamarca.	All localities and municipalities are classified into low seismic risk.
	Landslide	The possibility of slope failure that induces landslide disaster is high only for this case. Insatiable areas are mainly distributed in southern part of study area.	No landslide is expected.	No landslide is expected.

(2) Disaster Scenario

The disaster scenario shows an outline of the direct damage in the Case 1 scenario earthquake (Cajita fault) and also suggests necessary disaster prevention and emergency response to protect the Bogotá Metropolitan Area from disasters by severe earthquakes.

A. Earthquake

An earthquake with epicenter in the Cajita fault will occur early in the morning. The MMI will range from VII to X, i.e., the area near the epicenter: VIII-X, the southern part of Bogotá: VIII-IX, the central part and northwestern part of Bogotá: VII, but the terrace and cone in Facatativa and the piedmont soil at the eastern part of Bogotá and La Calera: VIII.

Buildings at the southern part of Bogotá will be heavily damaged, and from the central to the northwestern part, half of the buildings will be damaged but slightly. There will be numerous deaths and injuries in areas of heavily damaged buildings. In the southern part of Bogotá, due to the liquefaction effects, collapsed bridges will block the emergency road network at many places. The lifeline facilities, such as water supply, gas, electric power supply and telephone service facilities, will also be damaged, and public services will be stopped. The seismic damage of the Bogotá Metropolitan Area will affect the regional economy. Furthermore, the effect of the seismic damages will be spread and increased due to the delay of the arrangement related to government and non-government entities for emergency response and also the delay of the arrangement of inter-municipal, interregional and international cooperation. It will become a tragic disaster.

Consequently, the functions of the Bogotá Metropolitan Area will be paralyzed and resumption of operations will take a long time, and that will give serious impact not only to the regional economy but also to the national economy.

B. Expansion of the damage due to the delay of arrangement of disaster prevention and emergency response organizations

On the same day the, President will declare a curfew, and the next day, a state of national disaster. The Metropolitan Police and the Military will start their functions and responsibilities. The Bogotá Metropolitan Area will be militarized. Also, the President will establish a Fund for the reconstruction and social development of the Bogotá Metropolitan Area and set up a national emergency response headquarters.

The responsible entities for disaster prevention and emergency response of Bogotá City, Cundinamarca and the national government, will be affected due to blockage of the emergency road network. The emergency response activities will be delayed due to the lack of preparation for emergency response activities and there will be many difficulties for the administrative entities in conducting their emergency response activities, except the military, police, civil defense, the Red

Cross and firefighting bodies. The delay of overall emergency response and recovery activities by the administrative entities will cause and expand new problems and damages.

C. Building Damage

There are 956 thousand buildings either without any seismic resistance capacities or with low resistance capacities. However, a full-scale reinforcement of buildings have not been conducted yet, thus, about 400 thousand buildings in the Bogotá Metropolitan Area will be damaged, especially in the localities of the southern part of Bogotá City, i.e. Ciudad Bolivar, San Cristobal, Tunjuelito, La Candelaria, Rafael Uribe, Santa Fe, Antonio Nariño, Bosa and Kennedy. These localities are lack of basic infrastructure and are therefore vulnerable. The government or public buildings, except the buildings currently constructed, will be damaged in a seismic disaster. The destruction of many of the government buildings will paralyze emergency response activities and cause diminished administrative functions. The demolition of heavily damaged buildings and the clearance of a large volume of debris will be required.

The delay of arrangement of shelters and evacuation places and of reconstruction support activities, due to the lack of preparation, will lead social unrest.

D. Casualties and injuries due to building collapse

The collapse of about 400 thousand buildings will cause 39,000 deaths and 270,000 injuries. The scale of deaths and injuries will overwhelm the medical response capacity of the Bogotá Metropolitan Area. Due to the destruction of many medical facilities and hospitals, the emergency medical response capacities will be diminished and make difficult the conduct of relief activities and transportation of the injured. Also, due to lack of arrangement, support activities from the other cities and other countries will be delayed. Conditions will turn even more miserable.

E. Diminishing transportation capacity due to the damage to infrastructure

In the disaster 53 bridges will be collapsed. The trunk roads in the Bogotá Metropolitan Area will be blocked at many points and lose their function for emergency transportation. Removing the debris is the easy part; it is the recovery of function, which will take a long time because of the lack of preparation and the delay of clearing the roads. Emergency response activities and emergency transportation will be conducted through the bypasses. Traffic will totally be controlled and vehicles for emergency activities only will be allowed entry into the Metropolitan Area.

F. Victims, evacuation space and place of refuge

In the Bogotá Metropolitan Area, about 400 thousand houses/buildings would be damaged, leaving over 3 million people homeless. However, both evacuation spaces and places of refuge

will not be sufficient. Numerous victims will have to stay in the collapsed houses because of lack of evacuation spaces and evacuation facilities, water supply, food and other necessities of life.

G. Damaged lifeline facilities and lack of emergency response facilities

In the disaster, lifeline facilities will be damaged in a number of places, i.e., water supply pipeline at 3,753 places, gas pipeline at 428 places, electric cable at 2,077 places, and telephone cable at 2,771 places. The service companies will give their best efforts; however, the fundamental public services like water supply service will be stopped for a long time. In the Bogotá Metropolitan Area, there is almost no emergency water supply for victims.

H. Heavy damage in the vulnerable areas

Vulnerable areas in the southern part and some in the northern part of Bogotá, will show a high damage rate. The indirect damage will increase because of lack of basic infrastructure like evacuation sites and evacuation roads.

I. Communication

Telephone service will be cut locally in the southern part of Bogotá. Wireless telephones and portable telephones will be used. However, it will be difficult to communicate smoothly the necessary disaster and emergency information, including personal safety information.

J. Secondary damage

The earthquake will trigger fires at some of the industries, and will continue to burn, in the localities of Puente Aranda and Los Martires because of blockage of emergency road network and also because of diminished capacities of firefighting bodies owing to their own collapsed facilities. Landslides will occur in the southern part of Bogotá, in areas near to the epicenter, and some inhabitants will have to be evacuated. Landslide areas are shown in Appendices 4.2.11, 4.2.12 and 4.2.13.

(3) Issues for Disaster Management

For prevention and mitigation of the Seismic damages it requires to conduct countermeasures as follows:

A. Arrangement of disaster prevention organizations

In order to alleviate or mitigate the damages to casualties and assets it will be a basic measure for the Bogotá Metropolitan Area to establish organizations for disaster prevention and emergecy responses.

B. Strengthening of buildings, infrastructure and lifeline facilities

In order to decrease the number of casualties it is indispensable for the Bogotá metropolitan Area to alleviate or mitigate the building damages. Also for smooth conduction of

emergency response activities it is indispensable for infrastrcture like bridges and lifeline facilities to be strengthened against earthquake.

C. Arrangement of emergency responses to minimize the damage in a disaster

In order to conduct the necessary emergency responses it is necessary for the government organization to prepare for emergency responses and also to prepare initial emergency response activities. For smooth recovering and rebuilding, it is necessary to study on the necessary responses before disaster.

D. Enhancement of public awareness for disaster to alleviate casualties and damages in a disaster

It is important for the government to promote the participation of local people and communities in disaster prevention and emergency responses. In a disaster people's self support activities will be necessary in an initial stage. For the purposes it is necessary for the government continuously to enhance the people's awareness for disaster.

Table 4.2.45 Summary of Status

		Area		Population		Building		Water Pipeline		Gas Pipeline (60psi)		Electricity Cable (11kv)		Telephone Line		Industrial Facilities	
	Locarity or Municipality	(km2)	Ratio (%)	(persons)	Ratio (%)	Number (nos)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Length (m)	Ratio (%)	Number (nos)	Ratio (%)
Bogota	Usaquen	66.13	3.4	421,320	6.0	40,051	4.6	488,253	7.2	432,656	4.9	489,993	8.5	909,409	7.8	92	5.1
	Chapinero	27.39	1.4	122,991	1.8	16,108	1.8	253,606	3.7	171,736	2.0	153,649	2.7	624,075	5.3	42	2.3
	Santa Fe	56.22	2.9	107,044	1.5	15,850	1.8	183,903	2.7	168,985	1.9	122,543	2.1	273,938	2.3	28	1.5
	San Cristobal	55.23	2.8	455,028	6.5	54,156	6.2	394,344	5.8	577,386	6.6	108,693	1.9	455,996	3.9	10	0.6
	Usme	110.24	5.7	244,270	3.5	35,442	4.0	164,430	2.4	377,866	4.3	219,758	3.8	319,246	2.7	1	0.1
	Tuenjuelito	9.81	0.5	204,367	2.9	18,409	2.1	168,040	2.5	196,268	2.2	102,755	1.8	219,470	1.9	52	2.9
	Bosa	24.21	1.2	410,099	5.9	49,854	5.7	260,657	3.8	531,520	6.0	119,129	2.1	460,995	3.9	3	0.2
	Kennedy	38.39	2.0	912,781	13.1	92,050	10.5	668,722	9.8	981,395	11.2	481,478	8.4	912,358	7.8	113	6.2
	Fontibón	32.23	1.7	278,746	4.0	26,743	3.0	280,423	4.1	285,122	3.2	386,083	6.7	461,707	3.9	161	8.9
	Engativá	36.06	1.8	749,068	10.7	83,203	9.5	615,661	9.1	887,072	10.1	531,266	9.2	1,124,449	9.6	124	6.8
	Suba	100.81	5.2	706,528	10.1	85,586	9.7	717,165	10.6	912,479	10.4	883,720	15.3	1,199,997	10.3	85	4.7
	Barrios Unidos	12.02	0.6	176,552	2.5	29,077	3.3	272,517	4.0	310,006	3.5	254,921	4.4	625,227	5.3	117	6.4
	Teusaquillo	13.69	0.7	126,125	1.8	17,095	1.9	269,816	4.0	182,259	2.1	304,835	5.3	381,311	3.3	70	3.9
	Mártires	6.60	0.3	95,541	1.4	15,632	1.8	189,365	2.8	166,661	1.9	103,143	1.8	387,133	3.3	103	5.7
	Antonio Nariño	4.99	0.3	98,355	1.4	13,677	1.6	135,302	2.0	145,818	1.7	67,120	1.2	223,236	1.9	48	2.6
	Puente Aranda	17.68	0.9	282,491	4.0	38,082	4.3	418,009	6.2	406,013	4.6	242,553	4.2	756,847	6.5	334	18.4
	La Candelaria	2.08	0.1	27,450	0.4	2,864	0.3	55,631	0.8	30,535	0.3	13,951	0.2	96,182	0.8	10	0.6
	Rafael Uribe	13.68	0.7	384,623	5.5	51,679	5.9	333,689	4.9	550,978	6.3	178,746	3.1	533,466	4.6	32	1.8
	Ciudad Bolívar	232.56	11.9	575,549	8.2	66,505	7.6	384,162	5.7	709,046	8.1	156,880	2.7	538,203	4.6	4	0.2
	Sub Total	860.03	44.1	*6,378,928*	91.3	*752,063*	85.5	6,253,693	92.1	8,023,800	91.3	4,921,217	85.4	10,503,245	89.8	1,429	78.6
Cundinamarca	Chía	80.14	4.1	61,783	0.9	18,111	2.1	142,361	2.1	182,544	2.1	54,482	0.9	64,909	0.6	49	2.7
	Cota	53.68	2.8	14,784	0.2	4,631	0.5	15,903	0.2	0	0.0	90,491	1.6	90,491	0.8	23	1.3
	Facatativá	157.83	8.1	90,266	1.3	14,817	1.7	25,697	0.4	0	0.0	68,155	1.2	68,155	0.6	29	1.6
	Funza	70.29	3.6	51,808	0.7	9,246	1.1	66,958	1.0	0	0.0	141,510	2.5	141,510	1.2	83	4.6
	La Calera	317.93	16.3	24,188	0.3	4,800	0.5	18,661	0.3	0	0.0	94,364	1.6	94,364	0.8	17	0.9
	Madrid	119.44	6.1	52,110	0.7	10,249	1.2	49,869	0.7	0	0.0	45,499	0.8	45,499	0.4	48	2.6
	Mosquera	105.73	5.4	27,753	0.4	7,777	0.9	43,519	0.6	0	0.0	143,033	2.5	146,886	1.3	20	1.1
	Soacha	184.60	9.5	283,889	4.1	57,930	6.6	173,080	2.5	584,113	6.6	206,195	3.6	544,710	4.7	119	6.5
	Sub Total	1,089.65	55.9	*606,581*	8.7	*127,561*	14.5	536,048	7.9	766,657	8.7	843,730	14.6	1,196,524	10.2	388	21.4
	Total	1,949.68	100	6,985,509	100	879,624	100	6,789,741	100	8,790,457	100	5,764,947	100	11,699,770	100	1,817	100

Table 4.2.46 Summary of Estimated Damage (Case 1)

	Locarity or Municipality	Peak Ground Min (g)	Peak Ground Max (g)	Liquefaction Potential	Heavily Damaged Number (nos)	Heavily Damaged Ratio (%)	Human Death Number (persons)	Human Death Ratio (%)	Human Injury Number (persons)	Human Injury Ratio (%)	Water Pipeline Damage (point)	Water Pipeline Ratio (point/km)	Gas Pipeline (60psi) Damage (point)	Gas Pipeline (60psi) Ratio (point/km)	Electricity Cable (11kv) Length (m)	Electricity Cable (11kv) Ratio (%)	Telephone line Length (m)	Telephone line Ratio (%)	Indust. Facilities Seismic Risk
Bogota	Usaquen	0.120	0.370	None	11,070	30	1,081	0.3	7,651	1.8	55	0.11	3	0.01	64	0.01	91	0.01	Low
	Chapinero	0.162	0.436	None	5,771	35	336	0.3	2,426	2.0	81	0.32	5	0.03	75	0.05	249	0.04	Low
	Santa Fe	0.196	0.487	Possible	10,418	66	641	0.6	4,580	4.3	98	0.53	7	0.04	68	0.06	219	0.08	Low
	San Cristobal	0.241	0.605	Possible	43,281	80	5,104	1.1	35,136	7.7	519	1.32	53	0.09	139	0.13	498	0.11	Low
	Usme	0.213	0.754	None	33,740	95	3,027	1.2	21,028	8.6	517	3.15	71	0.19	1,038	0.47	1,471	0.46	Low
	Tunjuelito	0.169	0.384	Probable	13,959	76	1,544	0.8	10,854	5.3	129	0.77	10	0.05	57	0.06	112	0.05	Low
	Bosa	0.135	0.533	Probable	25,666	51	2,529	0.6	17,629	4.3	194	0.74	21	0.04	49	0.04	241	0.05	Low
	Kennedy	0.129	0.338	Probable	46,229	50	6,564	0.7	44,985	4.9	312	0.47	28	0.03	110	0.02	206	0.02	Medium
	Fontibón	0.125	0.280	None	4,153	15	299	0.1	2,162	0.8	3	0.01	0	0.00	0	0.00	1	0.00	Low
	Engativá	0.125	0.163	None	11,873	14	1,014	0.1	7,181	1.0	6	0.01	1	0.00	0	0.00	0	0.00	Low
	Suba	0.118	0.361	None	16,786	20	1,460	0.2	10,273	1.5	14	0.02	1	0.00	4	0.00	7	0.00	Low
	Barrios Unidos	0.130	0.163	None	4,854	17	213	0.1	1,552	0.9	4	0.01	0	0.00	0	0.00	0	0.00	Low
	Teusaquillo	0.163	0.453	None	4,989	29	269	0.2	1,947	1.5	62	0.23	4	0.02	100	0.03	127	0.03	Low
	Mártires	0.290	0.468	Possible	7,500	48	378	0.4	2,727	2.9	88	0.47	7	0.04	47	0.05	156	0.04	High
	Antonio Nariño	0.320	0.341	Possible	7,273	53	428	0.4	3,076	3.1	71	0.53	6	0.04	27	0.04	86	0.04	Low
	Puente Aranda	0.174	0.338	Pos.-Prob.	18,575	49	1,497	0.5	10,529	3.7	178	0.43	15	0.04	76	0.03	198	0.03	High
	La Candelaria	0.307	0.487	Possible	2,122	74	115	0.4	843	3.1	41	0.73	2	0.07	14	0.10	93	0.10	Low
	Rafael Uribe	0.266	0.625	Pos.-Prob.	38,244	74	3,848	1.0	26,622	6.9	342	1.03	48	0.09	212	0.12	584	0.11	Low
	Ciudad Bolívar	0.159	0.908	Probable	55,569	84	7,280	1.3	49,806	8.7	789	2.05	107	0.15	238	0.15	747	0.14	Low
	Sub Total				362,072	48	37,627	0.6	261,005	4.1	3,504	0.56	388	0.05	2,319	0.05	5,088	0.05	
Cundinamarca	Chia	0.112	0.263	None	3,725	20	85	0.1	628	1.0	1	0.01	0	0.00	1	0.00	1	0.00	Low
	Cota	0.118	0.153	None	1,460	32	23	0.2	177	1.2	0	0.02	0	0.00	0	0.00	0	0.00	Low
	Facatativá	0.109	0.210	None	5,078	34	227	0.3	1,650	1.8	0	0.02	0	0.00	0	0.00	0	0.00	Low
	Funza	0.123	0.130	None	1,555	16	45	0.1	334	0.6	1	0.01	0	0.00	0	0.00	0	0.00	Low
	La Calera	0.121	0.322	None	1,746	36	47	0.2	349	1.4	6	0.31	0	0.00	2	0.00	2	0.00	Low
	Madrid	0.118	0.158	None	2,089	21	60	0.1	443	0.9	0	0.01	0	0.00	0	0.00	0	0.00	Low
	Mosquera	0.125	0.185	None	1,329	17	23	0.1	175	0.6	0	0.01	0	0.00	0	0.00	0	0.00	Low
	Soacha	0.142	0.572	None	20,330	35	1,112	0.4	7,865	2.8	240	1.39	39	0.07	86	0.04	492	0.09	Medium
	Sub Total				37,312	29	1,622	0.3	11,621	1.9	249	0.46	39	0.05	90	0.01	495	0.04	
	Total	0.109	0.908		399,384	45	39,249	0.6	272,627	3.9	3,753	0.55	428	0.05	2,409	0.04	5,583	0.05	

Table 4.2.47 Summary of Estimated Damage (Case 2)

	Locarity or Municipality	Peak Ground Acceleration Min (g)	Peak Ground Acceleration Max (g)	Liquefaction Potential	Heavily Damaged Building Number (nos)	Heavily Damaged Building Ratio (%)	Human Death Number (persons)	Human Death Ratio (%)	Human Injury Number (persons)	Human Injury Ratio (%)	Water Pipeline Damage (point)	Water Pipeline Ratio (point/km)	Gas Pipeline (60psi) Damage (point)	Gas Pipeline (60psi) Ratio (point/km)	Electricity Cable (11kv) Length (m)	Electricity Cable (11kv) Ratio (%)	Telephone line Length (m)	Telephone line Ratio (%)	Indust. Facilities Seismic Risk
Bogota	Usaquen	0.105	0.309	None	14,697	39	1,564	0.4	10,996	2.6	69	0.14	4	0.01	84	0.02	156	0.02	Medium
	Chapinero	0.122	0.311	None	5,158	31	290	0.1	2,101	0.5	40	0.16	2	0.01	34	0.02	146	0.02	Low
	Santa Fe	0.134	0.336	Possible	8,232	52	472	0.1	3,388	0.8	41	0.22	3	0.02	28	0.02	68	0.02	Low
	San Cristobal	0.135	0.338	Possible	30,561	56	3,243	0.8	22,507	5.3	100	0.25	9	0.02	25	0.02	107	0.02	Low
	Usme	0.141	0.361	None	27,135	77	2,279	0.5	15,911	3.8	57	0.35	8	0.02	91	0.04	118	0.04	Low
	Tunjuelito	0.204	0.331	Probable	12,995	71	1,406	0.3	9,904	2.4	85	0.51	7	0.03	36	0.03	68	0.03	Low
	Bosa	0.184	0.306	Probable	28,442	57	2,892	0.7	20,106	4.8	39	0.15	5	0.01	11	0.01	43	0.01	Low
	Kennedy	0.186	0.311	Probable	49,964	54	7,263	1.7	49,688	11.8	290	0.43	25	0.03	94	0.02	181	0.02	Medium
	Fontibón	0.176	0.305	None	11,269	42	1,097	0.3	7,757	1.8	31	0.11	2	0.01	47	0.01	56	0.01	Medium
	Engativá	0.176	0.304	None	35,197	42	4,177	1.0	28,859	6.8	55	0.09	5	0.01	55	0.01	108	0.01	Low
	Suba	0.107	0.296	None	37,336	44	4,137	1.0	28,582	6.8	68	0.10	5	0.01	82	0.01	131	0.01	Low
	Barrios Unidos	0.245	0.312	None	13,242	46	788	0.2	5,608	1.3	47	0.17	4	0.01	67	0.03	148	0.02	Medium
	Teusaquillo	0.295	0.316	None	7,365	43	446	0.1	3,205	0.8	51	0.19	3	0.02	89	0.03	104	0.03	Medium
	Mártires	0.297	0.325	Possible	7,285	47	364	0.1	2,627	0.6	71	0.37	5	0.03	35	0.03	122	0.03	High
	Antonio Nariño	0.317	0.329	Possible	7,153	52	419	0.1	3,011	0.7	65	0.48	6	0.04	25	0.04	77	0.03	Low
	Puente Aranda	0.304	0.318	Pos.-Prob.	18,697	49	1,510	0.4	10,617	2.5	191	0.46	15	0.04	76	0.03	220	0.03	High
	La Candelaria	0.310	0.327	Possible	1,925	67	101	0.0	744	0.2	17	0.31	1	0.03	5	0.03	30	0.03	Low
	Rafael Uribe	0.132	0.338	Pos.-Prob.	29,062	56	2,691	0.6	18,733	4.4	107	0.32	13	0.02	50	0.03	143	0.03	Low
	Ciudad Bolívar	0.122	0.359	Probable	31,870	48	3,528	0.8	24,448	5.8	64	0.17	9	0.01	17	0.01	58	0.01	Low
	Sub Total				377,585	50	38,667	9.2	268,792	63.8	1,488	0.24	132	0.02	950	0.02	2,083	0.02	
Cundinamarca	Chia	0.100	0.263	None	8,014	44	230	0.1	1,674	0.4	14	0.10	1	0.01	7	0.01	8	0.01	Low
	Cota	0.096	0.267	None	2,447	53	46	0.0	343	0.1	2	0.14	0	0.01	5	0.01	4	0.00	Low
	Facatativá	0.078	0.243	None	5,325	36	241	0.1	1,753	0.4	1	0.03	0	0.01	2	0.00	2	0.00	Low
	Funza	0.209	0.225	None	3,329	37	120	0.0	885	0.2	4	0.06	0	0.01	6	0.00	5	0.00	Low
	La Calera	0.109	0.287	None	1,435	30	36	0.0	272	0.1	4	0.20	0	0.01	2	0.00	1	0.00	Low
	Madrid	0.088	0.260	None	4,069	40	142	0.0	1,040	0.2	3	0.06	0	0.01	4	0.01	4	0.01	Low
	Mosquera	0.103	0.223	None	2,436	32	51	0.0	381	0.1	2	0.05	0	0.01	2	0.00	2	0.00	Low
	Soacha	0.113	0.307	None	17,349	30	905	0.2	6,420	1.5	27	0.16	6	0.01	23	0.01	80	0.01	Medium
	Sub Total				44,404	35	1,771	0.4	12,768	3.0	57	0.11	7	0.01	51	0.01	106	0.01	
	Total	0.078	0.361		421,989	48	40,438	9.6	281,560	66.8	1,545	0.23	139	0.02	1,001	0.02	2,189	0.02	

Table 4.2.48 Summary of Estimated Damage (Case 3)

	Locality or Municipality	Peak Ground Acceleration Min (g)	Peak Ground Acceleration Max (g)	Liquefaction Potential	Heavily Damaged Building Number (nos)	Heavily Damaged Building Ratio (%)	Human Death Number (persons)	Human Death Ratio (%)	Human Injury Number (persons)	Human Injury Ratio (%)	Water Pipeline Damage (point)	Water Pipeline Ratio (point/km)	Gas Pipeline (60psi) Damage (point)	Gas Pipeline (60psi) Ratio (point/km)	Electricity Cable (11kv) Length (m)	Electricity Cable (11kv) Ratio (%)	Telephone Line Length (m)	Telephone Line Ratio (%)	Indust. Facilities Seismic Risk
Bogota	Usaquen	0.038	0.125	None	2,404	6	148	0.0	1,083	0.3	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Chapinero	0.038	0.125	None	481	3	13	0.0	101	0.0	1	0.00	0	0.00	0	0.00	0	0.00	Low
	Santa Fe	0.038	0.108	None	1,035	7	32	0.0	238	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	San Cristobal	0.038	0.108	None	2,506	5	125	0.0	916	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Usme	0.038	0.092	None	2,305	6	92	0.0	678	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Tunjuelito	0.086	0.108	None	2,144	12	134	0.0	987	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Bosa	0.086	0.108	None	3,466	7	186	0.0	1,359	0.3	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Kennedy	0.086	0.125	None	7,387	8	602	0.1	4,302	1.0	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Fontibón	0.086	0.125	None	2,217	8	132	0.0	968	0.2	1	0.00	0	0.00	0	0.00	0	0.00	Low
	Engativá	0.086	0.125	None	6,796	8	490	0.1	3,516	0.8	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Suba	0.038	0.125	None	7,628	9	522	0.1	3,743	0.9	2	0.00	0	0.00	0	0.00	0	0.00	Low
	Barrios Unidos	0.108	0.125	None	2,642	9	97	0.0	713	0.2	1	0.01	0	0.00	0	0.00	0	0.00	Low
	Teusaquillo	0.092	0.125	None	1,144	7	39	0.0	296	0.1	1	0.00	0	0.00	0	0.00	0	0.00	Low
	Mártires	0.092	0.108	None	937	6	25	0.0	190	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Antonio Nariño	0.108	0.108	None	932	7	29	0.0	222	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Puente Aranda	0.108	0.125	None	2,493	7	109	0.0	805	0.2	1	0.00	0	0.00	0	0.00	0	0.00	Low
	La Candelaria	0.092	0.108	None	287	10	8	0.0	65	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Rafael Uribe	0.038	0.108	None	3,066	6	144	0.0	1,053	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Ciudad Bolívar	0.038	0.092	None	2,038	3	98	0.0	724	0.2	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Sub Total				51,908	7	3,026	0.7	21,959	5.2	15	0.00	1	0.00	0	0.00	0	0.00	
Cundinamarca	Chia	0.038	0.125	None	2,370	13	47	0.0	352	0.1	1	0.01	0	0.00	0	0.00	0	0.00	Low
	Cota	0.038	0.125	None	722	16	9	0.0	72	0.0	0	0.01	0	0.00	0	0.00	0	0.00	Low
	Facatativá	0.038	0.125	None	1,372	9	41	0.0	309	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Funza	0.108	0.108	None	897	10	22	0.0	165	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	La Calera	0.038	0.092	None	71	1	1	0.0	6	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Madrid	0.038	0.125	None	1,240	12	30	0.0	227	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Mosquera	0.038	0.108	None	486	6	6	0.0	48	0.0	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Soacha	0.038	0.125	None	2,763	5	83	0.0	611	0.1	0	0.00	0	0.00	0	0.00	0	0.00	Low
	Sub Total				9,921	8	239	0.1	1,790	0.4	2	0.00	0	0.00	0	0.00	0	0.00	
	Total	0.038	0.125		61,829	7	3,265	0.8	23,749	5.6	16	0.00	1	0.00	0	0.00	0	0.00	

5) Damage cost estimation

(1) Buildings

The cost estimation of building damages has been carried out based on the cadastral values of the buildings. The damage ratios are derived from the damage estimation made by this study and each locality's or municipality's damage ratio is used accordingly. Only heavily damaged buildings are included in the calculation. The results of the estimation is shown as follows:

Table 4.2.49 Results of Damage Estimation

Name of Locality/Municipality	Building Damage Estimation (million Peso)		
	Case 1	Case 2	Case 3
Usaquen	1,527,466	2,198,765	416,495
Chapinero	959,667	1,227,096	144,505
Santa Fe	678,325	563,973	54,870
San Cristobal	963,621	721,133	61,432
Usme	471,341	371,193	29,098
Tunjuelito	628,678	601,803	104,671
Bosa	624,525	640,458	77,628
Kennedy	1,989,013	2,215,676	389,212
Fontibon	535,652	1,272,761	262,041
Engativa	821,082	2,136,084	435,318
Suba	1,475,195	2,533,829	705,022
Barrios Unidos	455,671	1,573,371	262,240
Teusaquillo	777,019	1,072,914	286,910
Maritires	822,409	803,029	134,039
Antonio Narino	592,323	582,041	90,375
Puente Aranda	1,333,960	1,506,143	312,727
La Candelaria	152,563	141,222	22,225
Rafael Uribe	1,138,378	956,086	94,604
Ciudad Bolivar	865,916	584,903	44,540
SubTotal	16,812,803	21,702,482	3,927,954
Chia	96,043	91,780	65,580
Cota	29,847	58,617	16,949
Facatativa	45,673	49,241	12,476
Funza	8,601	19,211	4,908
La Calera	185,599	135,594	1,911
Madrid	13,292	25,478	8,257
Mosquera	6,577	12,414	3,054
Soacha	117,725	103,822	15,684
SubTotal	503,357	496,157	128,820
Total	17,316,160	22,198,638	4,056,774

Source: JICA Study Team

The result shows that the building damage is approximately 22 trillion pesos for the medium case, which expects the most damage in the Study Area. It means that more than 32 percent of total buildings would lose their values and total damaged value would exceed this amount because it includes only severely damaged buildings. In the Armenia case, the number of partially damaged houses is 2.5 times more, compared with the number of totally destroyed houses. Therefore, the amount of damage would be more than that of severely damaged buildings.

(2) Infrastructure and lifeline

Rough unit price for reconstruction of one bridge is estimated based on information of the actual construction costs of several bridges from IDU and the rough amount of the damaged bridges is calculated as the amount equal to the product of number of damaged bridges and unit cost.

Also, the damage amount of each lifeline is estimated it like according to the rough unit price for each lifeline facility obtained from related institutions.

A. Unit price

Unit prices used to estimate damage amount is as shown in Table 4.2.50. Unit prices are sourced from concerned institutions. Pipe materials of the water supply pipeline shown in Table 4.2.50 are those incurring almost all damages of water supply pipeline.

Table 4.2.50 Unit Price of Pipe Cable and Bridge

Item	Description	Unit Price (1000pesos)	Unit	Source
Water supply pipes	ACP	300	1 damaged point	EAAB
	CIP	350	Ditto	
	GIP	350	Ditto	
	PVC	300	Ditto	
	RC	30,000	Ditto	
Gas supply pipes	Polyethylene	1,000	Ditto	Natural Gas Company
Electrical cable	Overhead	1,300	1 meter	CODENSA
	Underground	400	Ditto	
Telephone cable	Overhead (pole)	400	1 pole	ETB
	Underground	220	1 meter	
Bridge	RC bridge	7,000,000	1 bridge	IDU

B. Amount of damage of lifelines and bridges

Tables 4.2.51, Table 4.2.52 and Table 4.2.53 show the total amount of damaged bridges and lifeline facilities in case 1, 2 and 3 scenario earthquakes respectively. Unit of the amount is million Pesos.

About 380 billion pesos of damages are anticipated in Case 1 scenario earthquake. The amount of 410 billion pesos is anticipated in Case 2 scenario earthquake. While only 5 million pesos is anticipated in Case 3 scenario earthquake. Figures in the tables are rounded to million units.

The damage amount is almost due to that of the bridge damages.

Table 4.2.51 Case 1 (La Cajita: Near) Total Damage Amount

	Amount of Damage (Million pesos)		
	Bogotá	Cundinamarca	Total
Bridge	371,000	0	371,000
Water supply pipe	3,515	253	3,768
Gas supply pipe	388	39	427
Electric cable	2,715	117	2,832
Telephone cable	605	51	656
Total	**378,223**	**460**	**378,683**

Table 4.2.52 Case 2 (Guayuriba: Medium) Total Damage Amount

	Amount of Damage (Million pesos)		
	Bogotá	Cundinamarca	Total
Bridge	406,000	0	406,000
Water supply pipe	1,494	46	1,540
Gas supply pipe	132	7	139
Electric cable	912	66	978
Telephone cable	255	9	264
Total	**408,793**	**128**	**408,921**

Table 4.2.53 Case 3 (Subduction) Total Damage Amount

	Amount of Damaged (Million pesos)		
	Bogotá	Cundinamarca	Total
Bridge	0	0	0
Water supply pipe	4	0	4
Gas supply pipe	1	0	1
Electric cable	0	0	0
Telephone cable	0	0	0
Total	**5**	**0**	**5**

4.2.2 Landslide

The landslides are triggered by man-made causes and/or natural causes. Deterioration of slope stability by changing topographic conditions such as quarry, rising groundwater tables because of lack of drainage facilities, are examples of man-made causes. On the other hand, increment of groundwater tables by rainfall and lateral forces by earthquakes are examples of the natural causes.

All these causes except for earthquakes are regular phenomena.

1) Regular Scenario

Slope failures triggered by rainfall frequently occur in the rainy season in general. In Bogotá, rainy season lasts from March to May and from October to November. However, monitoring results at El Espino show that the landslides began in the dry season, in August and in September, and that the landslide movements and the rainfalls were not necessarily related. Any relationship is not found between rainy seasons and landslides.

The ground movement was rather related to the beginning of the sewage discharge due to the installation of water supply facilities. In the regular disaster scenario, it is not likely that many landslides occur at the same time in a particular season.

4.2.3 Flooding

The flood scenario should consider magnitudes of the external force and the probable flood of 100-year return period in the flood hazard areas.

The flood disaster scenario should consider magnitudes of the external force and estimate the extent of disaster under these conditions. The external force and disaster would be assumed as follows:

- External force: Amount of runoff.
- Disaster: Flooding and inundation including flash floods.

It is necessary to conduct a flood analysis for the Bogotá City Area to set up the probable flood hazard areas, but it has not been done yet. The flood disaster scenario is to be formulated based on the existing flood risk maps of Bogotá and of the eight municipalities in Cundinamarca.

1) Scenario under Existing Conditions (without Project)

According to the study report of EAAB, the existing conveyance capacity of the Rio Bogotá is evaluated at between 5-year and 10-year return period floods, so that the run-off of 100-year return period flood will overtop the river banks. The flooding area and the affected population are estimated at 11,000 ha and 615,000 as mentioned in Chapter 3.1.3 of this report.

2) Countermeasures against the Scenario under Existing Conditions

There are two countermeasures, namely, structural measures and non-structural measures to reduce the flood damage. However, the non-structural measures cannot prevent the natural phenomena of flooding. Therefore, to prevent the disasters caused by the inundation, the structural measures will basically be applied. The design scales of preventive structures have been determined with the consideration of the importance and accumulation of the assets of the possible inundation areas.

- Rio Bogotá and Tributaries in Bogotá City: 100-year return period flood.
- Other tributaries: 10-year return period flood.

3) Scenario under Future Conditions after Completion of Structural Measures

Even though the structural countermeasures will be completed, there will still be flooding larger than the design scale along the river. It means that it is impossible to prevent all floods by the structural countermeasures. It is, therefore, necessary to consider the non-structural measures as well as structural measures to minimize the flood damage.

4.2.4 Industrial Facilities

The disaster scenario for industrial disasters is to prevent a disaster caused by dangerous materials.

1) Dangerous Materials

According to the investigation in Bogotá, the most frequent events in the past were fires followed by the explosions and these explosions were mostly linked to gunpowder and propane gas.

In terms of frequency and impact of the event, the dangerous materials are gunpowder (including Christmas hot air balloons), propane, gasoline, ammonia, solvents, natural gas, chloride and hydrochloride.

2) Localities and Company Size

The related industries are mostly located in the 8 localities of Puente Aranda, Fontibón, Kennedy, Enqativá, Barrios Unidos, and in lower rates in Usaquén, Los Mártires and Suba. These localities have 78% of the related industries in Bogotá and almost 80% of the companies are small, according to the size classification criteria based on the gross assets reported by the Chamber of Commerce.

4.3 Resources Requirement

4.3.1 Earthquake

To prevent the seismic disasters and reduce the damages estimated by the severe scenario earthquake and also to take proper emergency responses, the preparedness required is as follows:

(Basic measures)

- To conduct geological and geo-technical study on the eight municipalities in Cundinamarca.
- To establish seismic instrumentation in the eight municipalities in Cundinamarca.
- To establish emergency response measures against seismic disasters.
- To select important buildings and facilities like emergency centers, medical centers for emergency responses.
- To conduct seismic safety evaluation on the major buildings, facilities, infrastructure and lifeline structures, and to plan their countermeasures.
- To plan disaster prevention centers required for emergency responses, and
- To establish a unified structure for disaster prevention and emergency responses among the concerned entities.

(Preventive measures)

- To conduct preliminary seismic design for the major buildings, facilities, infrastructure and lifeline structures, and to implement their countermeasures.
- To conduct preliminary seismic design for historical buildings and to implement their countermeasures.
- To prepare a seismic hazard map.
- To prepare a location map for emergency responses.
- To prepare manuals for emergency responses, and
- To set up a communication system as a Disaster Management Information System.

(Preventive actions)

- To enhance public education for preventing seismic disasters and mitigating seismic damages and emergency responses.
- To enhance the technical education for seismic design of buildings and public facilities due to the Colombian Regulation for Earthquake Resistant Design and Construction.
- To review the Colombian Regulation for Earthquake Resistant Design and Construction for masonry structures.
- To establish the inspection process for the construction of buildings.
- To establish a standard seismic design for masonry buildings.
- To prepare standard remedial measures for the existing non-reinforced masonry structures.
- To enhance public education for law-abiding behaviors, and

- To publicize information on seismic hazards and required emergency responses in the Bogotá Metropolitan Area.

4.3.2 Landslide

In the regular scenario, landslide disasters occur sparsely in potential landslide areas, while an earthquake like in Case1- La Cajita will cause landslides at the areas close to the epicenter.

Therefore, the disaster prevention system should be quite different between the cases of regular time and earthquake time. In regular period, relatively small numbers of people will have to make some decisions, while large numbers of people will have to make some quick decisions in case of an earthquake. The expected cost will be mostly equal in both cases. However, in the case of an earthquake, commitment of the engineer or specialists from private consulting companies as disaster aid volunteers is indispensable in order to secure the qualified engineers or specialists.

4.3.3 Flooding

The basic concepts against flood disasters are as follows:

- No inundation will be occurred under the event of new disaster scenario.
- To minimize flood damages with the optimum combination of structural and non-structural measures.

The preparedness required is as follows:

(Basic measures)

- To establish a hydrological observation network for flood warning.
- To establish a flood warning and evacuation system for the Bogotá Metropolitan Area as a part of the Disaster Management Information System.
- To study flood hazard areas of the Bogotá Metropolitan Area, and
- To review the flood disaster prevention program in the POT.

(Preventive measures)

- To conduct river improvement works for the Rio Bogotá from Alicachin to Conejera to have a conveyance capacity of the flood discharges of 100-year return period.
- To conduct improvement works for the flood control facilities of the Rio Tunjuelo.
- To conduct river improvement works for the Rio Botello in Facatativa, and
- To conduct river improvement works and mudflow disaster prevention works at La Calera.

(Preventive actions)

- To study and to improve operation methods of the Alicachin Gates during floods.
- To enhance the control of the land use along the river from river management aspects.
- To enhance public education for prevention of flood disaster and mitigation of flood damages.

- To conduct proper operation and maintenance activities for the river facilities, and
- To enhance the management of the Rio Bogotá basin from water resources and environmental aspects.

4.3.4 Industrial Facilities

In order to prevent the urban area from the disasters related to dangerous materials and the industries handling them and to mitigate the damages, the measures required by the national, regional and company levels are suggested as follows:

(Basic measures)

- To identify hazardous materials and hazardous industries in the Bogotá Metropolitan Area.
- To prepare location maps of hazardous spots in the Bogotá Metropolitan Area, and
- To establish disaster prevention measures and emergency responses.

(Preventive measures of national and regional levels)

- To guide all companies to prepare information about hazardous materials that they are handling and to prepare a Material Safety Data Sheet (MSDS) for the hazardous materials.
- To guide all companies to conduct labeling of bottles containing hazardous materials.
- To start a qualification and training program on technological emergency management on hazardous materials.
- To reconsider the gunpowder restriction in Bogotá or to develop a prevention program for the safe management of hazardous materials based on international standards, and
- To prepare regulations for handling of hazardous materials, referring to the UNCED, US (NFPA Code, EPA RPM), Mexican Regulation, Japanese Fire Service Law etc.

(Preventive measures of regional level)

- To instruct small companies about industrial safety.
- To instruct all companies to establish a Reporting System.
- To instruct all companies to report technological accidents.
- To instruct all companies to report their industrial processes, raw materials or new projects development.
- To regulate the land use in the Bogotá City Area, and
- To relocate the high-risk facilities and industries.

(Preventive measures of company level)

- To prepare prevention plans of propane gas and natural gas disasters, and
- To reconsider the gunpowder restriction in Bogotá or to develop a prevention program for the safe management of hazardous materials based on international standards.

(Preventive actions)

- To enhance the public education of hazardous materials and hazardous industries, and
- To publicize the hazardous spots in the Bogotá Metropolitan Area.

4.3.5 Others

1) Emergency Health and Medical Services

(Basic measures)

- To establish an emergency medical response network of hospitals.
- To set up an emergency medical information system as a part of the Disaster Management Information System.
- To establish medical aide teams.
- To compile manuals on emergency disaster medical services.
- To identify core hospitals for emergency medical services, and
- To conduct preliminary seismic safety evaluation on the core hospitals.

(Preventive measures)

- To increase capacity and capability to receive patients in case of emergency, and
- To prepare temporary hospitals.

(Preventive actions)

- To enhance public education for emergency medical responses.

Chapter 5

Basic Plan for Disaster Prevention of the Bogotá Metropolitan Area

CHAPTER 5 BASIC PLAN FOR DISASTER PREVENTION OF THE BOGOTÁ METROPOLITAN AREA

5.1 General

As the results of the disaster damage estimations, the most serious damage is earthquake damage and its secondary effects. Earthquake damage will extend to the whole Study Area, while other disaster damages are limited to small areas. Despite big impact on the earthquake damage, the existing disaster management plan has not or a little interested in earthquake damage mitigation and rescuer operation.

The study team focuses on earthquake disaster prevention plans, which are composed of preparedness for disaster prevention and emergency responses, because the existing disaster prevention plans have a limitation for handling relatively small area of disaster, such as landslide and flood. Moreover, the existing disaster prevention plan has not considered emergency responses after an earthquake disaster. The earthquake disaster prevention plan addresses improvement of urban area, public awareness and emergence responses in the Study Area. The first step for this issue is to establish disaster prevention and emergency response organizations at national, Bogotá City and Cundinamarca prefecture, and local government levels. Those organizations would act as the facilitators for the disaster management system in the Study Area.

5.1.1 Basic Concept

The Basic Plan aims to establish and strengthen the existing government organization for disaster prevention and emergency responses. The existing organizations of the Bogotá Metropolitan Areas have coped with landslides and floods, however, it is necessary for the Bogotá Metropolitan Area to arrange the organizations to cope with a disaster by earthquakes. Even the damages by the Case-3 scenario earthquake (subduction), of which the estimated damages are the smallest among the three earthquake scenarios, will cause the Bogotá Metropolitan Area by far bigger damages than that of the 1999 Quindio Earthquake in Quindio. It is urgent for the Bogotá Metropolitan Area to arrange the government entities of the National, the Bogotá D.C. and the Prefecture of Cundinamarca in order to prepare against seismic disasters.

5.1.2 Basic Disaster Response

The basic disaster responses are required for the Bogotá Metropolitan Area to establish the government entities of the national, Bogotá D.C. and the Cundinamarca Prefecture levels to cope with disasters, to alleviate the damages with preparedness for disaster prevention, and optimum emergency responses properly before, in and after a seismic disaster. The basic disaster responses required for the Bogotá Metropolitan Area are planned and summarized as follows:

Table 5.1.1 Basic Disaster Responses for the Bogotá Metropolitan Area

	Short Term	Midterm	Long Term
	2002-2004	2005-2007	2008-2010
1. Arrangement of Executing system			
	Arrangement and establishment of executing systems, Preparation of action plans	Arrangement and improvement of executing systems, Review of action plan	Arrangement and improvement of executing systems, Review of action plans
2. Disaster Prevention Plan			
2.1 Strengthen the urban area			
1) Strengthen public buildings	Seismic diagnosis study, Implementation of reinforcement of buildings of 1st priority.	Implementation of reinforcement of buildings 2nd priority,	Implementation of reinforcement of buildings of 3rd priority,
2) Strengthen private buildings	Promotion of construction of seismic resistant buildings, Strengthening or rehabilitation of existing buildings,	Promotion of construction of seismic resistant buildings, Strengthening or rehabilitation of existing buildings,	Promotion of construction of seismic resistant buildings, Strengthening or rehabilitation of existing buildings,
3) Strengthening of infrastructure	Promotion of seismic diagnosis study, Implementation of Strengthening or rehabilitation of infrastructure of 1st priority,	Implementation of Strengthening or rehabilitation of infrastructure of 2nd priority,	Implementation of Strengthening or rehabilitation of infrastructure of 3rd priority
4) Strengthening of lifeline structures	Promotion of Seismic diagnosis study, Implementation of strengthening of lifeline structures of 1st priority. Study on emergency response facilities	Construction of seismic resistant lifeline facilities of 1st priority, Implementation of emergency response facilities of 1st priority,	Construction of seismic resistant lifeline facilities of 2nd priority, Implementation of emergency response facilities of 2nd priority,
5) Preparation of open spaces in urban area,	Arrangement of open spaces in urban areas, Study on emergency response facilities,	Implementation of emergency response facilities of 1st priority,	Implementation of emergency response facilities of 2nd priority,
6) Arrangement of infrastructure of vulnerable urban area,	Study on infrastructure of vulnerable urban areas,	Implementation of infrastructure of urban vulnerable areas of 1st priority,	Implementation of infrastructure of urban vulnerable areas of 2nd priority,
7) Promotion of countermeasures for the liquefaction area,	Promotion of countermeasures for the liquefaction area of 1st priority,	Promotion of countermeasures for the liquefaction area of 2nd priority,	Promotion of countermeasures for the liquefaction area of 3rd priority
8) promotion of countermeasures for hazard materials	Study on storage of hazard materials	Promotion of safety measures for hazard materials	Promotion of safety measures for hazard materials
2.2 Enhancement of public awareness			
1) Enhancement of awareness for disaster prevention	Promotion of public education	Promotion of public education	Promotion of public education
2) Promotion of cooperation system of support inter-regions	Preparation of a cooperation system of support inter-region,	Strengthening of a cooperation system of support inter-region	Strengthening of a cooperation system of support inter-region
2.3 Arrangement of Emergency response system			
1) Strengthening of communication system	Improvement of disaster management information system	Strengthening of disaster management information system	Strengthening of disaster management information system
2) improvement and strengthening executing agencies	Establishment of executing agencies, Preparation of action plan	Improvement of action plan	Improvement of action plan
3) Improvement and strengthening of rescue and support system	Establishment of executing agencies,	Strengthening of the executing agencies,	Strengthening of the executing agencies
4) Arrangement of recovery system after a disaster	Arrangement of executing agencies, Study on rebuilding plan	Review of the rebuilding plan	Review of the rebuilding plan
5) Arrangement of cooperation system	Arrangement and strengthening cooperation system	Strengthening of cooperation system,	Strengthening of cooperation system,
6) Promotion of study and investigation,	Promotion of study and investigation	Promotion of study and investigation	Promotion of study and investigation

5.1.3 Basic Assumption for the Plan

The basic assumption is summarized as follows:

- A major seismic disaster will cause numerous fatalities and injuries, property loss, and disruption of life support systems, and will have an impact on the regional economy.
- The extent of casualties and damages will reflect factors such as time of occurrence, severity of impact, weather condition, distribution of population density, building density by types, and possible triggering of secondary events such as landslides and fires.
- When a large number of casualties, a heavy damage to buildings, basic infrastructures and lifeline structures, and disruption of essential public services overwhelm the capabilities of the local Bogotá City Governments D.C. and Cundinamarca to meet the needs of the situation, the central government shall take emergency responses.

5.1.4 Basic Concept for Operation

The basic concept for operation is:

- Most of the disasters and emergency responses in the Bogotá Metropolitan Area are to be handled by the Bogotá City and Cundinamarca governments. The central government is called upon to provide supplemental assistance when the consequence of a disaster exceeds the capabilities of the local governments.
- Following a disaster, immediate response operation to save lives and protect property has precedence over recovery and mitigation.
- Setting up a Primary Coordinating Agency for the Bogotá Metropolitan Area to promote preparedness for disaster prevention, and to conduct emergency responses and recovery activities. The primary coordinating agency requires to execute a wide range of administrative, programmatic, and specialized tasks, providing logistics management; communications and information technology, financial management, community relations, public information, information collection, analysis, and dissemination.

5.1.5 Basic Plan

In order to reduce the vulnerabilities to the disaster in the Bogotá Metropolitan Area, the Basic Plan is to be composed of preparedness, emergency responses, support functions before, in and after a disaster. The support plan is further divided into the three subsections, recovery and rebuilt, emergency health and medical services and disaster management information system. The structure of the basic plan is shown as follows:

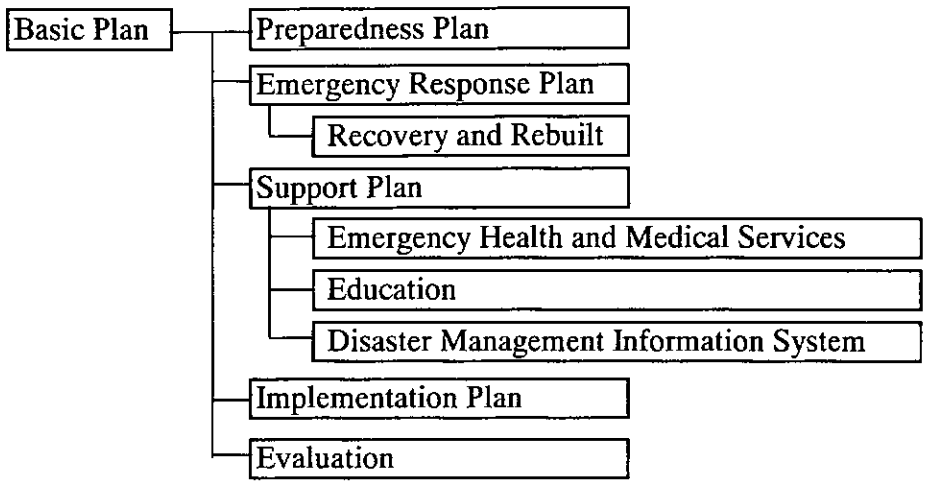


Figure 5.1.1 Structure of Basic Plan

(1) Preparedness for disaster prevention

The Bogotá Metropolitan Area requires to arrange the government entities of the National government, Bogotá D.C. and Cundinamarca against disasters. In order to reduce the existing vulnerabilities, the responsible government entities are necessary to strengthen the strategic public buildings, infrastructure and lifeline structures in the Bogotá Metropolitan Area against a seismic disaster. Also it is very important to strengthen the buildings in general in order to reduce the building damages in a seismic disaster.

Also it is necessary for the Bogotá Metropolitan Area to improve the existing communication systems and monitoring systems for establishing a disaster management information system, strengthen health and medical services and enhance public education for disaster prevention and emergency responses.

(2) Emergency response

It is necessary for the Bogotá Metropolitan Area to establish an emergency response system among the related government and non-government entities due to their responsibilities and functions before, in and after a disaster. Their responsibilities or functions as primary or support agencies, are to be decided duly. Also during the preparation stage, recovery or rebuild plan are to be prepared. The support functions required in and after a disaster are categorized as follows:

- Transportation.
- Communication.
- Public works and engineering.
- Fire-fighting.
- Information and planning.
- Mass care.
- Resource support.

- Health and medical services.
- Urban search an rescue.
- Hazardous materials.
- Food.
- Energy.

(3) Primary coordinating agency

For preparation and operation of disaster prevention plan and emergency responses, the Bogotá City Area requires to decide a Primary Coordinating Agency and strengthen it.

5.2 Preparedness for Disaster Prevention Plan

5.2.1 Emergency Management Entities

1) Basic Concept

The government entities related to Bogotá Metropolitan Area consist of three administrative levels i.e. the Bogotá City Government, the Cundinamarca Government Prefecture and the National governments. Each of them has had a Committee for Prevention and Attention of Disaster, but it is necessary for them to arrange the government entities for disaster prevention and emergency responses as soon as possible due to the responsibilities in preparedness for disaster prevention and in emergency responses before, in and after a seismic disaster. Though the required entities have already been existing, it is necessary for the Bogotá City Government, D.C. to arrange the related government entities through the District Committee for Emergency Prevention and Attention, for the Cundinamarca government Prefecture to arrange them through the Regional Committee for Prevention and Attention of Disasters of Cundinamarca, and for the National Government to arrange them through the National Committee for Emergency Prevention and Attention conduct their responsibilities and functions. The primary [5-1-1] and support[5-1-2] agencies for preparedness for disaster prevention and for emergency responses are identified and listed as follows:

2) Responsible Agencies in Preparedness

Responsible or supporting agencies identified in the Study are as follows:

(1) Bogotá:

1) Leading Agency: DAPD
2) Coordinating Agency: DPAE-FOPAE
3) Primary responsible agencies are:

- Government Secretary
- District Administrative Department of Planning (DAPD)
- Health Secretary
- DAMA
- DPAE-FOPAE
- EAAB
- IDU
- Education Secretary
- Metrovivienda
- District Institute of Recreation and Sport

5-1-1 Primary Agency : Responsible for Coordination
5-1-2 Support Agency : Supporting Primary Agency

4) Support agencies are:

- Treasury Secretary
- Firemen Official Bodies
- Civil Defense
- Red Cross
- Metropolitan Police
- District Administrative of Social Welfare
- Transit police
- EEB/CODENSA
- ETB/TELECOM
- ECOPETROL
- LOCAL MAYOR

(2) Cundinamarca prefecture:

1) Leading agency: Government Secretary

2) Coordinating agency: Government Secretary/OPAD

3) Primary responsible agencies:

- General Secretary
- Firemen Official Body
- Health secretary
- Government Secretary /OPAD
- Secretary of Public works
- Secretary of Education
- Local Mayoralties

4) Support agencies:

- Military Brigade
- National Police
- CAR
- Civil Defense
- Red Cross
- Secretary of Planning
- Secretary of Agriculture and Rural Development
- Secretary of Treasure
- Secretary of Environment
- Secretary of Social Development
- Housing Institute
- Traffic and Transportation Administration
- CUNDEPORTE

(3) National:

1) Leading Agency: Ministry of Interior

2) Coordinating Agency: DGPAD

3) Primary responsible agencies:

- DGPAD
- Ministry of Health
- Ministry of Communication
- Ministry of Education
- Ministry of Development
- Colombian Civil Defense

4) Support agencies:

- Ministry of Interior
- Ministry of Finance and Public Credit
- Ministry of National Defense
- Ministry of Environment
- National Department of Planning
- Colombian Red Cross
- Colombian Chamber of Construction
- Society of Construction Engineer
- National Police
- National Institute of Roads (INVIAS)
- Military Force (FF.MM)
- TELECOM
- National Institute of Familiar Comfort (ICBF)
- National System of Fire Fighter
- Ministry of Agriculture
- Ministry of Energy
- National University

5.2.2 Structural Measures

1) Strength Important Public Building

(1) Identification of strategic building

After the earthquake disaster, collapse of the important public building would be delay or insufficient emergency operation. The important public building should be free from disaster damage and those buildings should reinforce its structure to seismic resistance. It is essential to identify public building for priory repair.

The field survey done by the study team found that many of the public buildings are insufficient for seismic resistance. The Table 5.2.1 shows the existing building conditions for the public buildings.

Table 5.2.1 Existing Conditions for Public Building

Facility Name within Bogotá	Number of Buildings			No. of Facilities with Vulnerability Study	No of Facilities with Reinforcement
	Masonry	Concrete Frames	Others		
Bogota City					
Emergency Commanding Center	3	3	-	2	4
Fire Fighting Stations	14	2	-	9	3
Police Stations	26	2	-	-	-
Civil Defense	-	19	-	-	-
Red Cross	-	3	-	-	-
Hospitals	29	132	1	27	1
Army	71	44	13	-	-
Locality Offices (Commanding Centers)	11	8	-	-	-
Ministries	14	15	1	-	-
Airport	2	20	-	22	-
Bus Terminal	-	1	-	-	-
Goods Storage Place (Corferias)	-	21	4	11	11
Food Storage Place (Corabastos)	1	29	3	-	-
Kindergartens and Community Centers	54	34	7	-	-
Cundinmarca					
Emergency Commanding Center (Locality Offices)	7	5	2	1	1
Fire Fighting Stations	4	3	-	-	-
Police Stations	12	6	-	-	-
Civil Defense	2	2	-	-	-
Red Cross	3	-	2	-	-
Hospitals	25	28	1	1	-
Army	1	-	-	-	-
Schools (Public and Private)	11	8	-	-	-

Source: JICA Study Team

In order to identify important public buildings, the study team proposed to set criteria for the selection:

Table 5.2.2 Criteria for Building Selection

Priority	Building Type
First Priority	Commanding center Headquarter of rescuer operation organization Important Hospital
Second priority	Rescue operation building Hospitals Regional evacuation site buildings
Third priority	Other potential evacuation buildings Other important government buildings

Source: JICA Study Team

According to these criteria, the study team identifies the important public buildings in the study area.

(2) Lists of priority building

The list of priority building is shown in Table 5.2.3 and 5.2.4.

Table 5.2.3 Priority Building for Reinforcement in Bogotá City

Category	Facility Name	Building Type	Floor Area (m^2)	Remarks
FIRST PRIORITY:				
Emergency Command Centers	Ministry of Interior (Kra 8 #8-09)	Masonry	3,861	Very old buildings from 1860
	OPAD (Kra 58 # 10-05)	Masonry	600	Common neighborhood house
	Cundinamarca's Prefecture (Avenida El Dorado # 47-73)	Concrete	38,187	Built one year before the new building code NSR-98 was passed
	19 Locality Offices	Masonry	19,420	Not possible to collect data for Ciudad Bolívar Locality only
		Concrete	17,740	
Organizations for Rescue Operation	Police Headquarters La Estanzuela (Av. Caracas # 6-51)	Concrete	8,500	Operative Police Headquarters and available force in emergency cases
	Civil Defense Headquarters (Kra 27A # 52-60 - Galerías)	Concrete	720	Operatve and Administrative Headquarters for Bogotá only
	Red Cross Headquarters (Avenida 68 # 66-31)	Concrete	9,800	Red Cross National Headquarters and Emergency Services
	Central Command of Army (Avenida El Dorado - Kra 52)	Concrete	31,800	Buildings built almost 50 years ago
Important Hospitals	38 Hospitals and Clinics with Level III Service	Masonry	97,234	Level III Hospitals have more than 30 beds and offer surgery services. Several of them have vulnerability study or is undergoing one.
		Concrete	500,518	
SECOND PRIORITY:				
Category	Facility Name	Building Type	Floor Area (m^2)	Remarks
Rescue Operation Buildings	13 Fire Fighting Stations	Masonry	9,866	7 of 13 Fire Fighting Stations have Vulnerability Study
		Concrete	4,136	
	27 Police Stations	Masonry	149,620	Source of information is the Construction and Maintenance Group of the Bogotá Police
		Concrete	900	
	14 Civil Defense Branches	Concrete	11,770	Mainly neighborhood houses
	124 Army Buildings	Masonry	79,815	Mainly buildings of 30 to 40 years old. Building type "Others" includes prefabricated and steel frames.
		Concrete	179,665	
		Others	25,848	
Hospitals	15 Hospitals and Clinics	Masonry	8,468	Hospitals and Clinics of Levels I and II
		Concrete	50,740	
Regional Evacuation Sites	Parks & Open Spaces	Concrete	68,236	Information source is the IDRD
		Steel	22,675	
THIRD PRIORITY:				
Category	Facility Name	Building Type	Floor Area (m^2)	Remarks
Other Potential Evacuation Sites	84 Kindergarten Buildings	Masonry	21,367	Information source is the DABS. Several kindergartens are operated in neighborhood houses.
		Concrete	8,942	
		Others	1,788	
Other Important Government Buildings	28 Ministries Buildings	Masonry	20,962	There are many buildings over 70 years old. Buildings of steel type belong to the Agriculture Ministry.
		Concrete	247,834	
		Steel	10,000	
Transportation	Airport(Passenger & Cargo Terminals)	Masonry	1,639	
		Concrete	149,065	
	Bus Terminal of Bogotá	Concrete	37,665	Built in 1984 (better to check)
Goods Storage Site	Corferias - Exhibition Center	Concrete	39,811	16 buildings are without reinforcement at the moment; 11 have reinforcement works
		Steel	5,597	
Food Storage Site	Corabastos	Masonry	5,422	Correspond to 33 buildings within the food storage complex
		Concrete	65,046	
		Steel	15,900	

Source: JICA Study Team

Table 5.2.4 Priority Reinforcement Building in Cundinamarca

Within Cundinamarca:

FIRST PRIORITY:				
Category	**Facility Name**	**Building Type**	**Floor Area (m²)**	**Remarks**
Emergency Command Centers	Local Major's Offices	Masonry	5,768	Correspond to 14 buildings. Building type "Other" is over 100 years old.
		Concrete	8,614	
		Other	2,340	
Organizations for Rescue Operation	Fire Fighting Stations	Masonry	394	Correspond to 5 of the municipalities with Fire Fighting Force
		Concrete	2,568	
	Police Stations	Masonry	4,128	Information source is field survey of 14 police buildings
		Concrete	4,266	
	Civil Defense	Masonry	261	Only 4 municipalities have Civil Defense Force
		Concrete	475	
	Red Cross	Masonry	72	About 1815 m² of "Other" building type have adobe frames.
		Other	1,865	
	Army	Masonry	498	Air Force Maintenance Facility located in Madrid
Important Hospitals	Hospitals and Clinics	Masonry	4,340	Hospitals and clinics of Levels I and II (public and private)
		Concrete	8,079	
SECOND PRIORITY:				
Category	**Facility Name**	**Building Type**	**Floor Area (m²)**	**Remarks**
Hospitals	Health Consulting Centers	Masonry	13,978	Include 46 Health Consulting Centers (public & private) in the eight municipalities
		Concrete	38,149	
Regional Evacuation Sites	Parks & Open Spaces	Concrete	15,800	Municipal Stadiums in Facatativá and Mosquera
THIRD PRIORITY:				
Category	**Facility Name**	**Building Type**	**Floor Area (m²)**	**Remarks**
Other Potential Evacuation Sites	Schools & Kindergarten Buildings	Masonry	49,659	Correpond to 415 school and kindergarten (public and private) buildings in the eight municipalities
		Concrete	133,427	
		Other	15,542	

Source: JICA Study Team

2) Masonry Building Improvement

The building database shows that more than 81 percent of the buildings are masonry structure. The masonry building, however, would have affected most damage among the other building structures. Since the human casualty and injured person is linked with the building damage, the building damage would cause major part of earthquake damage. Therefore, reduction of building damage could contribute earthquake damage decrease.

It is urgent that weak buildings improve its structure for seismic resistance structure. Most of masonry structure building is used for the residential purposes and owned by the resident. The

improvement of masonry structure building, therefore, is responsible for each owner. However, most of building owner has a little motive of improvement of the weak housing because of ignorance of earthquake building damages.

The other issue is stop construction of new masonry building. The Curadurias Urbanas is responsible for authorizing and controlling licenses of urban development and building construction. The responsibility of the organization includes in the examination of construction licenses, yet the capacity of the office is not enough to cover constructed new house in each year. The capacity of the Curaduria Urbanas should increase to cover new construction house.

The summary of the number of the building is shown as follows:

Table 5.2.5 Number of Weak Building in the Study Area

	Number of Buildings		
	Bogotá	**Cundinamarca**	**Total**
Estrato 1 and 2	340,989	36,482	377,471
Estrato 3 and 4	304,168	73,260	377,428
Estrato 5 and 6	20,215	2,233	22,448
Total	**665,372**	**111,975**	**777,347**

Those buildings should improve its structure for seismic resistance. In order to improve seismic resistance, the government should consider following points. The problems of the improvement of the weak building can be categorized into three items: 1) insufficient technical accumulation for improvement of masonry building, 2) lack of financial support and 3) lack of public awareness for weak building improvement.

3) Road and Bridge

(1) Emergency road network

A. General

Under regional scale of the urban disaster event, collapsed road facility and obstacle on road would disturb major part of the present road network. Failure of road network system would cause rescuer to face difficulty to access damage site, because emergency vehicles could not pass the road. The study team found the expected collapsed items are summarized as follows:

Table 5.2.6 Summary of the Collapsed Items

Facility	Items
Road Facility	collapsed bridge girders of road and pedestrian, street lighting poles, traffic signals and poles, traffic and guide signboards and poles, fallen street trees, etc.
Lifeline Facility	collapsed electric and telephone poles, short-circuit by downed electric cables, flood by collapsed water pipes and sewers, gush out natural gas and fire/explosion from collapsed pipe, etc.
Falling Object	collapsed building, wall brick and window glass of damaged building, sign and bill boards, brick fences/wall, water high tanks, etc.

The major part of a traffic signal system will not work properly due to physical damage on the system and power failure. Moreover, the narrow roads may not be passed due to collapsed items. Since private vehicle often disturbs the emergency vehicle operation, it should be restrict to pass the road.

B. Emergency road network

The existing road network in the Study Area has constructed to form hierarchy road network system. The primary road has enough space for more than 100 meter of width and has formulated basic urban structure. The secondary road network also well developed in the Study Area.

After a disaster, the emergency transportation is the fundamental operation for emergency response. In order to secure emergency transportation, transport means and route should be established before the disaster situations. The basic idea of emergency road network is summarized as follows:

- Emergency road should be connected between the Study Area and other region.
- Emergency road network should be hierarchy road system.
- The alternative routes should be considered before the disaster.
- Emergency road allows operating only emergency vehicles and traffic police should control the traffic.
- Emergency road should have first priority for clearing activities.

Emergency road network system should be established in the Study Area. The emergency road network is defined as the emergency transportation network to operate search and rescue, first aid and medical treatment, lifeline repair and transport of emergency goods. The emergency road network should connect important emergency response organizations and facilities within the area.

The emergency road network should be formed as hierarchy system as shown below:

Table 5.2.7 Criteria for Emergency Road Network Selection

Classification	Descriptions
Primary Network	Commanding center Important government buildings Important transportation facilities, such as airport
Secondary Network	Emergency response organizational buildings Lifeline companies Hospitals Other important facilities for emergency operation

Source: Regional Disaster Prevention Plan (1998), Tokyo Metropolitan Government

C. Selection of emergency road network

The study team identifies primary and secondary emergency road network in the Study Area. The primary road network has connected important emergency commanding centers at local and regional level. The secondary network covers the important emergency response organizational buildings and facilities.

The primary emergency road network is almost same as primary road network in the Study Area. The secondary emergency road network is primary road as well as secondary road network in the Study Area. The emergency road network covers the whole stud area and connects important buildings and facilities.

The study team identifies regional food supply corridor, which connects other regions and the Study Area. Five national roads are identified for this purpose: Via Melgar, Via Sasaima, Autopista Medellin, Via a Tunja and Via Villavicencio.

Bogotá City has depended on the food and logistic supply from outside region and those roads are the most important road for this purpose. Therefore, the regional food supply corridor is the same importance as emergency road network.

The Figure 5.2.1 shows the emergency road network.

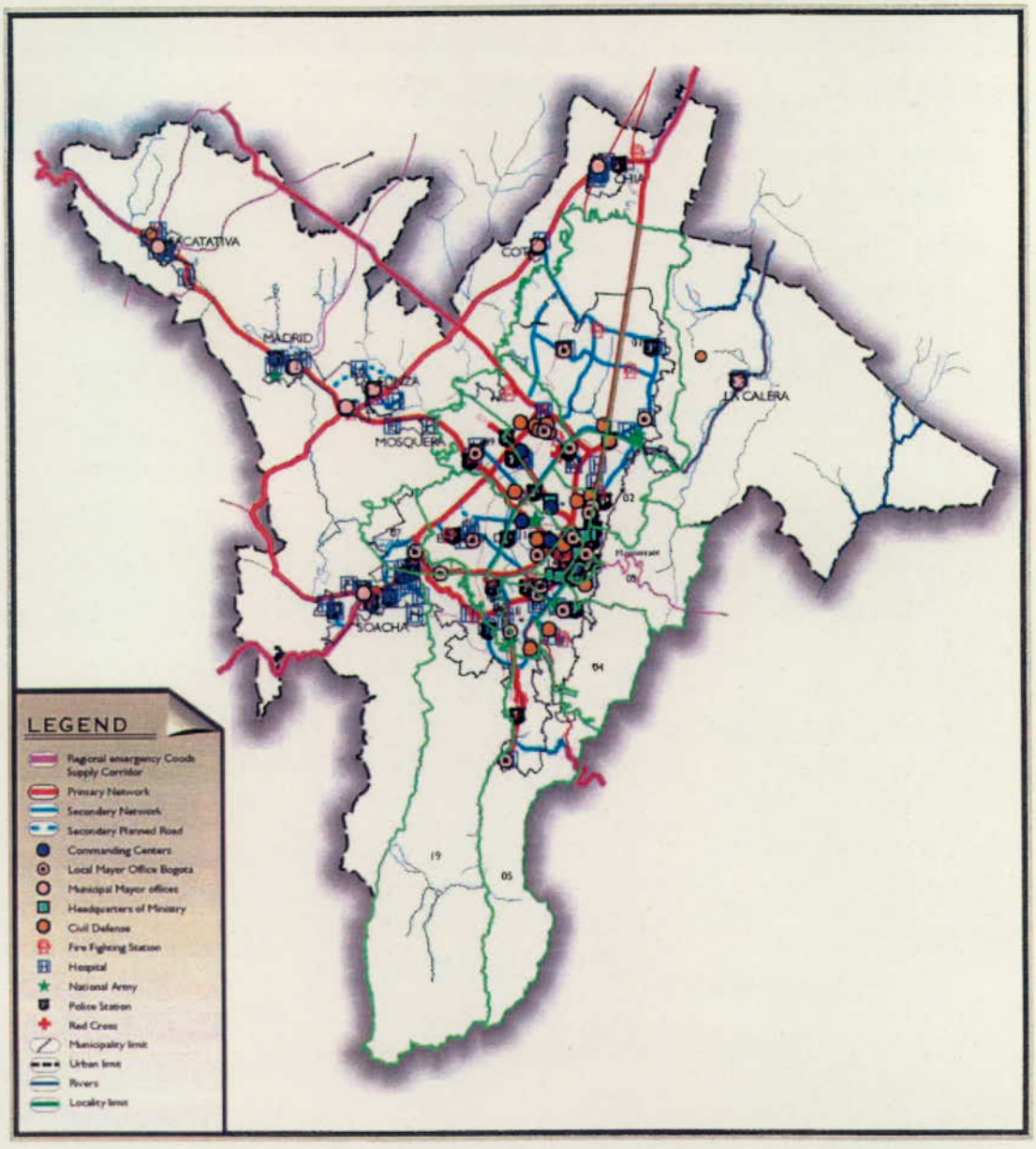


Figure 5.2.1 Emergency Road Network

D. Clearing for the emergency road network after disaster

On the emergency road network, it is required to clear-up activities due to the earthquake damage. The road network would not work properly just after the disaster because of collapsed obstacles and damages on the lifeline system.

The government should designate responsible organizations for such activities. The responsible organizations (Bogotá city: IDU, Cundinamarca prefecture: INVIAS, Cundinamarca and Municipalities) should prepare the teams and heavy equipment or machinery for the clean-up activities in the responsible areas.

(2) Bridge

A. Bridge reinforcement

58 bridges are anticipated to collapse during heavy earthquake by the Study. 80% of those bridges are located in southern part of Bogotá city, Kennedy, Puente Aranda, Tunjuelito, Rafael Uribe, etc. where high liquefaction potential is anticipated. Table 5.2.8 shows the list of bridges anticipated to collapse. 46 bridges are on the emergency roads. 37 bridges are located in liquefaction area.

Table 5.2.8 List of Bridges Anticipated to Collapse

	Bridge Location	BRIDGE_ID	TYPE	ER	Liq Area
1	Avenida Boyaca Carrera25 (Rio Tunjuelito)	R13	River		○
2	Autopista Sur (Rio Tunjuelito)	R15	River	◎	○
3	Autopista Sur (Rio Tunjuelito)	R16	River	◎	○
4	Autopista Sur (Canal)	R17	River	◎	○
5	Autopista Sur (Canal de la Albana)	R18	River	◎	○
6	Avenida Ontario (Canal de la Albana)	R19	River		○
7	Avenida Boyaca (Rio Fucha)	R2	River		○
8	Avenida 27 Sur (Canal de la Albana)	R20	River		○
9	Avenida Caracas (Canal de la Albana)	R21	River	○	○
10	Carrera 40 (Canal)	R22	River		○
11	Avenida 1 de Mayo (Canal)	R23	River	○	○
12	Avenida 1 de Mayo (Canal de la Albana)	R24	River	○	○
13	Autopista Sur (Rio Fucha)	R25	River	◎	○
14	Avenida Ontario (Rio Fucha)	R26	River	◎	○
15	Avenida la Hortua (Rio Fucha)	R27	River		○
16	Avenida la Hortua (Rio Fucha)	R27A	River		○
17	Avenida Caracas (Rio Fucha)	R28	River	◎	○
18	Avenida del Libertador (Rio Fucha)	R29	River	○	○
19	Carrera 7 (Rio San Cristobal)	R30	River		○
20	Calle 20 Sur (Rio San Cristobal)	R31	River	○	○
21	Carrera 86 (Rio TTunjuelito)	R32	River		
22	Avenida las Americas (Rio Fucha)	R33	River	○	○
23	Carrera 68 (Rio Fucha)	R34	River	○	○
24	Carrera 68 (Canal)	R35	River	○	○
25	Transversal 40 (Rio Fucha)	R36	River		○
26	Avenida Jorge Gaitan Cortes (Rio Tunjuelito)	RA27	River		○
27	Avenida Ciudad Villavicencio (Rio Tunjuelito)	RA28	River	◎	
28	Avenida Ciudad de Quito por Calle 13	V1	Vehicle	◎	○
29	Avenida Ciudad de Quito por Calle 68	V10	Vehicle	◎	
30	Avenida Ciudad de Quito por Calle 80	V12	Vehicle	◎	
31	Avenida Ciudad de Quito por Calle 80	V13	Vehicle	◎	
32	Avenida Ciudad de Quito por Calle 92	V14	Vehicle	◎	
33	Avenida Ciudad de Quito por Calle 92	V15	Vehicle	◎	
34	Avenida Calle 26 por Av. 68	V28	Vehicle	◎	
35	Avenida Calle 26 por Av. Boyaca	V30	Vehicle	◎	
36	Autopista Norte por Calle 100	V37	Vehicle	◎	
37	Autopista Norte por Calle 116	V39	Vehicle	◎	
38	Autopista Norte por Calle 134	V41	Vehicle	◎	
39	Autopista Norte por Calle 170	V44	Vehicle	◎	
40	Avenida Boyacá por Av. Villavicencio	V45	Vehicle	◎	○
41	Avenida Boyacá por Av. Villavicencio	V46	Vehicle	◎	
42	Avenida Boyacá por Av. 1o. De Mayo	V47	Vehicle	○	○
43	Avenida Boyacá por Av. 1o. De Mayo	V48	Vehicle	○	○
44	Avenida Boyacá por Av. 1o. De Mayo	V48A	Vehicle	○	○
45	Avenida Boyacá por Calle 13	V49	Vehicle	◎	○
46	Avenida Boyacá por Calle 80	V51	Vehicle	◎	
47	Avenida Boyacá por Calle 80	V52	Vehicle	◎	
48	Avenida Boyacá por Autopista Sur	V53	Vehicle	◎	○
49	Avenida Boyacá por Autopista Sur	V53A	Vehicle	◎	○
50	Avenida Carrera 68 por Calle 13	V56	Vehicle	◎	
51	Avenida Carrera 68 por Calle 68	V57	Vehicle	○	
52	Avenida Carrera 68 por Calle 80	V58	Vehicle	◎	
53	Avenida de las Américas por Av. Ciudad de Quito	V61	Vehicle	◎	
54	Avenida de las Américas por Av. El Espectado	V67	Vehicle	○	○
55	Avenida de las Américas por Av. Boyaca	V68	Vehicle	○	○
56	Avenida de las Américas por Av. Boyaca	V69	Vehicle	○	○
57	Avenida Ciudad de Quito por Calle 53	V7	Vehicle	◎	
58	Avenida Circunvalar por Barrio Egipto - Cra. 4a. E No. 10 - 26	V70	Vehicle		○

Note: ER(Emergency Road Network) : ◎ Primary Road Network, ○ Secondary Road Network
Liquification area ○
Source: JICA Study Team

Damages of vehicular flyover bridges are anticipated at intersections of main roads, such as intersections of Autopista Norte at Avenida Ciudad de Quito and at Avenida de Espana and Avenida 100, of Autopista Medellin at Avenida Boyaca, at Avenida de Espana and at Avenida Ciudad de Quito, of Autopista el Dorado.

Table 5.2.9 Classification of Priority for Bridge Improvement

Priority	Descriptions
Priority 1	- Vehicle bridge on the emergency road - Pedestrian bridges on the emergency road
Priority 2	- Vehicle bridges in the liquefaction areas - Pedestrian bridges in the liquefaction area
Priority 2	- All collapsed vehicle bridge - All pedestrian bridge except other bridges

Besides the number of pedestrian bridges on the emergency road is around 140 and about 30 of 140 are located in liquefaction area. Table 5.2.10 shows the recommendation of priority of bridge improvement considering the emergency road and liquefaction area.

Table 5.2.10 Priority of Bridge Improvement

	Bridge Location	Bridge ID	Priority	Detour
1	Avenida Boyaca Carrera25 (Rio Tunjuelito)	R13	Priority 3	N
2	Autopista Sur (Rio Tunjuelito)	R15	Priority 1	N
3	Autopista Sur (Rio Tunjuelito)	R16	Priority 1	N
4	Autopista Sur (Canal)	R17	Priority 1	Y
5	Autopista Sur (Canal de la Albana)	R18	Priority 1	N
6	Avenida Ontario (Canal de la Albana)	R19	Priority 3	N
7	Avenida Boyaca (Rio Fucha)	R2	Priority 3	N
8	Avenida 27 Sur (Canal de la Albana)	R20	Priority 3	N
9	Avenida Caracas (Canal de la Albana)	R21	Priority 1	Y
10	Carrera 40 (Canal)	R22	Priority 3	N
11	Avenida 1 de Mayo (Canal)	R23	Priority 2	N
12	Avenida 1 de Mayo (Canal de la Albana)	R24	Priority 2	N
13	Autopista Sur (Rio Fucha)	R25	Priority 1	Y
14	Avenida Ontario (Rio Fucha)	R26	Priority 1	Y
15	Avenida la Hortua (Rio Fucha)	R27	Priority 3	N
16	Avenida la Hortua (Rio Fucha)	R27A	Priority 3	N
17	Avenida Caracas (Rio Fucha)	R28	Priority 1	Y
18	Avenida del Libertador (Rio Fucha)	R29	Priority 2	Y
19	Carrera 7 (Rio San Cristobal)	R30	Priority 3	Y
20	Calle 20 Sur (Rio San Cristobal)	R31	Priority 2	Y
21	Carrera 86 (Rio TTunjuelito)	R32	Priority 3	N
22	Avenida las Americas (Rio Fucha)	R33	Priority 2	N
23	Carrera 68 (Rio Fucha)	R34	Priority 2	N
24	Carrera 68 (Canal)	R35	Priority 2	N
25	Transversal 40 (Rio Fucha)	R36	Priority 3	N
26	Avenida Jorge Gaitan Cortes (Rio Tunjuelito)	RA27	Priority 3	N
27	Avenida Ciudad Villavicencio (Rio Tunjuelito)	RA28	Priority 1	N
28	Avenida Ciudad de Quito por Calle 13	V1	Priority 1	Y
29	Avenida Ciudad de Quito por Calle 68	V10	Priority 1	Y
30	Avenida Ciudad de Quito por Calle 80	V12	Priority 1	Y
31	Avenida Ciudad de Quito por Calle 80	V13	Priority 1	Y
32	Avenida Ciudad de Quito por Calle 92	V14	Priority 1	Y
33	Avenida Ciudad de Quito por Calle 92	V15	Priority 1	Y
34	Avenida Calle 26 por Av. 68	V28	Priority 1	Y
35	Avenida Calle 26 por Av. Boyaca	V30	Priority 1	Y
36	Autopista Norte por Calle 100	V37	Priority 1	Y
37	Autopista Norte por Calle 116	V39	Priority 1	Y
38	Autopista Norte por Calle 134	V41	Priority 1	Y
39	Autopista Norte por Calle 170	V44	Priority 1	Y
40	Avenida Boyacá por Av. Villavicencio	V45	Priority 1	N
41	Avenida Boyacá por Av. Villavicencio	V46	Priority 1	N
42	Avenida Boyacá por Av. 1o. De Mayo	V47	Priority 2	Y
43	Avenida Boyacá por Av. 1o. De Mayo	V48	Priority 2	Y
44	Avenida Boyacá por Av. 1o. De Mayo	V48A	Priority 2	Y
45	Avenida Boyacá por Calle 13	V49	Priority 1	Y
46	Avenida Boyacá por Calle 80	V51	Priority 1	N
47	Avenida Boyacá por Calle 80	V52	Priority 1	N
48	Avenida Boyacá por Autopista Sur	V53	Priority 1	Y
49	Avenida Boyacá por Autopista Sur	V53A	Priority 1	Y
50	Avenida Carrera 68 por Calle 13	V56	Priority 1	Y
51	Avenida Carrera 68 por Calle 68	V57	Priority 1	Y
52	Avenida Carrera 68 por Calle 80	V58	Priority 1	Y
53	Avenida de las Américas por Av. Ciudad de Quito	V61	Priority 1	Y
54	Avenida de las Américas por Av. El Espectado	V67	Priority 2	Y
55	Avenida de las Américas por Av. Boyaca	V68	Priority 2	Y
56	Avenida de las Américas por Av. Boyaca	V69	Priority 2	Y
57	Avenida Ciudad de Quito por Calle 53	V7	Priority 1	Y
58	Avenida Circunvalar por Barrio Egipto - Cra. 4a. E No. 10 - 26	V70	Priority 3	Y

Source: JICA Study Team

4) Lifeline

(1) Disaster prevention of facility

Disaster prevention of facility is quite important role in disaster preparedness. Usually, following factors are considered in disaster prevention of facility

- Inspection and maintenance of Purifier, Distribution tanks, pipeline, mechanical and electrical equipment etc.
- Seismic vulnerability study for plant and pipeline
- Reinforcement of earthquake resistance of intake, purifier, distribution tank, pipeline, supply equipment
- Renewal or replacement of aged pipeline and installation of seismic resistant joint and tube where necessary
- Reinforcement of mechanical and electrical equipment
- Installation of emergency shut down valve
- Reinforcement of effective volume for preparation as emergency response measures
- Block supply system; diversification of facilities and mutual connection, Large blocks and small blocks for confining damaged supply area
- Reinforcement of Backup function; mutual supplement within large block and among large blocks, bypass
- Seismic resistant of trunk and supply pipeline (joint, expansive and flexible pipe piece), preparation of emergency equipment
- Countermeasure as total water supply system
- Pluralization of facility, installation of bypass route at distribution tank etc.,
- multi-flow line,
- Securing of material & equipment
- Custody of drawings and document
- Education and Training
- Order of reinforcement/repair

The following facilities are recommended as priority first. Especially facilities located in high liquefaction potential area should have high priority.

- Facility apt to cause the secondary disaster
- Facility apt to affect important facility such as evacuation place, hospital, prevention base, etc
- Upstream facility

The Study Team recommends seismic vulnerability study and reinforcement work should be performed to the tank and pump station located in high liquefaction potential area and purification plant, pipeline in the priority as shown in table 5.2.11.

Table 5.2.11 Priority of Seismic Vulnerability and Reinforcement

Priority	Facility	Remarks
Priority 1	Distribution Tank Santa Lucia with pump station Jalisco Castillo El Volador Casa Blanca with pump station Sierra Morena II with pump station Sierra Morena III Cazuca Cazuca IV Julio Rincón with pump station	Those tank facilities are located in high liquefaction potential area are seem to be reinforced where necessary for emergency water supply.
Priority 2	Transportation and distribution pipe laid in weak soil	Upstream facility is more important. Large movement is anticipated if those facilities are located in weak soil.
Priority 3	Purification plant and distribution plant Laguna plant with tank Laguna Tank Uval with pump station Tank Monteblanco with pump station	Those facilities are located in relatively high ground acceleration area.
Priority 4	Supply facility 1) Reinforcement of branch	Small leakage is usually found at branch
Priority 5	Other plant, pipeline and facility	Other plant, pipeline and facility seem to have less damage and last priority is allocated for reinforcement.

Source: JICA Study Team

(2) Target volume for emergency water supply

It is recommended to prepare minimum target volume plan after disaster break out. Target volume of storage for emergency water supply has to be estimated based on the minimum target volume. The minimum target volumes are set stepwise according to the elapsed time after disaster. An example of Japan is shown as follows;

- Supply water to keep life by manual transportation within 3 days after disaster
- Temporary water supply and each house supply within 2 weeks after disaster
- To maintain and reinforce water supply system to usual operation and to wider supply

The example of minimum target volumes in Japan is shown as follows:

- Up to 3rd day: 3 litters/person
- From 4th to 10th day: 20 to 30 litters/person
- From 11th to 20 day: 30 to 40 litters/person

Table 5.2.12 shows the capacity of existing distribution tanks and water volume per person in locality wise.

Present allowable water volume per person is 55litter in Bogotá city as a whole and 0.7 litter in Eight Municipalities.

Only four localities, Chapinero, Santa Fe, San Cristobal and Usme have certain water supply capacity by existing tank facility. But it is insufficient capacity except Santa Fe.

The study team recommends installing emergency water supply facilities as shown priority.

- The existing water purification tanks improve to emergency water facilities
- Every regional parks should install emergency waster tanks
- The southern part of Bogotá should have priority for improvement of emergency tanks

The recommended tanks with volume are shown in Table 5.2.12.

Table 5.2.12 Recommended Emergency Water Tank Installation

Locality	Existing Water Tank			Proposed Emergency Tanks (m3)			
	Volume (m3)	Population	Capacity (liter)	Unit	Total	Total Volume	Capacity (liter)
Bogota							
Usaquén	4,106	421,320	9.7	2,500x2	5,000	9,106	21.6
Chapinero	8,619	122,991	70.1	-	-	8,619	70.1
Santa Fé	133,600	107,044	1,248.1	-	-	133,600	1248.1
San Cristóbal	22,886	455,028	50.3	-	-	22,886	50.3
Usme	9,000	244,270	36.8	-	-	9,000	36.8
Tunjuelito	0	204,367	-	5,000x1	5,000	5,000	24.5
Bosa	0	410,099	-	2,000x5	10,000	10,000	24.4
Kennedy	0	912,781	-	2,500x6 4,500x1	19,500	19,500	21.4
Fontibón	0	278,746	-	6,000x1	6,000	6,000	21.5
Engativa	0	749,068	-	2,500x6	15,000	15,000	20.0
Suba	6,000	706,528	8.5	1,000x3 2,000x4	11,000	17,000	24.1
Barrios Unidos	0	176,552	-	1,000x4	4,000	4,000	22.7
Teusaquillo	0	126,125	-	1,000x3	3,000	3,000	23.8
Los Martires	0	95,541	-	2,000x1	2,000	2,000	20.9
Antonio Nariño	0	98,355	-	1,000x2	2,000	2,000	20.3
Puente Aranda	0	282,491	-	3,000x2	6,000	6,000	21.2
La Candelaria	0	27,450	-	600x1	600	600	21.9
Rafael Uribe	0	384,623	-	2,000x4	8,000	8,000	20.8
Ciudad Bolivar	167,710	575,549	291.4	-	-	167,710	291.4
Bogota	**351,921**	**6,378,928**	**55.2**	**-**	**97,100**	**449,021**	**70.4**
Cundinamarca							
Chia	0	61,783	-	1,500x1	1,500	1,500	24.3
Cota	0	14,784	-	400x1	400	400	27.1
La Calera	0	24,188	-	600x1	600	600	24.8
Facatativá	0	90,266	-	1,000x2	2,000	2,000	22.2
Funza	0	51,808	-	1,200x1	1,200	1,200	23.2
Madrid	0	52,110	-	600x2	1,200	1,200	23.0
Mosquera	0	27,753	-	800x1	800	800	28.8
Soacha	400	283,889	1.4	2,000x3	6,000	6,400	22.5
Cundinamarca	**400**	**606,581**	**0.7**	**-**	**13,700**	**14,100**	**23.2**

Source: JICA Study Team

The emergency tanks are arranged at localities where water supply capacity is short for emergency supply. Thus emergency water tank is not allocated in Chapinero, Santa Fe, San Cristobal and Usme which have enough supply capacity for emergency.

Emergency water tank volume are provided to supply almost of target volume which are decided on condition that inhabitant endure one week after disaster with a minimum water consumption of 3 litter/day/person. It means water supply system should be recovered somewhat at least one week after disaster.

Sewerage pipeline is also recommended to install nearby or in the regional evacuation place to ensure a minimum sanitary life for evacuated people. Necessary valves, pipe installation and faucet should be provided for sewerage pipeline.

(3) Electrical supply system

In all substations where vulnerability study is already performed, adequate vigilance, general maintenance, neatness and cleanliness are made according to the vulnerability study report.

The following items are generally recommended for preparing or detailing of the disaster preparedness plan:

- Sufficient Seismic design where necessary
- Vulnerability study for each plant and facility first should be performed.
- Disaster preparedness plan and emergency response plan should be prepared based on the vulnerability study result.
- It is preferable to select the important facility and to prepare those plans with respect to the selected facility as concretely as possible.
- It is recommended to refer to JICA study result for preparing concrete plans.

A. Vulnerability study of existing plant and facility

Vulnerability study should be carried out to existing plant and facility in order to clarify where the vulnerability exist in each plant and facility.

According to the existing vulnerability study, there found two main details of vulnerability that should be reinforced as soon as possible. They are reinforcement of the fixing of the voltage transformers to the foundation base and of the brace of some cooling tanks for this kind of transformers. Proper device should be prepared to prevent the derailing of transformer.

Bushing equipment should be seismically reviewed and if necessary reinforced

The buildings where instrumentation and control panels are accommodated, should be reviewed and if necessary revised, taking in consideration the seismic resistant code for buildings.

If some weak structures are found by the vulnerability study, they should be reinforced as seismic prevention measures.

Relatively high damages to overhead cable are anticipated in such localities as San Cristobal, Usme, Kennedy, Teusaquillo, Puente Aranda, Rafael Uribe Ciudad Bolivar and Soacha. Those localities are almost located in high liquefaction potential area and in relatively high seismic intensity based on the result of the Study.

Plant and facility located in those localities seem to have high priority to perform vulnerability study.

B. Proper seismic design for new construction or reinforcement of plant and facility

Proper seismic design is recommended to building, structure and equipment etc. in accordance with the relevant design codes as well as the result of 1997 Micro-Zonation Study and to apply rational measures to reinforce earthquake resistance if necessary.

C. Stable supply of electricity

Whole electricity supply system consists power generation, transmission, substation, and distribution. In addition, transmission is connected with the national transmission system most part of which institution, ISA (Interconexión Eléctrica S.A.) is in charge of.

Stable supply will be ensured during seismic disaster in the Bogotá Metropolitan Area. But the system around Bogotá City area is divided into major 3 institutions as mentioned before.

It is recommended to have close cooperation among major institutions for stable electric supply in an emergency.

Also, It is recommended to install additional transmission line to important one in order to have redundancy as dual line. Especially, transmission line, which is installed in high liquefaction area, has high priority to consider the dual line system or reinforce properly to increase redundancy.

D. Organization

It is necessary to establish coordination committee among the related institutions in order to discuss and prepare disaster preparedness plan considering electric supply system as a whole.

(4) Gas supply system

A. General

Increase of seismic resistance in structure and pipeline is major factor for disaster preparedness. It is required to implement rational seismic prevention measures considering the importance of the facilities.

The following is recommendation for preparation of disaster preparedness plan because Gas Natural doesn't prepare any specific disaster preparedness plan and there is a little information on the plan.

B. Disaster prevention of facility

If there is a plan to construct new facility, rational seismic design based on current design procedure should be applied considering liquefaction where necessary.

Existing facility should be evaluated against seismic resistance and be reinforced if necessary.

Further study is recommended to perform to the pipeline network and other facilities referring to JICA study result in order to know, in detail, the necessity of reinforcement of emergency shutdown device and other reinforcement against earthquake disaster.

Current materials such as steel pipe and polyethylene pipe are recommended to use in a newly constructed pipeline because those material are high seismic resistant.

Renewal or replacement of aged pipeline is recommended especially in high liquefaction potential area.

Promotion of block supply system is recommended in order to distinguish supply stop area and continuous supply area.

The Study Team visited the City Gate receiving station. Followings are recommendation based on the site visit.

The support of pipe and fittings is recommended to reinforce because the pipe support seems vulnerable against earthquake due to that support is somewhat slender and no bundle or other fixing device is not applied at saddle support.

Reinforcement of control house is also recommended to examine earthquake vulnerability because all control equipment is accommodated in the house.

C. Measures and installation of equipment for emergency situation

Importance for emergency measures is to prevent secondary disaster due to damage during earthquake. Necessary equipment or emergency measures is recommended to apply to facility and routine training should be planned for emergency use. Those measures and equipment are listed as follows;

- Monitoring and alarm devices; seismic sensor, leakage sensor, fire alarm, where necessary
- To divide distribution pipeline into certain blocks of network
- Installation of emergency shutdown valves where necessary

(5) Telecommunication system

A. General

As above mentioned, there is no information available for present disaster preparedness and emergency response plan, only requisite recommendation is made for preparation of those plans.

B. Recommendation for disaster preparedness plan

It is recommended that securing of telephone communication network, rational measures to reinforce earthquake resistance considering importance of facilities and reduction of congestion of telephone line after disaster be incorporated into the plans. Besides, promotion of fire-preventive structure and buildings are recommended for disaster preparedness.

The following items are generally recommended for preparing or detailing of the disaster preparedness plan:

- Vulnerability study for each plant and facility should be performed first.
- Disaster preparedness plan should be prepared based on the vulnerability study result.
- It is preferable to select the important facility and to prepare the plan with respect to the selected facility as concretely as possible.
- It is recommended to refer to the Study result for preparing concrete plans.

a) Disaster preparedness of buildings and facility

Vulnerability study of existing buildings and facility

Vulnerability study should be carried out not only to the building but also to cables and structures in order to clarify where the vulnerability exist in buildings, cables and structures.

If some weak portions are found by the vulnerability study, they should be reinforced as seismic prevention measures.

Relatively high damages to overhead and underground cable are anticipated in such localities as Chapinero, Santa Fe, San Cristobal, Usme, Bosa, Kennedy, Puente Aranda, Rafael Uribe Ciudad Bolivar and Soacha. Those localities are almost located in high liquefaction potential area and in relatively high seismic intensity based on the result of the Study.

Facility located in those localities seems necessary to have redundancy and to have high priority to perform vulnerability study and if necessary, reinforcement.

Proper seismic design for new construction or reinforcement of plant and facility

Proper seismic design is recommended to building, structure, equipment and cable installation, etc. in accordance with the relevant design codes as well as the result of 1997 Micro-Zonation Study and to apply rational measures to reinforce earthquake resistance if necessary.

Preparation of equipment for ensuring of communication supply in disaster

The followings are recommended to consider for preparation of equipment for disaster.

- Installation of wireless communication equipment,
- Preparation of movable radio station, electricity generator car & movable generator,
- Optical fiber cable for emergency response, portable satellite communication equipment, others

Back up measures

It is recommended take following back-up measures in order to increase of reliability of telecommunication system to keep communication;

- Loop system of main transmission line,
- Multi-transmission system,
- Diversification of monitoring and control system,
- Alternative monitoring and control system,
- Manual for reducing congestion of communication lines after disaster

Especially, facilities, transmission line, which are located in high liquefaction area has high priority to consider proper reinforcement to increase redundancy.

5) Reduction of Vulnerable Area by Urban Redevelopment

(1) Priority areas for development

A. General

In order to identify high risk area for the earthquake damage, the Study Team analyze the area by using variables of evacuation place, population density and building damage ratio. The identfied areas should be priority for the urban re-development.

B. Selection of Priority Area

The result of regional risk classification done in Chapter 3.3 for earthquake was used for the analysis. A unit of analysis is Urban Planning Zone (UPZ) and micro zones, which is established in the study, because it is applied to the urban planning practice in Bogotá. The Study Area can be divided five classifications the following rules.

- Zone 1 where includes the point 5
- Zone 2 where is covered 50% or more with the point 4
- Zone 3 where is covered 50% or less with the point 4
- Zone 4 where is covered by point 3
- Zone 5 where is covered by point 2 and 1

Based on this classification, the priority areas are selected. The results are shown in figure 5.2.2.

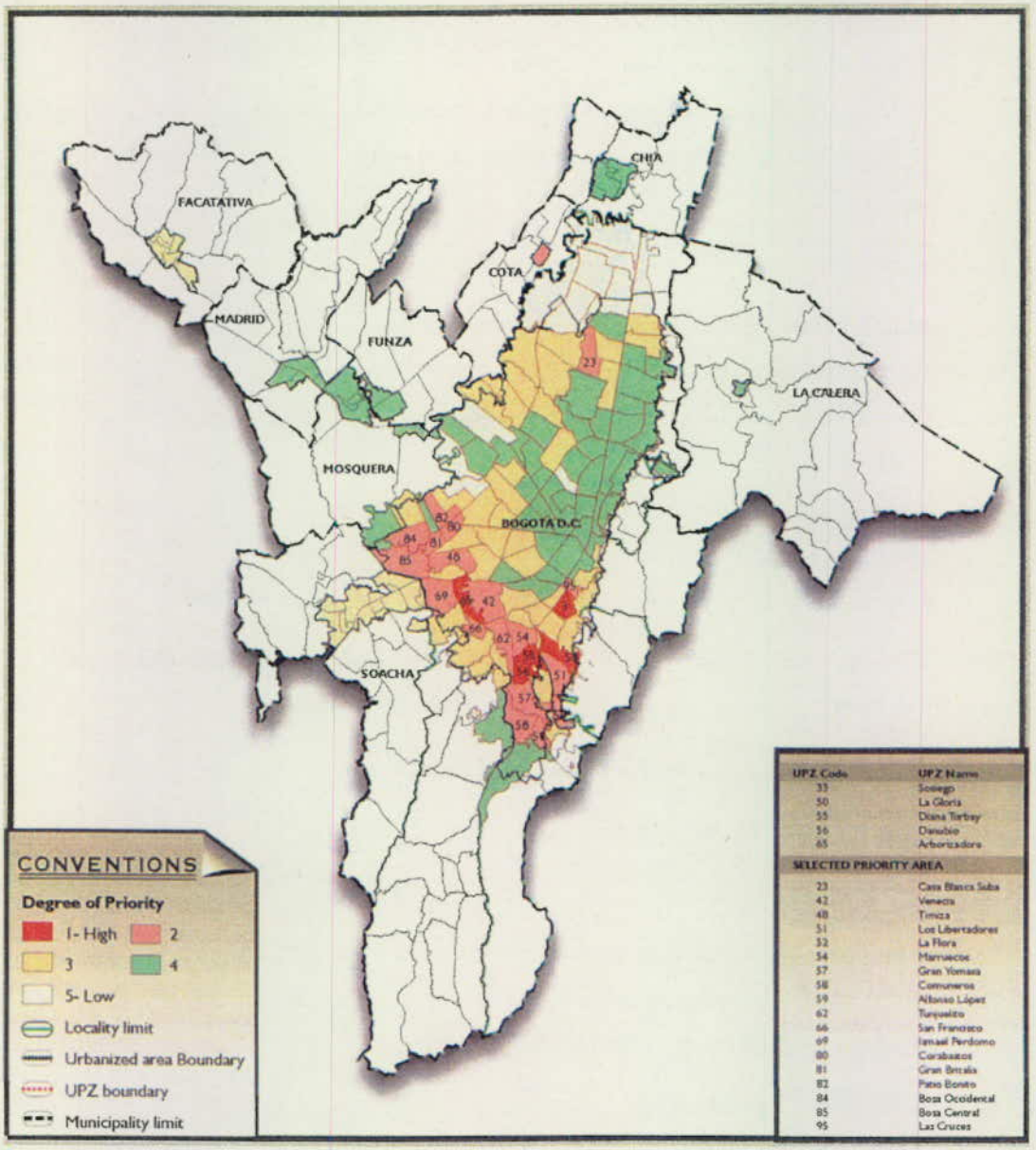


Figure 5.2.2 Priority Area

It is selected five priority areas in the Study Area. The list of the priority area is shown as follows:

Table 5.2.13 Priority Area by UPZ

Locality	UPZ	Ha
San Cristobal	33 Sosiego	235.49
San Cristobal	50 La Gloria	385.88
Usme	56 Danubio	268.11
Rafael Uribe	55 Diana Turbay	182.12
Ciudad Bolivar	65 Arborizadora	326.97
Total		1398.57

The priority area can be categorized by insufficient open space, high density of population and concentration of weak residential buildings. Those areas should have first priority for urban re-development.

The classification results show that send priority area, called selected area for urban re-development. Selected area should have the second priority for urban development.

Table 5.2.14 Selected Area for Urban Re-development

Locality	UPZ	Ha
Santa Fe	95 Las Cruces	98.48
San Cristobal	51 Los Libertadores	389.08
Usme	52 La Flora	206.88
Usme	57 Gran Yomasa	530.24
Usme	58 Comuneros	483.22
Usme	59 Alfonso Lopez	233.54
Bosa	84 Bosa Occidental	717.45
Bosa	85 Bosa Central	402.24
Kennedy	48 Timiza	431.38
Kennedy	80 Corabastos	187.51
Kennedy	81 Gran Britalia	179.41
Kennedy	82 Patio Bonito	314.21
Suba	23 Casa Blanca Suba	419.92
Rafael Uribe	54 Marruecos	358.6
Ciudad Bolivar	66 San Francisco	182.34
Ciudad Bolivar	69 Ismael Perdomo	554.89
Total		5689.39

The integrated risk point for each UPZ is summarized in Appendix 5.2.4. The risk point of each UPZ by the disaster type will be an indicator to the locality and municipality.

The methods of development are summarized as follows:

(1) Redevelopment program

This program is applied to the area of residential or residential and commercial, where the weak buildings are concentrated. It will include the all aspect of disaster mitigation measures to the targeted areas. The development of urbanized area included widening of narrow road and provision of park.

(2) Public education and enlightenment

In order to promote disaster resistance urbanized area, it is important to make a consensus on urban disaster management. The public education and enlightenment is one of the important tools for agreement for the urban development.

(3) Road development program

This program is applied to the area where is composed of narrow roads and concentrated weak buildings. It will include the aspect of only the road widening; however, the widened road will be effective to the disaster mitigation and can be used as the evacuation route.

(4) Open space development program

This program is applied to the area where don't have enough developed open spaces. It aims to create new open space where can be used as the evacuation site in case of emergency.

6) Open Space

After a disaster, evacuation of the residence is required to secure the safety of the victims and to provide effective support to the victims. The evacuation place also formulated as a hierarchy system and organized with evacuation route. The evacuation places and routes should be identified before the disaster situation. In general, the victims would evacuate the community evacuation place after the disaster and move to the regional evacuation place through identified evacuation route.

The evacuation place is classified in the Table 5.2.15.

Table 5.2.15 Summary of Evacuation Place

Level of evacuation place	Descriptions
Community level	Each community should identified evacuation places such as primary school, community park etc. After the disaster situations, the victims are expected to gather in community level evacuation place to identify the lost personnel and then establish community rescue operation.
Regional level	Regional evacuation place required relative huge area. After the disaster situations, secure the life and safety of the victims. The area is utilized for disaster management center at local level.
Temporary shelter	The victims who lost house are expected to provide temporary housing from the government.

Source: Regional Disaster Prevention Plan (1998), Tokyo Metropolitan Government

A. Community level

Identification of the community level evacuation place is matter of urgency. The locality government should select an open space as a community level evacuation place in cooperation with the residents. The possibility of the community level evacuation place is primary or

secondary school, parks and open space etc. Each community member should know his or her evacuation place.

Information and communication system should be established each community before a emergency situation and the community leader should report their damages, causality, injured personnel etc., to the commanding center at local level. The community organization should take initiative to guide the community members in cooperation with police and locality staff after the disaster.

B. Regional level

Regional level evacuation will be taken place when the victims may face the danger of the life and safety at the community level. The residents should move to regional evacuation place after the instruction from the government. The government should inform the community before the disaster situation where the regional evacuation place would be in each community. The respective government should designate the regional evacuation place. The conditions of the regional evacuation place are to keep safety from disaster and the capacity of the evacuation place is sufficient.

The functions of the regional evacuation place are as follows:

- To keep the safety of the victims
- To provide first aid and water supply
- To provide temporary housing space.

In this study, the regional evacuation place is proposed to select whole Study Area. In order to select regional evacuation place, the study team sets the criteria for the regional evacuation place.

- Regional evacuation place is less than 2 km from each community
- Area for one person is 2 m^2
- Total area is more than 5 ha

At first, the study team established the evacuation boundaries for each locality and selected the regional evacuation places in each boundary. The candidates for the regional evacuation places should fulfill the following conditions:

- Public owned land and facilities
- Park, open space and sport ground
- Without any designated and identified natural hazard area
- Without any hazardous chemical facilities in and surrounding area

The public land is the first priority, but some of the localities cannot find public open space. Then the study team selects private land for proposed regional evacuation place. The private land, however, is not appropriate for the regional evacuation place in the long run. The governments should identify another land for the evacuation place.

The list of the proposed regional evacuation places are shown as follows:

Table 5.2.16 List of Regional Evacuation Place in Bogotá City

WITHIN BOGOTA :					
No	*Locality*	*Name of the Place*	*Address*	*Area (Ha)*	*Remarks*
1	1 - Usaquén	Cementerio Jardines de Paz	Autopista Norte Km. 14	59.7	Private Cementery
2	1 - Usaquén	Country Club	Diagonal 129 Carrera 15	92.2	Private Club - Big Golf Curt
3	2 - Chapinero	Parque El Virrey	Calle 87 Y 88 Carrera 15 Y Autopista Norte	16.1	Urban Park, 45% Tree Planted
4	3 - Santa Fé	Parque Nacional	Calle 26 Avenida Circunvalar	14.1	58% Tree Planted , 3% Water Surface
5	4 - San Cristóbal	Parque Nueva Granada	Carrera 1 B No. 20 A 97 Sur	7.4	Barrio Park
6	4 - San Cristóbal	Parque San Cristóbal 1° de Mayo	Calle 18 Y 13 Sur Carrera 3 Y 5 Este	23.0	70% Area available for Evacuation
7	5 - Usme	Parque Famaco	Calle 91 Sur Carrera 53B 55A Este	5.6	85% Available Area , 4% Water Surface
8	5 - Usme	Parque San José	Calle 97 Sur Avenida Caracas	20.5	Metropolitan Propossed (Designed)
9	6 - Tunjuelito	Parque El Tunal	Avenida Mariscal Sucre Carrera 24 y Calle 48B Sur Avenida Boyacá	66.0	89% Available Area , 1% Water Surface
10	7 - Bosa	Parque Laureles Naranjo	Calle 70A Carrera 86 - Diagonal 3A Calle 14C	5.0	Zonal Park
11	7 - Bosa	Parque Villa del Rio II	Calle 55 Sur Carrera 67 I	8.9	Barrio Park
12	7 - Bosa	Parque el Recreo	Proyecto Metrovivienda	15.0	Under design - Zonal Park
13	7 - Bosa	Parque del Rio	Carrera 99A N° 74A - 09	10.5	Zonal Park, 20% Tree Planted
14	7 - Bosa	Parque Tibanica	Diagonal 73F Sur Transversal 83	20.4	Metropolitan Propossed (Designed)
15	8 - Kennedy	Parque Mundo Aventura	Carrera 71 - 71B Calle 26 Sur	18.3	40% Area available for Evacuation
16	8 - Kennedy	Parque Marsella	Carrera 68 B Avenida Américas a Calle 10	9.5	Barrio Park
17	8 - Kennedy	Parque Cayetano Cañizares	Carrera 86 Entre Calles 40 Y 42D Sur	11.6	20% Built in concrete frames
18	8 - Kennedy	Parque Timiza	Calle 39 a 40 Sur Carrera 70 a 68A	52.0	9% Built (concrete), 40% Water Surface
19	8 - Kennedy	Parque El Tintal	Carrera 84 Calle 13A Y 13B	5.5	6% Built in concrete frames
20	8 - Kennedy	Parque La Igualdad	Avenida Américas - 3A Sur Carrera 68F - Rio Fucha	5.9	Zonal Park Propossed in Recovering
21	8 - Kennedy	Parque Urapanes	Transversal 62A Y 62D Calle 42 Sur	6.9	Barrio Park
22	9 - Fontibón	Parque Canal Boyacá	Carrera 74 Calle 43B	17.5	25% Tree Planted
23	10 - Engativa	Parque Ciudadela Colsubsidio	Carrera 110 a 112 C Entre Calles 83 A 89 B	12.9	30% Tree Planted
24	10 - Engativa	Parque Bonanza	Avenida Boyacá con Calle 72A	9.9	Barrio Park
25	10 - Engativa	Parque San Andrés	Calle 82 Carrera 100	7.4	20% Tree Planted
26	10 - Engativa	Parque Jardín Botánico	Avenida Rojas Calle 63	20.3	65% Tree Planted
27	10 - Engativa	Unidad Deportiva El Salitre	Avenida 68 con Calle 63	25.2	70% Area available for Evacuation
28	10 - Engativa	Parque La Florida	Avenida Engativá Rio Bogotá	279.5	18% Tree Planted , 2% Water Surface
29	11 - Suba	Parque La Gaitana	Carrera 116 con Transversal 116	6.4	30% Tree Planted
30	11 - Suba	Canal Salitre	No Address	7.2	Urban Park
31	11 - Suba	Parque Mirador de Los Nevados	Cerros de Suba	6.6	Urban Park
32	11 - Suba	Carmel Club Campestre	Diagonal 154 Carrera 43	51.1	Private Club
33	11 - Suba	Club Campestre El Rancho	Calle 195 Carrera 45	42.5	Private Club
34	11 - Suba	Club Deportivo Los Arrayanes	Vía Suba - Cota Desviación Carretera Aeropuerto Guaymaral Km.13	78.3	Private Club
35	11 - Suba	Club Los Lagartos	Diagonal 103 Carrera 61	55.1	Private Club
36	12 - Barrios Unidos	Parque Deportivo El Salitre	Calle 63 Carrera (Avenida) 68	66.1	20% Tree Planted , 5% Water Surface
37	12 - Barrios Unidos	Centro de Alto Rendimiento	Calle 63 Carrera 38	57.3	5% Built mainly in concrete frames
38	12 - Barrios Unidos	Parque de Los Novios - El Lago	Calle 63 Carrera 30	22.7	28% Water Surface (Lake mainly)
39	12 - Barrios Unidos	Escuela Militar de Cadetes José María Córdoba	Calle 80 Carrera 38	43.9	Army School
40	13 - Teusaquillo	Parque Virgilio Barco	Calle 63 Carrera 38	14.5	70% Area available for Evacuation
41	13 - Teusaquillo	Parque Central Simón Bolívar	Calle 63 Carrera (Avenida) 68	101.1	58% Available Area , 12% Water Surface
42	13 - Teusaquillo	Universidad Nacional	Carrera 30 Calle 45	121.8	State University - No Data available
43	15 - Antonio Nariño	Parque Villa Mayor Principal	Avenida - Carrera 30-35 Calle 34-30A Sur	7.9	Zonal Park
44	15 - Antonio Nariño	Parque Ciudad Jardín	Avenida Carrera 10 y Avenida Caracas y los 2 costados del Canal	8.1	Zonal Park
45	16 - Puente Aranda	Parque Ciudad Montes	Carrera 38 a 41C Calle 10 a Diagonal 16 Sur	6.8	18% Tree Planted , 5% Water Surface
46	16 - Puente Aranda	Parque Milenta - Tejar San Eusebio	Diagonal 17A a Calle 18 Sur entre Transversal 5	7.9	Zonal Park
47	18 - Rafael Uribe	Parque Bosque San Carlos	Calle 27A Sur Diagonal 39A Sur Carrera 13A y 12 Bis	22.7	40% Tree Planted
48	18 - Rafael Uribe	Parque Diana Turbay	Carrera 1A Y 2A Este Calle 48 R Sur	5.5	Zonal Park
49	18 - Rafael Uribe	Parque Estadio Olaya Herrera	Calle 22 y 27 Sur Carrera 21 y Avenida 19	5.1	Zonal Park, 10% Built In Concrete Frames
50	18 - Rafael Uribe	Parque Santa Lucía	Diagonal 36 Sur Carrera 16 B	10.7	Urban Park, 7% Built, 50% Tree Planted

Source: JICA Study Team

Table 5.2.17 List of Regional Evacuation Place in Cundinamarca

No	Locality	Name of the Place	Address	Area (Ha)	Remarks
51	Chia	17501 - Urban Place to define	Undefined	-	Urban Place to define with municipalities
52	Cota	21401 - Urban Place to define	Undefined	-	Urban Place to define with municipalities
53	La Calera	37701 - Urban Place to define	Undefined	-	Urban Place to define with municipalities
54	Facatativá	Estadio Municipal de Facatativá	Not Available	7.5	Urban Park, 20% Built in Concrete
55	Facatativá	26901 - Urban Place to define	Undefined	-	Urban Place to define with municipalities
56	Madrid	Estadio Municipal de Madrid	Not Available	6.6	Urban Park
57	Madrid	43001 - Urban Place to define	Undefined	-	Urban Place to define with municipalities
58	Mosquera	Villa Olímpica Municipio de Mosquera	Not Available	11.6	With possible Expansion, 7% Built
59	Soacha	75401 - Urban Place to define	Undefined	-	Urban Place to define with municipalities
60	Soacha	75402 - Urban Place to define	Undefined	-	Urban Place to define with municipalities
61	Soacha	75403 - Urban Place to define	Undefined	-	Urban Place to define with municipalities

Source: JICA Study Team

The study team analyzes the capacity of parks and the required evacuation area in the each locality. The results of analysis are shown in Table 5.2.18.

Table 5.2.18 Analysis of Regional Park

Within Bogota				
Locality	*Urban Population*	*Park Area (Ha)*	*Required Area (Ha)*	*Capability Area (Ha)*
1 - Usaquén	421,321	151.82	84.26	67.56
2 - Chapinero	122,994	16.12	24.60	-8.48
3 - Santa Fé	107,046	14.11	21.41	-7.30
4 - San Cristóbal	455,030	30.32	91.01	-60.69
5 - Usme	244,268	26.09	48.85	-22.76
6 - Tunjuelito	204,365	65.99	40.87	25.12
7 - Bosa	410,099	59.76	82.02	-22.26
8 - Kennedy	912,782	109.77	182.56	-72.79
9 - Fontibón	278,745	17.55	55.75	-38.20
10 - Engativa	749,072	355.17	149.81	205.36
11 - Suba	706,529	247.26	141.31	105.95
12 - Barrios Unidos	176,549	189.90	35.31	154.59
13 - Teusaquillo	126,126	237.35	25.23	212.12
14 - Los Mártires	95,541	0.00	19.11	-19.11
15 - Antonio Nariño	98,356	15.95	19.67	-3.72
16 - Puente Aranda	282,488	21.56	56.50	-34.94
17 - La Candelaria	27,451	0.00	5.49	-5.49
18 - Rafael Uribe	384,627	43.95	76.93	-32.98
19 - Ciudad Bolívar	575,549	0.00	115.11	-115.11
Within 8 Municipalities (Cundinamarca) :				
Chia	61,783	0.00	12.36	-12.36
Cota	14,784	0.00	2.96	-2.96
Facatativá	90,266	7.50	18.05	-10.55
Funza	51,808	0.00	10.36	-10.36
La Calera	24,188	0.00	4.84	-4.84
Madrid	52,110	6.58	10.42	-3.84
Mosquera	27,753	11.56	5.55	6.01
Soacha	283,889	0.00	56.78	-56.78

Source: JICA Study Team

The results show that the some of twelve localities are not enough regional evacuation areas and seven municipalities in Cundinamarca cannot provide enough regional evacuation places, especially Soacha. Those localities and municipalities should identify the regional evacuation place.

7) Landslide

The priority areas are selected among the landslide areas caused by human factors. La Carbonera and El Espino in Bogotá city are typical area of this kind, where sewer and surface drainage are not installed along with the installation of potable water supply.

It is also appropriate to choose the landslide area where implementation of countermeasures has not yet been enough in spite that the investigation and design of countermeasures were fully performed. Jerusalen, Montebello San Luis and El Paraiso in Bogotá City are typical of this kind. La Carbonera is also in this kind. These five areas are selected to have priority because essential countermeasures are not implemented yet though relocation has been applied in some areas for mitigating landslide disaster.

The countermeasures for these five landslide areas are described as follow.

(1) La Carbonera

The construction of a surface water drainage system, which covers the expanding area, is urgently required.

(2) El Espino

Sewerage and surface water drainage works, which are countermeasures against seepage of surface water into landslide areas, are urgently required. The total cost of existing design is 214,464,162 Colombian pesos.

(3) Jerusalen

The recommended procedure of countermeasure is as follows: Initial stabilization of the steep slope should be done. After that, installation of drainage works at the upper side of the slope is recommended.

(4) Montebello San Luis

The countermeasures according to existing design are counterweight fill work and drainage drilling. Study of piling work in upper part is required since possibility of soil pressure increase due to lateral flow, which is caused by progress of landslide in the upper part, is still a concern.

(5) El Paraiso

The total length of anchoring is 1020m, 341million pesos. Pilling works is 460m3, 267million pesos. Underground drainage is 400m, 18million pesos, horizontal drainage drillings are 207m, 17million pesos. However, all of these have not implemented yet.

As for eight municipalities, the most of investigation, design and installation of countermeasures are not performed, yet it is inappropriate to describe measures against landslide in eight municipalities comparing with that in Bogotá City.

Briefly mentioning, relocation of the houses, which occupy illegally, is necessary at El Atico in Soacha, where rock fall is anticipated. Concrete spray or other proper slope protection is necessary at the road slopes along the road to Granada in Soacha. Removal of overhung rock is necessary along the road at the foot of Majuy hill in northern part of Madrid, where rock fall is anticipated during heavy earthquake.

8) Flood

(1) Proposed structural measures

The structural measures for flood mitigation are composed of dredging, enlargement of the river channel, re-construction and improvement of the riverbanks, improvement of existing structures, etc.

The structural measures against the flood prevention are summarized in the following table.

Table 5.2.19 Summary of Structure Measures Against Flood

Name of River	Design Return Period	Contents of Improvement	City	Remarks
Rio Bogotá	100-year	River improvement from Alicahin to Conejera - Relocation of left dike from the existing position to 30 m behind, - Heightening of the relocated dike by 3 m - Channel excavation for the widened area.	Bogotá Chia Cota Mosquera Soacha	Based on EAAB study
Rio Tunjuelo	100-year	Improvement of the flood control structures	Bogotá	
Rio Botello	10-year	River improvement by canalization.	Facatativa	Hydrological/ hydraulic study is necessary.
Rio Soacha	10-year	River improvement by dredging and widening of existing stream.	Soacha	Hydrological/ hydraulic study is necessary.
Qda. Toma	10-yeqr	Improvement of water course and drainage pipe located in the urban areas	La Calera	Hydrological/ hydraulic study is necessary.

Appendix 5.2.1 and 5.2.2 shows the sections to be improved and proposed cross sections of Rio Bogotá, respectively. And Appendix 5.2.3 shows the image of improvement of the flood control structures in Rio Tunjuelo.

(2) Recommendations on proposed structural measures

A. Consideration of seismic resistance

The structures such as dike, flood control structure, etc. should have resistance against earthquake especially the structures located in the zone of liquefaction. Therefore it is recommended to carry out the seismic analysis on the structure.

B. Alignment of Rio Bogotá

The recommended river improvement work for Rio Bogotá is the same of the conclusion of EAAB study. Since EAAB is responsible for the flood management in Bogotá City, widening of the river was proposed by relocation of dike on left bank. The left bank of Rio Bogotá was urbanized and it is necessary to relocate some houses/buildings while the right bank of Rio Bogotá has not been highly urbanized. It is, therefore, recommended that the alignment of the river should be reconsidered to minimize the adverse impact to the habitants who is forced to relocate involuntary with good coordination of related agencies.

C. Implementation of Rio Bogotá

It is difficult to implement all the work in same time because of the constraining of budget and other resources necessary for the project, less coordination among the related organizations, etc., so that, the stepwise river improvement would be proposed as follows:

- **Short/medium term plan: (Target flood = once in 50-year)**
  - Relocation of left dike with an enough height of 50-year flood
  - Heightening of right dike to the design water level of once in 50-year flood
- **Long term plan: (Target flood = once in 100-year)**
  - Heightening of dikes on both side to the design water level of once in 100-year flood
- **Reconsideration of Purpose of Cantarrana Dam**

Proposed Cantarrana Dam, located in the mid-stream of Rio Tunjuelo (location is shown in Appendix 5.2.1, H = 30 -35 m, V = 10,000,000 m^3) to regulate the flood discharge of Rio Tunjuelo. EAAB also have a plan to construct proposed La Regadera II Dam (H = 30 m, V = 3,000,000 m^3) at just downstream of existing La Regadera Dam for the water supply purpose.

It is usually not convenient to construct two dams with the different purpose within the same river system from the viewpoints of effective water resources development and investment.

Since Cantarrana Dam is located in the downstream of La Regadera II Dam, Cantarrana Dam would have an advantage for both water resources development and flood control. Therefore, it is recommended that the purpose of Cantarrana Dam should be reconsidered as a multipurpose dam of water supply as well as flood control.

9) Industrial Facilities

In the industrial facilities where hazardous materials, high-pressure gas or toxic materials are handled, the equipment failure leads to leaks, spills, fire or explosion. It is probable that they can be breeding grounds for catastrophic disaster. Countermeasures for prevention of earthquake disaster are briefed as follows:

(1) Countermeasures for the prevention of earthquake disaster

Some of the countermeasures for the prevention of earthquake disaster are described as follows:

A. Countermeasures for the hazardous materials

a) Storage tanks

Conduct a check of the following items; if reinforcement is required, this should be done as soon as possible.

- Anti-seismic checkup should be done for the petroleum liquid holding tanks like gasoline or propane by API etc. (API 620 9th edition ADDENDUM3, December 1998 "SEISMIC DESIGN OF STORAGE TANKS, API650 9th edition, July 1993), Japanese FIRE SERVICE LAW Technical Standard).
- Connecting pipe to the tank must be fixed by strong support and flexible hose or flexible joint must be installed to absorb the movement change between pipe and tank.
- Automatic emergency shut-off valve should be installed in the continuous line of supply pipe to the supplier by detecting PGA reading on seismometer.
- If oil happens to be discharged, dike should have enough volume and anti-seismic strength to prevent the spread of oil to other places. Prepare sandbags in case of dike damage to protect from the spreading oil.

b) Fixing method of gas cylinders

There are a lot of examples that the combustible gas holding cylinderor connecting pipes are destroyed because the cylinders break off and fall. The holding gas leaks and explosion occurs. Fixing methods are as follows:

- Each cylinder is fixed on the rigid wall by chain or wire.
- If more than two cylinders are placed, the pedestal made by steel, which is anchored with the foundation, should be used.

c) Safety measures for hazardous materials

Prevention of breakage of chemical bottles

- Shelf that accommodates chemical bottles should be incombustible and rigid.
- Shelves should be fixed on wall or pillar.

- Separation box or partition should be installed so that chemical bottles do not turn over and break.

Caveat for handing of chemicals

- Bottles should be non-breakable and tightly shut off.
- Pay attention to incompatibility and store bottles separately so that there will be no fire break out in case of chemicals mixing by bottle breakage.
- More dangerous chemicals should be stored in the lower shelves.
- Do not leave dangerous chemicals on the table for a long period of time.

B. Countermeasure for earthquake

a) Pedestal reinforcement

Reinforcement of pillars by concrete or installation of brace.

b) Installation of seismometer

Seismometers are installed where more important and dangerous equipment are located and the output seismometers are connected to emergency shut down system.

c) Plant emergency shut down system

If a PGA over 150 gal is detected, this signal goes to the emergency shut down system and plant will be automatically shut down.

d) Emergency isolation system

In the inlet and outlet pipe of the tanks holding hazardous materials and toxic materials, the emergency remote controlled valves are installed. If a PGA over 150 gal is detected, these valves are automatically shut off.

e) Piping flexibility

Flexible hose, joint or flexible piping system to absorb movement is installed at the tank inlet, outlet piping or upward piping from underground.

f) Tank sloshing

Sloshing is very dangerous at the time of resonance. It is important to control liquid level so that resonance will not occur.

5.2.3 Non-Structure Measure

1) Monitoring and Warning System

To reduce the damage of the disasters, monitoring of phenomena and provide early warning is very important. It is, therefore, establishment of monitoring and warring system is proposed as a part of the Plan.

Since the plan should be corresponded to multi kinds of disaster namely, earthquake, landslide, flood and industrial disaster, the monitoring and warning system should also be corresponded to them. However, as monitoring system for industrial disaster shall be provided by the entity who own the industrial facilities, the information on earthquake, landslide and flood are monitored by this system.

Figure 5.2.3 shows the image of monitoring and warning system.

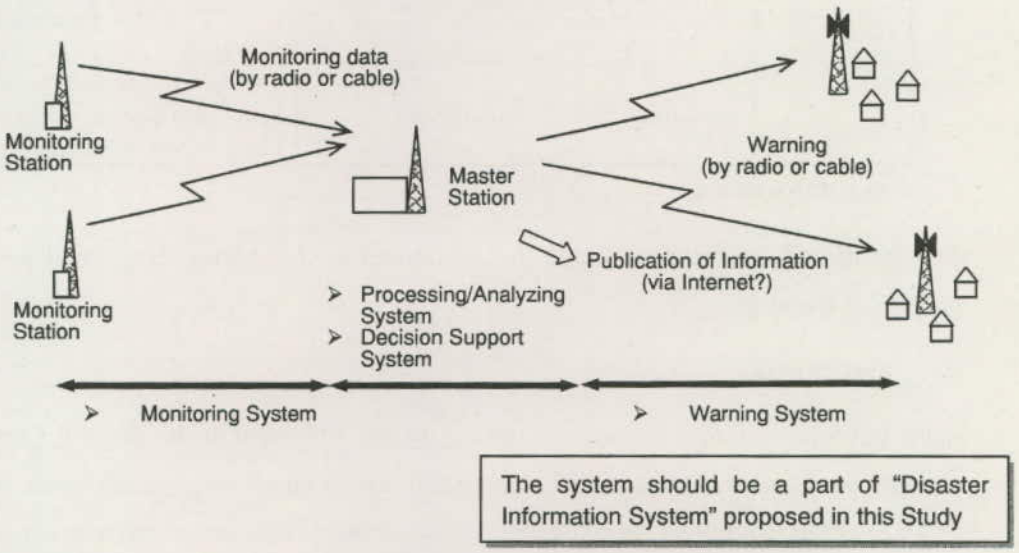


Figure 5.2.3 Image of Monitoring and Warning System

(1) Monitoring system

Many kinds of information (e.g. seismic wave, hydrological data, etc.) should be monitored to provide early warning. Table 5.2.20 summarizes the information to be handled by the monitoring system.

Table 5.2.20 Information to be Handled by Monitoring System

Kinds of Disaster	Information	Data Transmission Method	Frequency
Earthquake	Seismic wave	Telemetric (radio)	Continuous Event monitoring if amount exceeds pre-set criteria
Landslide	Movement of landslide mass	Telemetric Semi-Automatic Manual	Every 10 min. in normal Event monitoring if amount exceeds pre-set criteria
	Rainfall	Telemetric	Every 10 min. Event monitoring if amount exceeds pre-set criteria
	Groundwater level	Telemetric Semi-Automatic Manual	2 times/day in normal
Flood	Rainfall	Telemeter	Every 10 min. in normal Event monitoring if amount exceeds pre-set criteria Every 1 min. in pre-emergency and emergency
	Water level	Telemeter	2 times/day in normal Every 30 min. in pre-emergency Every 10 min. in emergency

Source: JICA Study Team

The monitored information should be transmitted to the master station and processed for the publish of warning.

A. Earthquake

Seismic wave monitoring station is necessary not only within the Bogotá City area but also nationwide. Since it is impossible to install nationwide monitoring system by local organizations, as for the Plan, nationwide seismic wave information will be collected from existing monitoring system and the information of local earthquake will be collected from the monitoring station installed by local organizations.

The monitored information shall be transmitted to master station by automated transmission system,

B. Landslide and flood

Monitoring items for warning of landslide are rainfall and movement of landslide block. The stations for movement monitoring should be located on the landslide block. Rainfall monitoring stations are not necessary located on each landslide block; however, rainfall monitoring station should be installed to represent all landslide blocks.

To publish the warning on flood, monitoring of rainfall and water level are necessary. The locations of station should be determined based on the considerations of topography, river system, density of monitoring station, etc.

The monitored information of rainfall can be utilized for both landslide and flood warning, therefore, locations of the station should be determined with the consideration of maximum utilization for both disasters.

Figure 5.2.4 shows the proposed location of rainfall and water level monitoring stations.



Figure 5.2.4 Proposed Location of Rainfall and Water Level Monitoring Station

(2) Warning system

Early warning system is effective in reduction of damage of disasters, especially effective on landslide and flood, of which the disasters can be predicted for its occurrence. Thus, the warning system planned to be installed to the high-risk areas of landslide and flood.

Wireless transmission/communication system with loudspeaker will basically applied for warning system. However, the transmission/communication method to inhabitants should be determined after the study on reliability of communication, social, etc.

2) Land Use Regulation

As for the disasters which the damage extent only limited areas such as landslide and flood, land use regulation is the one of most effective measure to prevent the damage. Therefore land use regulation for high risk area of landslide and inundation will be set up as a part of the plan.

Based on the risk map prepared, land use regulation should be imposed strictly. As it is very difficult to resettle the people once they immigrate in, the important thing is to prevent housing development in dangerous areas.

(1) Landslide area

Following regulation will be made for the landslide areas.

Risk Grade 1	Non-building, Non-residential Area (Utilize as green area, park, etc.)
Risk Grade 2	Building Regulation (Not permit public, large and important facilities)
Risk Grade 3	Not applied

(2) Flood area

In POT, Bogotá City and other cities, the municipalities designated the river area along Rio Bogotá and tributaries with 75 m and 50 m respectively, from the centerline of the river. Based on this plan, following regulation will made for the flood areas.

River Area	Rio Bogotá: 75 m each side from the centerline of the river
	Tributaries: 50 m each side from the centerline of the river
	Not permit any activities except environmental conservation activities
High Risk Area	Non-building, Non-residential Area (Utilize as green area, park, etc.)
Medium Risk Area	Building Regulation (raised floor)
Low Risk Area	Not applied

5.3 Emergency Response

In and after a major disaster, the disaster prevention organization is required to respond and undertake recovery activities rapidly and effectively, in order to track the disaster: saving lives, protecting property, and meeting basic human needs; restoring the disaster-affected area; and reducing vulnerability to future disasters. The necessary tasks and activities are to be compiled in manuals.

For conducting the tasks, the resources and assistance efforts required are as follows.

5.3.1 Resources

The resources to be prepared are:

- Specialized teams for damage assessment, emergency communications, medical assistance and support, urban search and rescue, etc.;
- Equipment and supplies required (food, water, power generators, camping goods, etc.) for affected areas; and
- Facilities and equipment required for disaster field office, disaster recovery centers, etc.
- Emergency support activities (opening critical transportation routes, establishment of shelters and feeding facilities),
- Financial support (loans and grants) for the victims to repair or replace damaged houses in order to reduce damages and recover after the disaster,
- Financial arrangement to repair roads and public buildings,
- Technical assistance to identify and implement mitigation opportunities to reduce future loss, and other assistance, including crises counseling, tax relief and legal services.

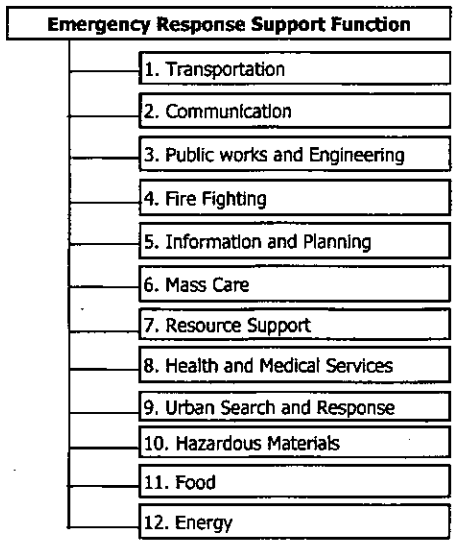
5.3.2 Types of Assistance

The assistance to be provided by the disaster prevention organizations cover the following:

- Immediate relief:
  a) Initial response resources including food and water,
  b) Emergency services to open critical transportation routes, shelters and feeding centers,
- After the disaster for reducing damages and recovery:
  a) Financial support (loans and grants) to repair or replace damaged housing,
  b) Financial arrangement to repair roads and public buildings,
  c) Technical assistance to identify and implement mitigation opportunities to reduce future loss, and
  d) Other assistance, including crises counseling, tax relief and legal services.

5.3.3 Emergency Response Plan

The emergency response plan establishes a process and organizational structure for coordination and effective delivery of assistance to the disaster areas. According to the Law 919 of Article 62 b) in 1989, each territorial entity or public service entities should act to handle emergency response during the disaster situations. Each public service entity's emergency response is attached in Appendix 5.3.1. Although the Study Area has no integrated emergency response plan, the basic structure of the emergency responses will be arranged as follows:



Source: FEMA and EMI

Figure 5.3.1 Structure of Emergency Response Support Functions

In order to minimize the damage in a disaster it is important for emergency response entities to prepare the following initial Responses.

- For arrangement of initial responses it is necessary for each emergency response entity to review the organization and prepare a manual for its initial activities,
- Arrangement of base offices for emergency response activities and preparation of necessary equipment for the base offices,
- For strengthening of disaster information management systems it is necessary for the related entities to reinforce the existing communication system and monitoring systems, and their equipment,
- For strengthening of rescue and support systems it is necessary for the related emergency response entities to arrange evacuation places, evacuation roads, and also to strengthen shelters, and to secure water and foods,

- For arrangement of fire fighting and rescue activities, it is necessary for the related emergency response entities to strengthen the fire fighting capacity, fire fighting apparatus and rescue equipment.
- For arrangement of first aid and medical care system it is necessary for the related emergency response entities to arrange first aide system, communication system, initial medical care system, back up medical facilities and medical care environment,
- For arrangement of transportation system it is necessary for the related emergency response entities to arrange emergency traffic control system, emergency transportation system, teams and equipment for opening of emergency transportation routes and airport facilities.

5.3.4 Emergency Response Organization

1) Primary and Support Agencies in Emergency Response

The Study team carried out discussion to identify emergency response organization at national, Cundinamarca and Bogotá City governments. Detailed organizations for emergency response and preparedness are shown in Appendix 5.3.2, which is the conclusion of the responsible organization. Primary and support agencies identified in the Study are as follows:

(1) Bogotá

1) Leading Agencies: DAPD
2) Coordinating Agencies: DPAE-FOPAE
3) Primary Agencies:

- Health Secretary
- Traffic and Transport Secretary
- District Administrative department of Planning (DAPD)
- DPAE-FOPAE
- Firemen Official Body
- District Administrative of Social Welfare
- IDU
- EEB/CODENSA
- ETB/TELCOM

4) Supporting Agencies:

- Government Secretary
- Treasury Secretary
- DAMA
- Civil Defense
- Red Cross
- Metropolitan Police
- Military Unit

- Transit Police
- EAAB
- Department of Community Action
- Local Mayor
- Concejo Colombiano Segridad (CCS)
- TRANSMILENIO
- Natural Gas

(2) Cundinamarca

1) Leading agency: Government Secretary

2) Coordinating agency: Government Secretary/OPAD

3) Primary agency:

- Firemen Official Body
- Secretary of Health
- Civil Defense
- Government Secretary/OPAD
- Secretary of Public Works
- Secretary of Social Development

4) Support agencies:

- General Secretary
- Military Brigade
- National Police
- CAR
- Red Cross
- Secretary of Planning
- Secretary of Agriculture and Rural Department
- Secretary of Treasure
- Secretary of Environment
- Traffic and Transport Administration Department
- Human Talent Administrative Department
- Alcalde Local
- Empresa Energy
- CODENSA
- TELECOM
- Community
- Concejo Colombiano de Seguridad (CCS)

(3) National

1) Leading agency: Ministry of Interior

2) Coordinating agency: DGPAD

3) Primary agencies:

- Ministry of Transport
- Ministry of Communication
- DGPAD
- National System of Fire Fighters
- National Institute of Familiar Comfort (ICBF)
- Ministry of Health
- Colombian Civil Defense
- Ministry of Energy

4) Support agencies:

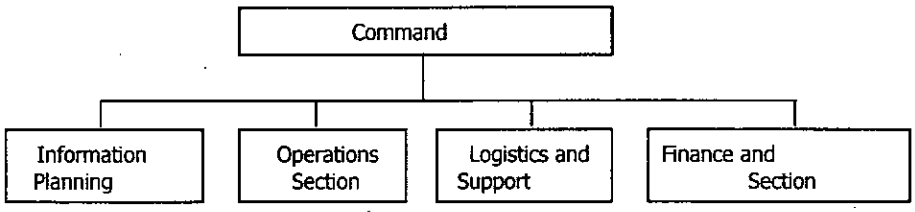
- Ministry of Interior
- Ministry of Finance and Public Credit
- Ministry of Environment
- National Department of Planning
- Colombian Red Cross
- Colombian Chamber of Construction
- Colombian Society of Construction Engineer
- National Institute of Roads (INVIAS)
- Military Force (FF.MM)
- TELCOM
- Ministry of Education
- Ministry of Agriculture
- Ministry of Development
- Concejo Colombiano de Segridad (CCS)

2) Basic Concepts of Organizational Structure

The emergency organization should be established prior to a disaster. Under normal situations, the organization is not in operation, but the emergency response organization is to be activated under the disaster situation. In normal situation, only the disaster management organization would act as the facilitator and coordinator of the disaster management. In case of emergency, the governmental organization at each level should activate the emergency response organization at each administrative unit.

The Federal Emergency Management Agency (FEMA) and Emergency Management Institute (EMI) propose to establish an emergency management system based on the Incident Command

System (ICS), which is the model for command, control and coordination. ICS organization is built on five major components: command, planning, operation, logistics and finance/administration [5-3-1].



Source: FEMA and EMI

Figure 5.3.2 Emergency Management Organization

According to FEMA and EMI, major responsibilities for each component are summarized as follows:

Table 5.3.1 Responsibility of Components

Component	Responsibility
Incident Commander	Commanding activities Protecting life and property Controlling personnel and equipment resources Maintaining accountability for responders and public safety, as well as for task accomplishment Establishing and maintaining an effective liaison with outside agencies and organizations.
Planning section	The responsibility for the planning section includes collection, evaluation, dissemination, and use of information about the development of the incident and status of resources.
Operation section	The Operation section is responsible for carrying out the response activities.
Logistics section	The Logistics section is responsible for providing facilities, services, and materials including personnel, to operate the requested equipment for the incident.
Finance and Administration section	The Finance and Administration section is critical for tracking incident costs and reimbursement accounts.

Source: FEMA and EMI

The Incident Command will have three command staff: information officer, safety officer and liaison officer. The responsibility for those officers are shown as follows:

- The information officer handles all media inquires and coordinates the release of information to the media.
- The safety officer monitors safety conditions and develops measures for ensuring the safety of all assigned personnel.
- The liaison officer is the on-screen contact for other agencies assigned to the incident.

[5-3-1] FEMA and EMI (1998) Independent Study Course: Incident Command System (ICS).

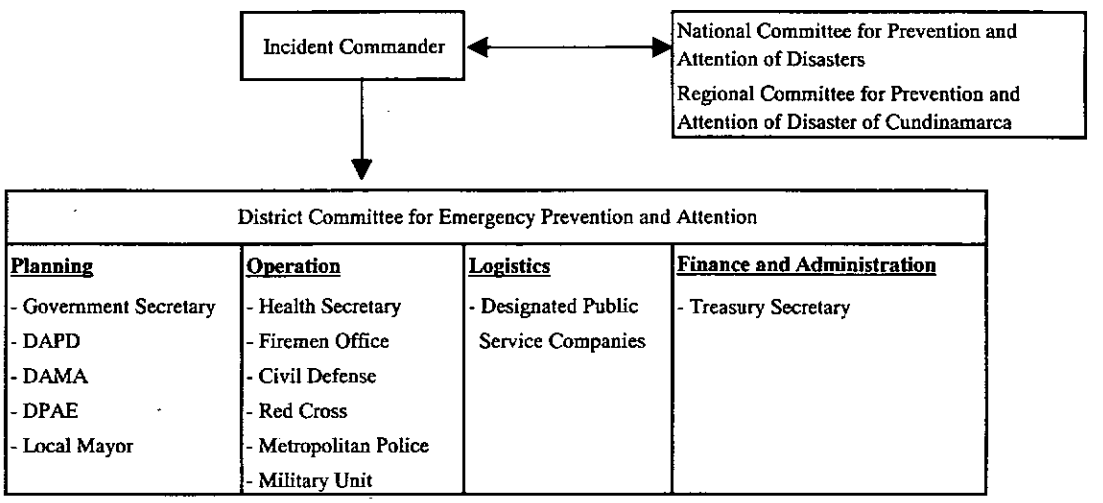
The emergency response organization should have those functions. Those basic ideas could be applied in the emergency response organization in the Study Area.

3) Emergency Response Headquarters

(1) Organization

The emergency response command center should be established in the Study Area from local level to regional and national levels. As to who should be the incident commander should be clarified by law. At the local level, the incident commander is local mayor, while for the Bogotá City or Cundinamarca governments, it should be the Mayor of Bogotá City or Governor of Cundinamarca, respectively. The members of district or regional emergency prevention committees should situate in emergency response headquarters.

The proposed organization for Bogotá City Area is shown as follows:



Source: JICA Study Team

Figure 5.3.3 Proposed Organizational Structure of Emergency Response Headquarters

Each disaster response organization is attached to the Emergency Response Headquarters. The incident commander has the power to direct all emergency response organizations.

(2) Functions

The function of the emergency response headquarters can be categorized into three items:

- Data collection and analysis
- Decision, discussion and coordination for disaster countermeasures
- Order and instruction to other organizations

The disaster management center should have disaster information system, data collection system, telecommunication system, damage information collection system and communication system to other disaster response organizations.

The sub-center should have the supplemental functions of headquarters. When the command center is rendered inoperable, sub-centers will replace its roles and functions.

4) Location and Buildings

The command center should have seismic resistance structure and should be equipped with the emergency facilities to operate emergency activities. Those buildings should furnish the emergency facilities as listed below:

- Seismic resistance structure
- Generators during emergency situation with storage of energy
- Water
- Toilet

In the Study Area, it is not clear where the command center would be. The proposal is possibly an emergency command center at regional and locality levels.

(1) Bogotá city

The secretary of health building seems to be the Bogotá City command center, yet the room has not been used under normal situation. Moreover, there is no information and communication facility in the room to connect disaster related organizations. The sub-center would be DPAE's building. DPAE has a disaster communication system, which operates 24 hours. However, there is no space for the commanding functions.

(2) Cundinamarca government

The disaster command center would be the Cundinamarca government building, and the sub-center would be OPAD office. It is not clear where the command center of the Cundinamarca government is.

(3) Locality and municipality

The locality or municipality should be the disaster management center in each locality. Each locality or municipality building should be a disaster management center in each locality or municipality.

The proposed locations of command centers are shown as follows:

Table 5.3.2 List of Proposed Emergency Response Center

Category	Name of Facility	Location	Building Information			Seismic Reinforcement
			Floor Area (m²)	Structure	Year of Construction	
National Level	Ministry of Interior	Bogotá	3,861	Unreinforced Masonry	1860	No
	Health Secretary of Bogotá	Bogotá	35,827	Reinforced Concrete	1999	Yes
Regional Level	Department of Prevention and Emergency attention (DPAE)	Bogotá	1,015	Reinforced Concrete	1992	Yes
	Office for Prevention and Disaster Attention (OPAD)	Cundinamarca	600	Unreinforced Masonry	1986	No
	Major's Office of Bogotá D.C.	Bogotá	6,825	Unreinforced Masonry	1900	Yes
	Cundinamarca Prefecture	Cundinamarca	38,187	Reinforced Concrete	1997	Yes
Local Level	Local Office of Usaquén	Bogotá	1,272	Unreinforced Masonry	1840	No
	Local Office of Chapinero	Bogotá	3,250	Reinforced Concrete	1975	No
	Local Office of Santa Fé	Bogotá	1,093	Reinforced Concrete	1993	Yes
	Local Office of San Cristóbal	Bogotá	776	Unreinforced Masonry	1980	No
	Local Office of Usme	Bogotá	2,538	Reinforced Concrete	1955	No
	Local Office of Tunjuelito	Bogotá	1,783	Unreinforced Masonry	1985	No
	Local Office of Bosa	Bogotá	1,144	Unreinforced Masonry	1982	No
	Local Office of Kennedy	Bogotá	4,176	Reinforced Concrete	1984	No
	Local Office of Fontibón	Bogotá	1,236	Unreinforced Masonry	1961	No
	Local Office of Engativá	Bogotá	800	Unreinforced Masonry	1997	Yes
	Local Office of Suba	Bogotá	1,330	Unreinforced Masonry	1928	No
	Local Office of Barrios Unidos	Bogotá	8,938	Unreinforced Masonry	1940	No
	Local Office of Teusaquillo	Bogotá	499	Unreinforced Masonry	1940	No
	Local Office of Los Mártires	Bogotá	640	Reinforced Concrete	1958	No
	Local Office of Antonio Nariño	Bogotá	2,268	Reinforced Concrete	1971	No
	Local Office of Puente Aranda	Bogotá	3,422	Reinforced Masonry	1978	No
	Local Office of La Candelaria	Bogotá	243	Unreinforced Masonry	1900	No
	Local Office of Rafael Uribe	Bogotá	1,752	Reinforced Concrete	1949	No
	Mayor's Office of Chía	Chía	1,680	Unreinforced Masonry	1939	No
	Mayor's Office of Cota	Cota	273	Reinforced Concrete	2000	Yes
	Mayor's Office of Facatativá	Facatativá	2,205	Reinforced Concrete	1989	Yes
	Mayor's Office of Funza	Funza	1,734	Reinforced Concrete	1960	No
	Municipal House of La Calera	La Calera	2,046	Unreinforced Masonry	1778	No
	Government Palace of Madrid	Madrid	1,488	Unreinforced Masonry	1890	No
	Mayor's Office of Mosquera	Mosquera	852	Unreinforced Masonry	1900	No
	Government House of Soacha	Soacha	4,675	Reinforced Concrete	1997	Yes

Source: JICA Study Team

5) Emergency Response Organization

(1) Required personnel

It is important to establish disaster management organizations based on the disaster level. The required personnel should be determined before the emergency situation. The proposed level of emergency is shown as follows:

Table 5.3.3 Proposed Emergency Level

Emergency Level	Disaster Situation	Organization
Level 1	It is expected that the disaster may happen within the territory. The mayor determines when to call all personnel.	The information collection and preparation for the rescue should be activated. It is also important to minimize damage.
Level 2	A limited area has been affected by disaster. The affected area is one locality.	The organization should be established to handle the situation.
Level 3	Several localities have been affected by a disaster and it is expected that damage will spread widely.	The organization should be established to handle more than one locality.
Level 4	The disaster damage has expanded to whole territory.	Whole governmental organization should be established to handle the disaster situation. The mayor calls for the district committee of emergency prevention and attention to deal with the situation.
Level 5	The president of Colombia declares a state of disaster in the territory.	It is required to call whole administrative staff for emergency response operation.

Source: JICA Study Team

The required personnel vary, depending on the disaster situation and emergency response plan. It should be noted that the emergency response personnel would be decreased depending on affected disaster situations because administrative staff will be victims of the disaster. Therefore, the plan allows implementing less administrative staff just after the disaster.

6) Responsibility of Each Organization

(1) Locality or municipality government

The locality or municipality government should convene their emergency local committee and implement emergency rescue operation based on their plan. The local mayor is the person responsible for this and makes the call for the required personnel. The local mayor also gives information to the other organizations.

(2) Bogotá city government

The primary responsibility of the Bogotá City government is to give assistance to the local government to be directly involved in the rescue operation. The Bogotá City government should establish operational procedures and construct disaster management organizations.

5.3.5 Data and Information Collection and Distribution

1) Basic Concepts of Data Collection

The disaster data collection is carried out by several governmental organizations. The following shows the communication system that has already been operated in the Study Area. Each organization should collect information based on its responsibility.

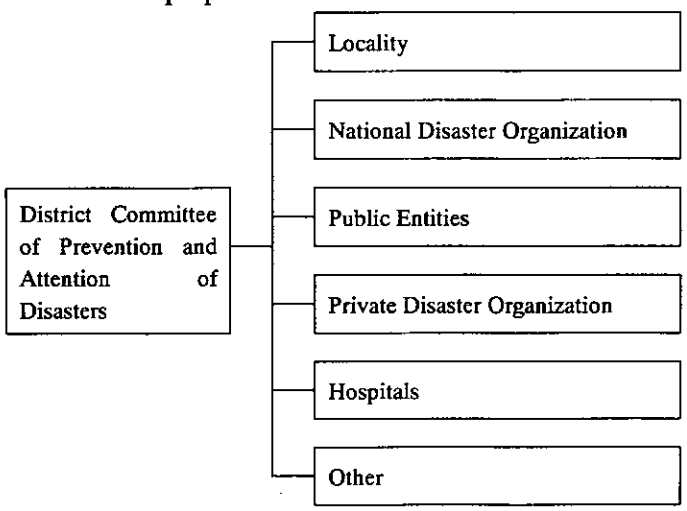
Table 5.3.4 Existing Communication System

Type of Communication System	Organization
Disaster Communication System	DGPAD DPAE OPAD
Seismic Information Network	Ingeominas
Security Communication System	Metropolitan Police Traffic Police Military Force Fireman's Office
Health Communication System	Secretary of Health
Other organization	Civil Defense Red Cross

Source: JICA Study Team

The information should be integrated and distributed among disaster related organizations to formulate accurate disaster response activities. Although several organizations have an information system to collect data for their respective purposes, not one system exists that allows a sharing of information among the related organizations. Moreover, there is no integrated disaster information system in the Study Area.

The figure below shows the proposed basic structure of the information system.



Source: JICA Study Team

Figure 5.3.4 Proposed Information System in the Study Area

The roles of the organizations are summarized as follows:

Table 5.3.5 Summary of Organizations' Roles

Organization	Descriptions
Locality or municipality	The mayors should collect the disaster information in their respective localities. The collected information is then transferred to the national and Bogotá City governments. Each locality should establish a means of communication during disaster situations. Each locality government should establish a disaster information system network among the police station, firemen's office and infrastructure companies.
Bogotá City government	DPAE has a disaster communication system within Bogotá City, which connects 16 disaster related organizations. These organizations have subscribed to disaster information communication. The DPAE also developed the SIRE, which is an information system using the Internet.
Cundinamarca government	Cundinamarca government established a disaster communication system under the secretary of government. The communication system connected 116 municipalities in the prefecture.
Other organizations	A communication system has been established in each organization. During disaster situation, these communication systems should be used for the response purposes.

Source: JICA Study Team

2) Data Collection and Distribution

Each organization should collect information for its own responsibility and report to the disaster command center. Also, each organization should have a disaster information system to connect to disaster command centers. The communication methods shall be established prior to disaster situations. The following figure shows the proposed disaster information network.

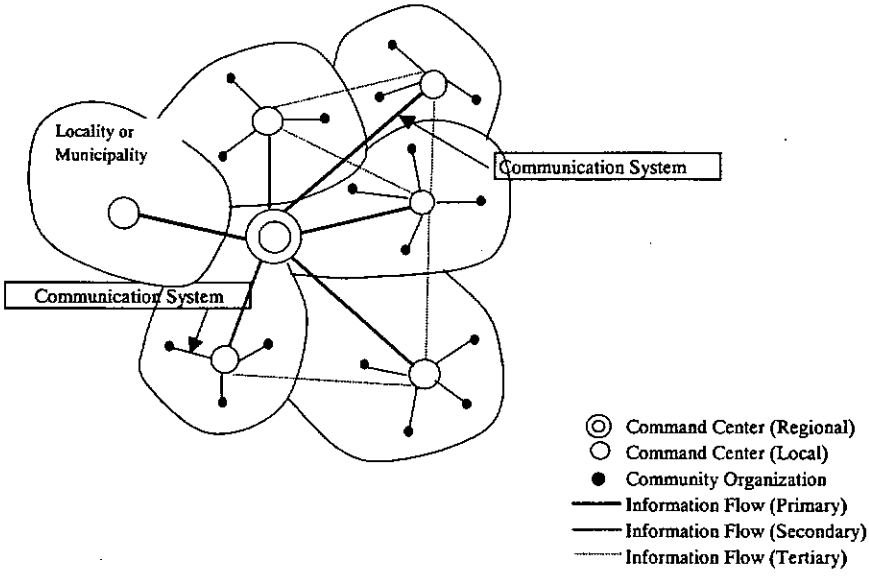
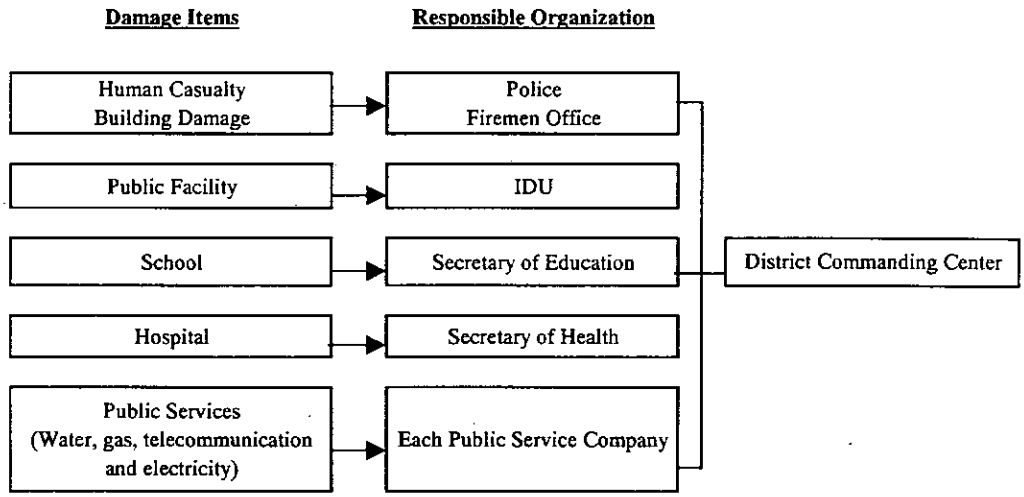


Figure 5.3.5 Disaster Information System

Each organization should determine the items to be reported to the disaster command center. The following figure shows the responsible organization and proposed report items to the command center.



Source: JICA Study Team

Figure 5.3.6 Proposed Damage Information Collection System

3) Information Distribution

The government should provide information on the disaster and damage situations as well as restoration of lifelines. The government and news media should work together to distribute information on what victims need the most. The methods of information provision should be established prior to the disaster. Each disaster management organization should define the contents and means of information distribution.

4) Emergency Broadcasting

The roles of broadcast companies for the emergency are important to disseminate information on disaster, damage and restoration of lifelines. The government should forge an agreement with them for emergency broadcast.

5.3.6 Coordination and Cooperation

1) Basic Concepts

Each government agency should establish the corresponding emergency response procedure for its own organizations. When damage expands to the whole Bogotá City, the government organization itself should proceed with the emergency response plan. However, it has formed an agreement for the disaster response activities with other local governments as well as private sector groups. The involvement of private sector groups is also important to handle situations. Therefore, the government should have agreements with other local governments and private sector groups and should create a network for the emergency response.

2) Areas

The areas for the agreement are classified into five categories. The following table shows the areas of agreements during disaster situations.

Table 5.3.6 Summary of Agreements

Areas of agreements	Organization	Contents
Local governments	Other local governments to support the emergency response.	Dispatch of personnel, machinery, materials Duration and location
Disaster related organization	Non-governmental organizations and private sector, which carries out the disaster operations	Dispatch of doctor Emergency broadcasting Supply of emergency vehicles and trucks Others
Other governmental organization	The agreement between other governmental organizations	National level government Other prefectural governments
Private sector	The private sector for the emergency assistance	Contents of emergency response Clearing work
Other organizations	Other organizations required for assistance	Supply of food stuff Clothes and daily necessities

Source: JICA Study Team

The Bogotá City governments and Cundinamarca agreed on the cooperation of disaster situations. The agreement is the first step towards the cooperation among the governments, yet the effort should be directed to make an agreement with other organizations.

5.4 Emergency Health and Medical Services

5.4.1 Planning Policies and Outlines

1) Planning Policies

In its "Methodology Guide for Elaboration of Hospital Emergency Plan," Secretary of Health, Bogotá, defines the preparation level for emergency situations into the following three, according to the magnitude of the disaster:

Level	Definition
I	Available human and physical resources are enough to face the situation.
II	Mobilization of all the hospital resources is necessary to face the situation.
III	Hospital capacity is surpassed and it is necessary to request external support.

Estimated magnitude of damages by any type of disaster analyzed in the Study corresponds to level III or even surpasses it to fall under level IV, if any (meaning, all the district health capacity is surpassed and it is necessary to seek national and international assistance). Only the system with a nation's strength behind it, that is, mobilizing national health resources in combination with international humanitarian assistance can cope with this overwhelming need. This significant result of the study consequently leads the Health Disaster Management Plan to target on a level III event situation. And preparedness for this kind of disaster is likely to be largely insufficient in the existing plan and ideas of the central and local authorities in the health sector.

Emergency health service in a massive disaster requires entirely different response procedures from an independent emergency event in normal time. Response policies to meet a Level III situation are summarized as follows:

(1) Give priority to life-saving care

It means exerting all efforts to attend to the patients who have a good chance to survive, since disaster medical services aim at providing 'the best for greatest number of victims'. Triage process plays a crucially important role from this point of view.

(2) Mobilize all health resources to attend to victims, in or about the metropolitan area

It means preventing many victims from converging spontaneously on some specific hospitals by guiding and transporting them to hospitals out of the affected area in as wide an area as possible.

(3) Respond systematically according to institutional service hierarchy

It means meeting the greatest needs by the response system with three levels of health zones: Provincial, Metropolitan and National. In order to establish this system, role and responsibility of all organizations involved in the health disaster management must be defined, and inter- and intra-institutional coordination mechanism among them should be worked out.

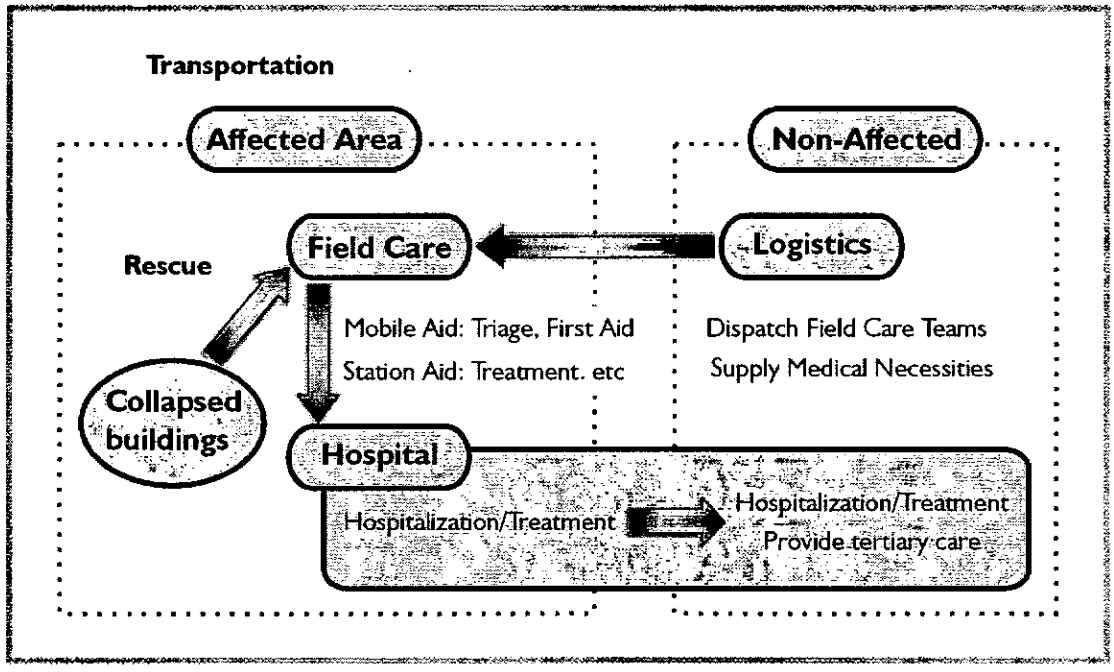
(4) Provide timely services to meet changing needs with time

It means responding to ever-changing health needs as time passes, that is, attending to serious injuries first, to acute internal diseases next, then to chronic cases, and finally to mental disorders.

2) Outline of the Plan

Health disaster management plan consists of two parts: Preparedness and Response. And both parts contain the following medical aid activities, which are composed of five essential sub activities. Figure 5.4.1 shows the flow of the injured according to these health activities.

- Information collection and distribution.
- Field care (Pre-hospital care).
- Hospital care.
- Logistics.
- Transportation.



Source: JICA Study Team

Figure 5.4.1 Flow of Medical Aid Activities in a Disaster

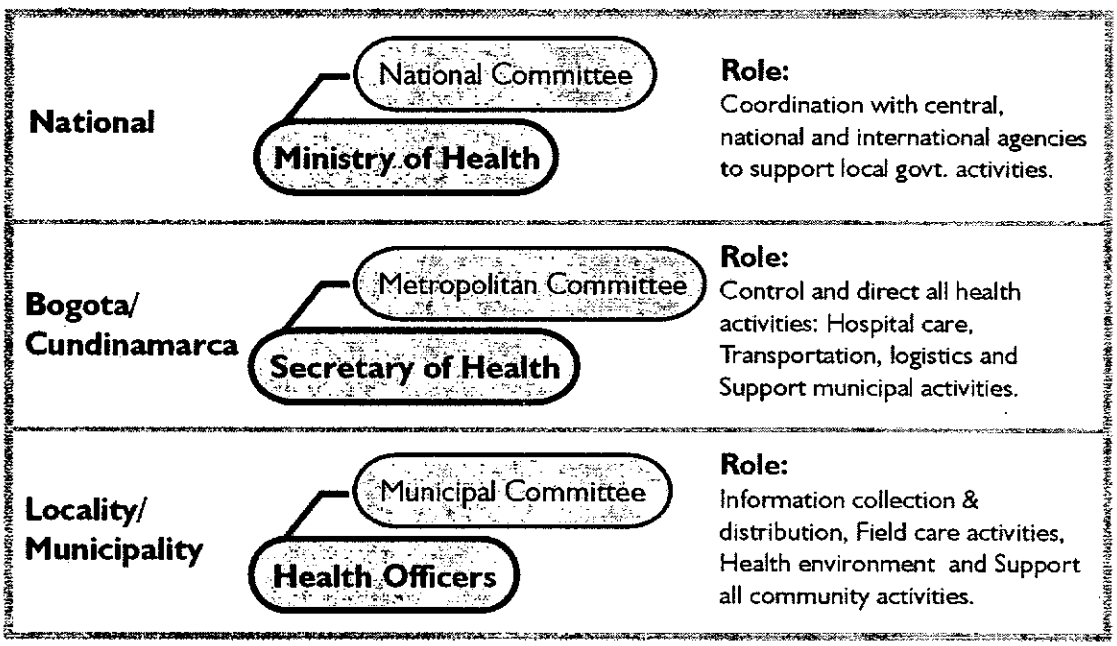
In the Preparedness plan, essential issues, which must be addressed before carrying out medical aid activities, are described. And in the Response plan, procedures of these activities and responsibilities of many health entities concerned are clarified.

5.4.2 Health Disaster Preparedness

The preparedness plan aims at showing important points to improve and strengthen existing health resources for disaster emergency response in the metropolitan area, with focus on mass casualty management.

1) Disaster Response Mechanism

The Ministry of Health, Bogotá D.C, and Cundinamarca set up a disaster response organization with three functional levels described below and arrange the definitive role of all its members.



Source: JICA Study Team

Figure 5.4.2 Three Levels of Disaster Response Mechanism

Response organization at any level should be strengthened to have appropriate staff, management and technical capacity to cope with a large-scale disaster under its responsibility. Especially it is urgently necessary to organize the system at locality/municipal level where preparedness is very behind.

2) Health Disaster Information Network

Health authorities need precise and comprehensive information on the status of their health facilities, health personnel, relief activities, lifelines, and roads/traffic etc., in order to make decisions and give commands/directions quickly. For this purpose, the following are essential:

- Bogotá D.C and Cundinamarca need to strengthen and upgrade their existing Radio Communication Centers for emergency services in CRU and CRUC into the 'Health Disaster Information and Command Center' in order to perform the following functions:
- Collection of information on damages- human damages and health facilities.

- Collection of information on health activities- field care teams, health institutions and transportation.
- Distribution of information- to media, population including patients' families, other relief agencies, international assistance agencies and NGOs.
- Bogotá D.C and Cundinamarca have to come up with a mechanism to collect and dispatch information of all disaster relief agencies as well as health information system and facilities, with the assistance of the Ministry of Health.

3) Transportation Arrangement

It is the responsibility of health authorities to make the proper arrangements for the transport of large numbers of disaster victims, health personnel and medical supplies over a very wide area. Especially airplanes are expected to play an important role in transporting severely wounded patients to other cities like Cali, Medellin, etc.

Table 5.4.1 Transport Measures by Administrative Level

Level	Area to cover	Measures
National	Nation-wide	Aircraft, Helicopter, Truck, etc.
Bogotá/Cundinamarca	Health aid stations-Hospitals, Hospitals-Hospitals, -Airport	Ambulance, Helicopter, Bus, Taxi, Truck, All kinds of vehicles
Locality/Municipality	Sites-Health aid stations	All kinds of vehicles

Bogotá D.C and Cundinamarca shall make specific arrangements with private transport operators (Ambulance/Bus/Taxi/Truck companies) to hire a number of vehicles during disaster emergency period.

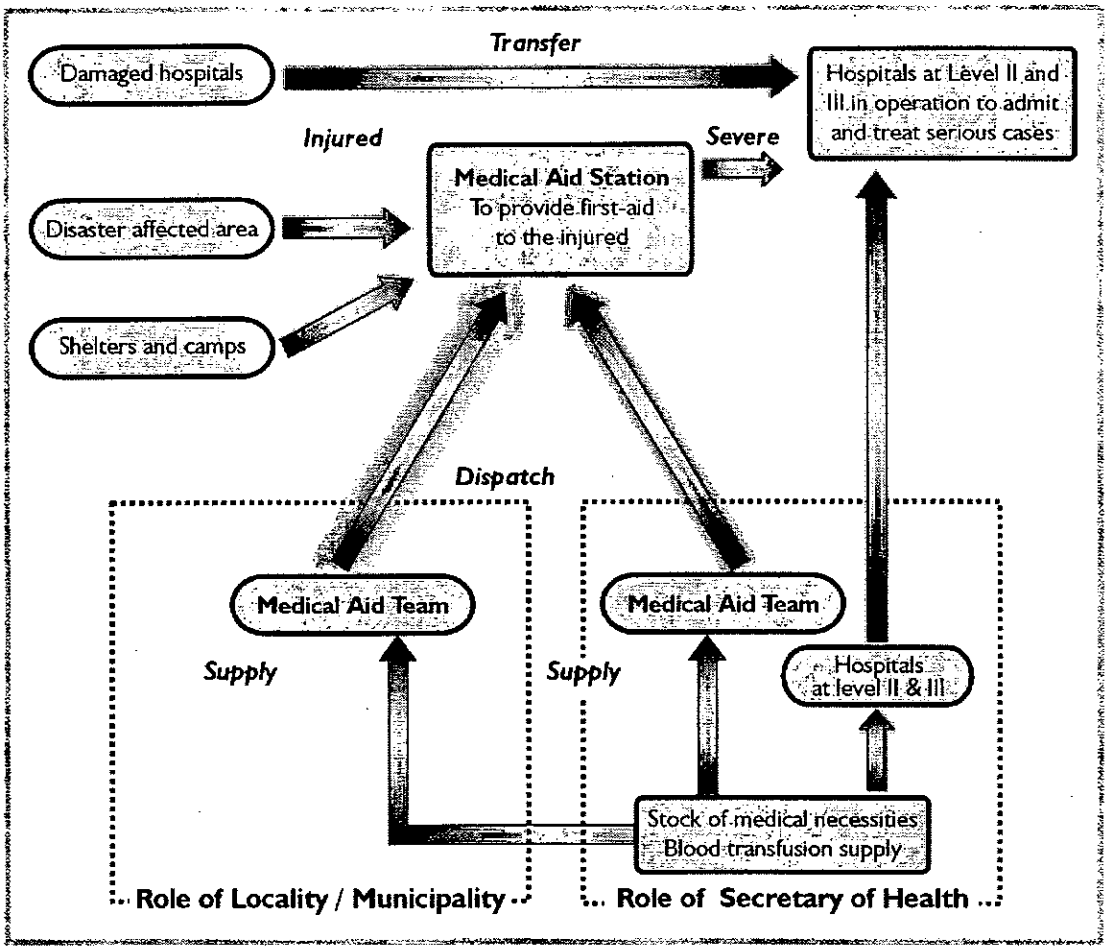
4) Pre-hospital Care System

Greatest needs for emergency care occur in the first few hours after the event of an earthquake. Thus, pre-hospital care is likely to be crucial because hospital resources are fatally short to meet massive needs in the metropolitan area. Health authorities have the responsibility to prepare and arrange the following components of pre-hospital care system in cooperation with agencies concerned:

- Spread knowledge and technique of first aid to citizens.
- Prepare to form a number of field care teams; and
- Prepare to set up a number of fixed first aid stations.

Localities in Bogotá D.C and Municipalities in Cundinamarca are primarily in charge of providing pre-hospital emergency care by mobile aid teams at the disaster sites. Secretary of Health, which plays a supporting role to localities and municipalities, shall also form and dispatch its own medical aid teams in the following cases:

- If a request is made by a locality or municipality for a medical aid team.
- If the *Secretary* deems it necessary to send a medical aid team.



*Note: 1) In Tokyo, 2,410 teams at locality / municipal level and 213 at metropolitan level are scheduled to be formed in cooperation with Doctors Associations, Red Cross and Central government, etc. to cope with estimated 158,000 injured victims.
2) One team consists of one physician, one to three nurses, and one assistant, at the minimum.

Source: JICA Study Team

Figure 5.4.3 Conceptual Diagram of Medical Aid Procedures

(1) Activities of medical and other related aid teams

Three kinds of aid team, medical, dental and pharmacist teams, will take on the following responsibilities at appropriate sites in a disaster time cycle.

Table 5.4.2 Characteristics and Responsibility by Type of Aid Team

Team	Responsibility
Medical aid team	First aid to the injured Triage Treatment for severely injured cases who are not likely to bear transport, or health care for mild cases Urgent delivery Confirmation of death and identification of body
Dental aid team	Quick dental treatment to the injured Triage Cooperation in identification of bodies
Pharmacist team	Preparation of medicine and instruction to the injured at medical aid stations Handling and storage of drugs at aid stations

Table 5.4.3 Time, Place and Job Principle of Teams in the Aftermath

A. During emergency period -within 2 days after the event
Target: patients who are injured by hazard Work place: medical aid stations at sites with many victims and at health facilities Job principle: to provide care with rescue teams as well as at aid stations to carry out triage, give minimal treatment, and transport severe cases to hospitals to provide 24 hours service to have medical necessities for injured cases mainly
B. Post emergency period - 3 days after the event
Target: inhabitants at shelters and camps, and patients who need care at sites Work place: not always fixed- shelters/camps, and affected area by hazard Job principle: to transport severe cases to hospitals to provide 12 hours service to carry out dental aid activities to have medical necessities for internal, chronic, and mental cases mainly

5) Hospital Care System

Health authorities must mobilize whole medical institutions not only in the metropolitan area but also across the country. However, a systematic response is crucially important to provide intensive care to patients who may be saved. If the authorities and prehospital care system fail to properly manage the victims' condition for medical relief, it will bring ruin on the hospital care system. Health authorities shall arrange the following measures as the preparedness activities:

- To make the best use of surviving hospital resources by filling their specific role by level.

Table 5.4.4 Role of Hospitals by Level During the Disaster Period

Level	Role to play during the disaster
Level I	1. External Consultation: Triage, screening and providing initial treatment Base for activities of field care teams 2. Hospitalization: Momentary care till transport to Level II or III hospital
Level II	External Consultation: Triage, screening and providing initial treatment Hospitalization: Wounded intermediately
Level III	External Consultation: Not provided in principle but emergency care for patients transported from lower level institutions Hospitalization: Wounded severely and in critical condition

- Hospitalization of the severely wounded will be the responsibility of Level II and III hospitals in principle.
- Therefore, beds of level I hospitals will not be taken into account for the hospitalization capacity in the event of a massive earthquake.
- To fully utilize the capacity of private clinics to increase the hospitalization capacity, especially in Norte and Centro Occidente zone in Bogotá D.C.
- To make an effort to keep the balance of potential hospitalization needs against providing capacities by health system zone in Bogotá and by province in Cundinamarca.

Table 5.4.5 Spatial Planning Units of the Health Disaster Response

	Health Zone		Province
Bogotá D.C.	Norte-Occidente	**Cundinamarca**	Sabana Centro
	Sur-Occidente		Sabana Occidente
	Centro Oriente		Guavio
	Sur		Soacha

- To transfer the patients, who are already in hospitals at the time of the event, to hospitals in other provinces and prefectures, in order to increase the capacity of and allow the admission of casualties in the hospitals, as shown below.

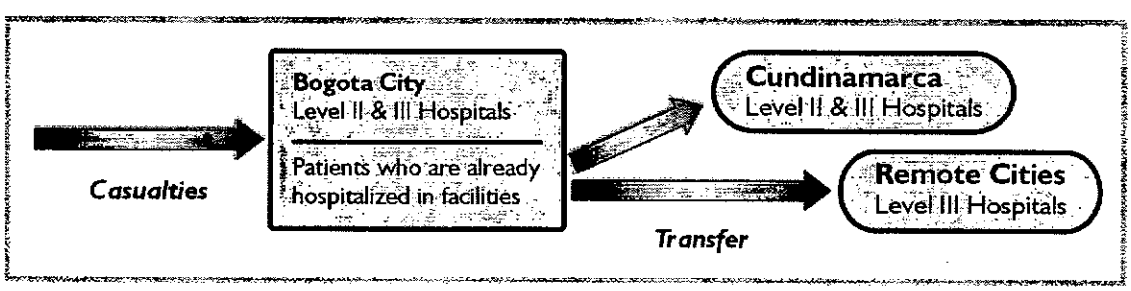


Figure 5.4.4 Conceptual Diagram of Patients' Transfer

- To hospitals in Cundinamarca: Level II and III hospitals and clinics
- To hospitals in remote areas: Cali, Medellín and other major cities

It is necessary for the government to specify the hospitals and to make arrangements with those supporting hospitals on admitting patients in priority.

- To appoint some Disaster Medical Centers to play a central role for disaster relief. Role of the Disaster Medical Center is defined[5-4-1] as follows:
  a) To provide life-saving care to severely injured patients with multi-injuries, crash syndrome and burns all over the body.
  b) To manage the transfer of those injured severely; and
  c) To lend medical equipment to local hospitals.

Table 5.4.6 Required Conditions

*Required conditions for the disaster medical center
1. Seismic-resistant structure
2. Self-sustainable lifelines: water, electricity, fuel, sewerage, for three days at least
3. Tertiary emergency services with 1) inpatient beds, 2) ICU, 3) consultation room, 4) laboratory, 5) X-ray room, 6) operating room and 7) hemodialysis room
4. Enough space to admit twice as many patients and see five times more out-patients than those in ordinary time in case of a massive disaster
5. A terminal installation of wide-area disaster & emergency information system
6. Function to transport patients in and out over a wide-area:
1) having an emergency ambulance to transport patients
2) having a heliport with a medical doctor
7. Function to dispatch medical aid teams which are sustainable by themselves:
1) portable equipment for aid, drugs, triage tags, tent, power generator, water, food and daily necessities
2) stand-by system to dispatch medical aid teams in cooperation with fire fighting rescue teams
**Required conditions for the core disaster medical center
8. Function to lend equipment to health institutions in the area:
1) storage of equipment and supplies
2) simple beds, aid kits, etc.
9. Function to educate and train personnel of health institutions in the area

- To have enough open spaces next to or near Level III hospitals, in case there is a need to expand hospital services temporarily. Open spaces such as parks or unused fields must have enough area to accommodate at least 500 injured persons at a time.

6) Environmental Health and Disease Prevention Activities

Natural disasters, such as landslides, floods and small-scale earthquakes, do not always cause outbreaks of communicable diseases. However, it is likely to increase potential for them to occur considering that more than 40% of total buildings are predicted to be damaged severely in the study. Therefore, sanitary intervention should be started right after the event in parallel with medical relief. Secretary of Health will prepare the following planning and arrangements on disaster environmental health and disease prevention with participation of communities:

- To plan the organizational set-up and its operation plan for disaster environmental health and disease prevention. Since area and population to be covered will surpass the capacity of

[5-4-1] Reference: Japan's newly established system
To appoint one hospital as the disaster medical center* in one secondary health service zone.
To appoint one hospital as the core disaster medical center** in one prefecture. One prefecture consists of several secondary health service zones.

Secretary of Health, it is necessary to strengthen the capacity of *locality*/municipality to assume most of the responsibilities on environmental health.

- To plan the coordination and cooperation mechanism with *Ministerio de Salud* and other local governments to obtain external assistance.
- To prepare a detailed plan which shows responsibilities, procedures and operation methods for environmental health and disease prevention.
- To purchase and improve equipment and instruments for activities.
- To provide institutional training to health personnel on disaster environmental health and disease prevention. Secretary of Health needs to prepare Manuals for training/educational purposes; and
- To continue education and enlightenment activity for community with assistance of the Red Cross. Environmental health activities will not be effective and sustainable without the cooperation of community population.

7) Disaster Reduction in Hospitals

Destruction of hospitals is likely to give a definitely bad effect on the social stability of the area. It is predicted that most of hospital facilities surveyed in the metropolitan area will be damaged severely or will collapse when they are hit by a big earthquake, according to the sector study report on vulnerability analysis. Therefore, it is crucially important to execute the retrofitting plan of the hospitals as originally scheduled.

(1) Strengthen the structures

Retrofitting works of Level III public hospitals with key services will be given priority, followed by Level II hospitals. As to private clinics with level II and III, legislation should be considered to force them to comply with current building codes, or a government system should be created to subsidize the fund for the necessary reinforcing work.

(2) Keep the lifelines

It is also indispensable to increase the utility capacity of electric generators, water reservoir tanks, fuel and medical gases of level III hospitals in top priority.

Amount of fuel and water should be stored to sustain themselves for at least three days.

(3) Carry out disaster simulation exercises

It is strongly recommended that hospitals prepare a 'Disaster Response Manual' and carry out the disaster simulation exercises. In addition, Level III hospitals should store the essential emergency equipment such as stretchers to serve as temporary beds to be lent to level II hospitals.

8) Stockpile of Medical Necessities

Health institutions should have a stock of drugs and other medical necessities enough to keep operating for 72 hours without any replenishment.

(1) General policy

Stock that private wholesale traders have should be counted as well for the emergency purpose. To utilize privately owned stock in time of disasters, it is essential for the government to conclude agreements with concerned parties in advance. In addition to this, it is also important to prepare a list of essential drugs and necessities to avoid duplication of request for external assistance.

(2) Stockpile at health institutions

Hospitals at level II and III are strongly recommended to keep a stockpile for three days at least by adopting the so-called 'running stock method'.

(3) Stockpile at central storages

Medical necessities stocked at Central Storage will be for medical aid teams and level I public hospitals. Judging from the estimated number of injuries of about 260 thousand and more, an extensive amount of drugs and other supplies need to be stored. Health authorities need to estimate the necessary quantity.

In addition, there will not be enough space to store all these necessities in one place. Health authorities also need to decide how to improve the stock system, taking their administrative capacity into account. Potential methods are: a) one huge central storage system, b) dispersing system of four branch storages at each health service zone, and c) another dispersing system of 19 branch storages at each *locality* or municipality.

(4) Stock of blood for transfusion

Capacity of storage at Secretary of Health needs to be upgraded. It is strongly recommended that agreements with donor agencies be prepared to supply blood for transfusion in times of disaster, on the assumption that the supply in the metropolitan area is clearly not enough to meet the expected needs.

9) Education and Enlightenment on Disaster Emergency Care

Education and training for disaster health relief is definitely in short supply. Only education and training can make people build their capability to survive until a rescue team arrives and to make full use of a few resources in the disaster situation. Secretary of Health, with assistance of Ministry of Health, will spearhead the preparation of manuals for disaster health education and training.

(1) Prepare manuals for health disaster management

Secretary of Health will prepare several kinds of manuals and textbooks, with the cooperation of academic and hands-on professionals for disaster preparedness. Some titles of manuals are listed in Table 5.4.7. Result of the damage estimation study should be fully utilized to include more realistic information in the manuals.

Table 5.4.7 Manuals to be Prepared for Educational Purpose

No	Title	Targets
1	Disaster Medical Aid Activities - General	Disaster relief personnel
2	Disaster Medical Aid Activities - Locality	Locality/Municipality
3	Hospital Disaster Simulation Exercises	Hospitals
4	Practical Training Textbook for Triage	Hospitals, Medical aid teams
5	Guideline for Identification of the Dead	Locality, Police
6	Health Management at Refugee Camps/Shelters	Locality/Municipality
7	Disaster Health Environment Activities	Locality/Municipality
8	Disaster Activities of Secretary of Health	Secretary of Health
9	Leaflet "First aid at disaster"	Community population

(2) Execute trainings for health professionals

Manuals and textbooks prepared will be used for disaster education and training to the targeted groups shown in Table 5.4.7. Target groups cover not only health professionals but also administration staff in the sector.

(3) Execute public education to provide citizens with knowledge and technique on first aid

Disaster victims are not likely to expect having organized relief activities nor medical aid activities for several hours, and if things come to worst, for one or two days after the initial impact. Consequently, public education on first-aid technique to community people will play a crucial role in the disaster.

10) Private Sector Involvement

Central and local health authorities shall conclude specific arrangements in advance with all health-related entities listed in Table 5.4.8, public or private, in any regions of the country, to give and take priority assistance in the event of a disaster.

Table 5.4.8 Entities to Conclude Arrangements with the Government

Sector	Name of entity	Arrangements
Media	Newspaper	Public information activities and hour-by-hour status reports of damage at a disaster. Activities of medical aid teams, health institutions and guidance for medical aid, etc.
	Television	
	Radio	
	Newspaper	
Transport	Ambulance	Cooperation of Patient's transportation Health personnel transportation Refugees transportation Supplies transportation
	Taxi	
	Bus	
	Truck	
	Airplane/Helicopter	
Health	Private Clinics	Emergency hospitalization services
	Doctors Association	Formation and dispatch of medical aid teams
	Red Cross	Emergency medical services and ambulances
	Dentists Association	Formation and dispatch of dental aid teams
	Pharmacists Association	Formation and dispatch of teams of pharmacists
	Drug/Consumables Suppliers Association	Priority supply of drugs and necessities in stock
	Equipment Supplier	Priority supply of equipment and parts in stock
	Medical Gas Supplier	Safety check and priority supply to hospitals
Infrastructure	Natural gas	Priority restoration and supply to health facilities
	Propane gas	Priority supply to health facilities
	Water supplier	Priority supply to health facilities
	Electricity	Priority restoration and supply to health facilities
	Sewerage	Priority restoration of health facilities
	Telephone	Priority restoration of health facilities Installation of priority lines to health facilities

Note: General goods for daily life such as food, fuel and linens, which are not specified in the health sector, are excluded from the list.

11) Arrangement with International Agencies on Humanitarian Assistance

Disaster never waits for the government to complete the preparation of physical and organizational set-ups for it. In addition, preparedness for disasters requires a huge fund and a long time to implement. This is a major reason to make the best use of international humanitarian assistance for disaster relief. Preparedness and arrangement are important even in this field to make clear what and how much are in short supply.

The Government of Colombian shall endeavor to fulfill the shortage of human resources and physical supply on its own at first, and then make arrangements with international agencies about the possibility of receiving assistance to supplement the shortages. Specific actions toward this effort are as follows:

- To clarify the health items which need to be supplemented by international humanitarian assistance.
- To have contact with assistance agencies to know what they are capable of providing; and
- To negotiate to make arrangements with suitable agencies about technical and physical assistance.

5.5 Recovery and Rebuilt

The disaster recovery in the Study Area should consider not only in Bogotá City itself but also in Colombia. The Bogotá City is the capital of Colombia as well as Cundinamarca prefecture. The capital functions should recover as soon as possible. Since Bogotá City also has developed economic linkages to the other regions in Colombia, economic damage may influence to the Colombian economy. Therefore, recovery plan should be formulated before a disaster.

The rehabilitation and reconstruction can be divided into the two categories: restoration of normal life and restoration of urban area. The government sector also involves in the restoration activities. The cooperation of the Bogotá City and Cundinamarca governments is the most important.

5.5.1 Restoration of Normal Life

The objectives of the restoration of normal life are to recovery of the life before the disaster situations. Many victims are lost their house, living conditions and jobs. The people who suffer the most in the disaster should be identified and the government should work together to restore the life.

The items for consideration are summarized as follows:

Table 5.5.1 Restoration of Normal Life

Items	Descriptions
Reconstruction of medical System	The priority should be given to the reconstruction of the damaged hospital. The temporary hospital is an alternative for reconstruction.
Sanitation and health	The governments should carry out the monitoring of sanitary conditions. The necessary measures should be taken when the problems have identified.
Education	The damaged school should be reconstruct by the governments. The damaged private school also should reconstruct in cooperation with the public sector.
Information and support	The government should open information and support office for the damaged victims.

5.5.2 Rehabilitation of Infrastructure

1) Infrastructure and Lifeline Company

(1) Financial aspects

All of the public organizations have to protect their possessions, properties and resources (Art.269, Constitution, Art.2, Law 87/1993). The General Board of Audit obliges the public organizations including lifeline service enterprises, whichever private or public, to have necessary disaster and fire insurance to protect their possessions, properties and resources (Art.101, Art.107 of Law

42/1993, Art.6 of Resolution 5145/2000 of the General Board of Audit). It will give sanction with a fine to the organizations without observance.

As the results of the survey, EAAB, TELECOM, ETB, Natural Gas Company, Madrid and Mosquera Aqueduct Enterprises have disaster insurance to cover their infrastructures, and IDU will introduce insurance from the 2002 fiscal year. However, it was found that not all of Colombian public organizations including Lifeline Service Enterprises have disaster insurance.

(2) Technical aspects

Each public service companies should prepare the rehabilitation and reconstruction plan prior to events.

2) Resident Building

(1) Laws and regulations

The Law 675 of 2001 obligates joint owners to have Disaster and Fire Insurance to protect properties of joint ownership like common facilities of apartments (Art.15). In Bogotá total amount of 1,004,254 million pesos were paid for damage insurance in 2000, the 13 % of which 127,999 million pesos were for fire insurance, and 9 % of which 89,465 million pesos were for earthquake insurance (FOSECOLDA). The earthquake insurance is not yet common in this country. The National Fire Fighting Fund receives 1 % of paid fees of fire insurance (Art. 28, Law 322/1996, Art.2, 3 Decree 2211/1997).

(2) Technical aspects

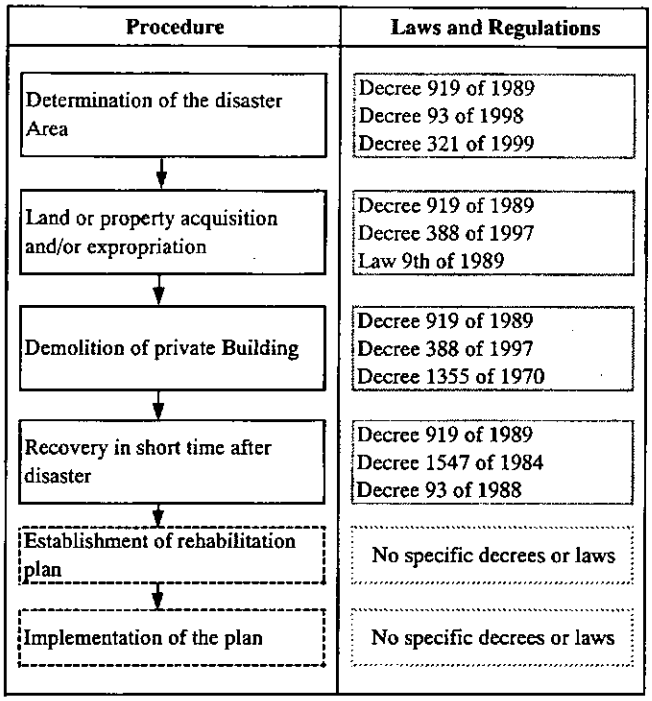
The governments should prepare reconstruction methods and procedures based on the existing laws and regulations.

5.5.3 Urban Area Reconstruction

1) Laws and Regulations

The existing laws and regulations show the procedure of urban rehabilitation and reconstruction process in the most affected area. The rehabilitation and reconstruction in public facilities are responsibility for the each government organization. For the public service organization, Law 142, 1994 regulates the responsibility for the public service companies. The each public service companies should take responsibility for primary responsibility in order to maintain the public facilities. The summary of the laws and regulation is shown in Appendix 5.5.1.

According to the existing laws and regulations, the procedure of the rehabilitation and reconstruction process is shown as follows:



Source: JICA Study Team

Figure 5.5.1 Rehabilitation and Reconstruction Process

2) Organization

The rehabilitation process includes many organizations. The primary organization for the rehabilitation and reconstruction is District Planning Department in Bogotá City and department of Planning in Cundinamarca. Those organizations should act as the coordinator of the rehabilitation.

5.6 Education Plan

5.6.1 Creation and Promotion of Public Awareness

1) Background

In order to build a strong society against disaster, it is very important that citizens take the initiative to make an effort by themselves. The dual concept that "People should protect their own lives by themselves" and that "Inhabitants should protect their own community by themselves" are basis of disaster prevention and mitigation. People are expected to increase active behaviors for disaster management under various circumstances. Additionally, the countermeasures for large-scale disaster can be effective, if there is concurrence between governmental measures and disaster prevention by local society such as community and industries. Based on the results of the analysis of the present conditions as well as workshops and seminars, it can be concluded that public awareness of disaster among the people is generally low. Even though there are some who are aware of disaster risks, they do not know what to do in case of disaster and how to access the appropriate information. Individual citizens should have enough awareness and continue the exercises in normal time to be prepared for the disaster. As one of the emergency support functions, public awareness should be created and increased for various target groups to operate emergency responses. The basis can be created from the daily enlightening and learning activities of disaster prevention. The aim of public awareness programs is to promote an informed, alert and self-reliant community, capable of playing its full part in support of and in cooperation with government, in all relevant disaster management matters.

2) Target Groups

Target groups for awareness creation and promotion for disaster prevention are as follows.

(1) Government staff

This includes government officials at all levels (especially, agencies handling disaster such as OPAD, DPAE, Secretariat of Education, Secretariat of Health, Fire Department, Police Department, Civil Defense, etc.)

(2) Educational staff

School teachers and other staff in public and private schools, universities

(3) Community

- Community leaders
- Community groups, coordinators, NGOs
- Local people including school children
- Private sector (business offices, factories, hotels, shops, etc.)

3) Approaches

(1) Measures

Main measures for increase of awareness of disaster prevention are categorized into the following three: public relations for information sharing, education for increase of awareness and enlightenment, and drill and training for acquisition of skill.

A. Public relations

In order to act based on one's best judgment in case of disaster, people should be enlightened by correct and adequate knowledge of disasters and countermeasures in advance. Depending on the local conditions, suitable ways should be utilized for enlightenment and dissemination of information in cooperation with government. In order to provide the citizens any time with whatever information they want to know, a system of public relations on disaster information should be improved. Public relations activities by private sector handling lifelines should also cooperate. In addition to the public relations, public hearing activities such as public opinion and questionnaire surveys can be considered in order to understand level of awareness and needs related to disaster prevention of the local people.

The format for communicating information to the public can vary. Some possible options are:

- Pamphlets, leaflets, posters
- Videos to be rented as requested
- PR paper, bulletin, notice and other publication issued by government
- Manual, guidebook
- A series of radio and TV broadcasts
- Fair (exhibition, demonstration)
- Symposium and talks utilizing experts with special knowledge
- Cartoon strip method for children including messages
- Designation of "Disaster Prevention Month" and implementation of a one-month campaign in cooperation with locality (award for best self-reliant groups and individuals for disaster prevention, organization of seminar and symposium, spot programs of radio and TV, exhibition of posters, photos, film showing of the topics, etc.)
- Message of disaster prevention printed in telephone directories and shopping bags
- Utilization of popular sporting events, concerts and rallies, etc. to display posters or banners
- Community gathering/meetings of various kinds including church, women and youth, etc.
- Utilization of the existing government-sponsored community schemes (as carriers for disaster-related information)
- Presentation of the disaster experience by the victims

- Establishment of Consulting Sections in the government

The citizens can access to the countermeasures and information related to disasters by each agency with designated works. General items related to disaster can be consulted at DPAE, OPAD, and CLE in each locality.

B. Education

The importance of disaster education to all people has been recognized in many countries. Education for school children and students, local inhabitants and staff in government, and industries/business offices is very important to create/enhance the public awareness and promote activities for disaster prevention. For the disaster with long cycle of occurrence especially, it is necessary to prepare for it over generation. Therefore, education should also play a role of passing down prevention techniques and lessons onto the next generation. It should be implemented in various opportunities such as school education and social education, through:

- School programs, which offer good long-term dividends, especially in developing an informed, alert and self-reliant community
- Publication
- Lectures, seminars, workshops and training courses
- Rallies, discussion meetings
- Manual, guide
- Drill, learning by experiences
- Voluntary activities
- Competition of posters, photos, slogans, essays, etc. by students, children, adults regarding disaster prevention
- Creation of safety map by community

Table 5.6.1 Basic Concept of Disaster Education

	School Education	Social Education
Objectives	To develop awareness of disaster To consider safety and act for disaster prevention in daily life	To get the concept of self-help and mutual-help To develop awareness of self-reliance To take measures in cooperation with local people, society and government
Place for Education	In school Outside school (in and out of community)	Various lectures, workshops and meetings Training session for main leaders and members of self-reliant groups of disaster
Materials	Side readers, teaching aids Textbooks	Distribution of pamphlets, leaflets to all households and self-reliant groups
Comprehensive Drills	Students and staff participate in drills organized by self-reliant groups in the community where they live	All activities necessary from proclamation of warning until rehabilitation supposing a large-scale earthquake, in cooperation with local government
Local Drills	All students and staff participate in the drills in school	Suppose a sudden earthquake, drill appropriate for the living area with initiative of the self-reliant groups

The guidelines and target of disaster education toward school children should be instructed and the implementation should be led using the following approaches:

- Through a whole package of educational activities such as subjects, classroom activities and school events, etc., the basic knowledge of various kinds of disaster and countermeasures in case of disaster should be provided.
- Voluntary learning should be expanded and the actual activities in case of supposed disaster should be implemented.
- Model schools for disaster education should be designated.
- Practical skills for first aid should be provided targeting secondary school students.

Education can be provided in various places and occasions. It is necessary to consider the best way for different target groups and their conditions. Basic knowledge on disaster prevention should be disseminated through various training, seminar, workshop and discussion meeting, etc. toward women groups, parents and teachers association and youth groups. The objective is to make the participants conscious of their role as a responsible member of the society and to increase awareness and capacity contributing to regional disaster prevention. The participants can spread their experience to other members in offices, groups, families, etc. Managers and chief operators in the facilities dealing with dangerous items, and places where many people come in and out such as department stores and theaters, etc. also should be enlightened for preparation and implementation of the emergency plan. Other occasions such as the course of driver licenses acquisition/renewal, the training courses for staff in charge of labor affairs of industries/offices, the general assembly and meetings of women and religious groups, etc., can be utilized to impart the necessary activities, responses and preventive measures for disaster and emergency. It is necessary for government to promote organization and reinforce voluntary groups. Through the

coordination meeting of the groups, knowledge of disaster should be disseminated and enlightened in order to increase awareness of cooperation in case of disaster.

C. Drill and training

Major drills and training can be conducted in form of:

- Evacuation,
- Fire fighting at the early stage,
- First aid, and
- Lifesaving.

The implementation will be done in school, community and region in collaboration with government, voluntary groups, and other emergency-related organizations.

(2) Contents of the information

In line with the above aim, many recognize that community members need to know the following facts in relation to possible disaster impact. Additionally, depending on the characteristics of each group, appropriate contents should be provided. The information to be communicated to the public can be divided into various categories, for example:

A. Information on disaster preparedness

- Basic information and knowledge of disaster (mechanism and disaster occurrence)
- Calculation of risk level of disaster
- Information on the area with high risk of disaster
- Ways of acquisition of disaster information
- Knowledge of preparation of emergency
- Preparation in normal condition such as diagnosis of disaster-proof housing, remodeling, preventive measures of damages, fires and emergency goods
- Knowledge of fire fighting, rescue, relief, first aid, etc.
- Guidance of activities in the house, community and offices for disaster prevention
- Basic information of action guidelines for local people
- The importance of self-reliant groups in region and industries and their cooperation
- Ways of formation of citizens groups for disaster prevention and measures to improve activities in case of disaster
- What the government has planned to assist the community

B. Information on government assistance programs

This might include:

- Community-relevant details of the national disaster management system

- Any necessary information to amplify the foregoing basic community needs. This might include special warning signals, designated shelters of safe havens, evacuation procedures and so on.
- The limitations that are imposed on government assistance by factors such as the need for survey and the time takes, logistical problems in providing relief supplies and the necessity to establish priorities for various relief measures
- Any other information, which is applicable to particular circumstances
- Countermeasures prescribed in regulations/rules

C. Information on emergency responses

- What will the disaster do
- The best immediate action to take, personally, by families and other groups
- How best to help other members of the community
- How to participate effectively in the disaster communication and warning process
- How to improvise shelter and sustenance until assistance is available
- Emergency measures in case of sudden occurrence including action guidelines
- Information on refuge, evacuation route, and other evacuation measures

If considered appropriate, various themes can be utilized in implementing public awareness programs. These, which can be changed and/or given particular emphasis from time to time, might include the following;

- Disasters are not discriminative. Certainly they affect individuals, families and communities. However, they also affect the infrastructure, the economy and the efforts of government in improving regional development and the living standards of the people.
- The community and the government are interdependent in coping with disaster. They must work together to overcome the problems that arise and to restore things to normal.
- The community is better equipped to cope with disaster if it is able to undertake certain basic measures for preparedness, self-reliance and self-help, and if they accurately understand the aims, scope and limitations of government assistance programs.

(3) Points of awareness programs to be considered

Responsibility for public awareness programs needs to be clearly defined. It is probably best in most cases to place responsibility with the authorities that also cover training. In other words, overall responsibility should rest with the Regional and District Education Committee, with day-to-day matters being delegated to Secretariat of Education.

The following main aspects of public awareness programs need to be clearly established.

- The information that needs to be communicated to the public;
- The format in which the information is to be communicated;

- The medium or channel which is to be used to convey the information to the public; and
- The community responsibility for taking action on receipt of this information, where required.

In establishing these main program aspects, it is beneficial to consider to what extent government/community factors, can and should be reflected in the programs themselves. Other factors, which need to be taken into account, are:

- Community experience of disaster, and
- Expectancy and dependency factors, which may have led communities to become over-dependent on government assistance, thus eroding community and individual self-reliance.

In organizing public awareness programs it is usually advisable to seek advice from information specialists (e.g. the government information service). Use can also be made of any systems, which may be applicable to local circumstances. Radio is widely utilized for disseminating government information programs. These radio links can similarly be used for passing training information down to community level.

(4) Monitoring and evaluation of the programs

It is important to check, where possible, the effectiveness of public awareness programs. This particularly applies to the ability of programs to gain and maintain the interest of the people who are being targeted. It is also advisable to check periodically that the public in its intended sense is receiving the information being imparted by programs. The maintenance of adequate awareness levels needs to be continuously monitored. Otherwise, it is likely that programs will become stale and public interest will fade. It is recommended that a definite program, or series of programs, should be established to assist in maintaining the viability of plans. This kind of approach probably provides the most effective basis for maintaining awareness levels. However, it is also suggested that a watch should be maintained for any innovative ideas, which may help to renew or refresh awareness interest. Some of these ideas, whilst basically simple, can be very effective. For instance, manufacturers and distributors of everyday household goods can often be persuaded (in their own as well as the community's interest) to use some promotional gimmick, which will have strong public appeal. Overall, however, watchfulness by the responsible disaster management authority is the best insurance for maintaining public interest.

4) Role of Community in Disaster Prevention and Emergency Responses

(1) Background

Following a major disaster, first responders who provide firefighting and medical services will not be able to meet the demand for these services. Factors such as number of victims, communication failures, and road blockages will prevent people from accessing emergency

services they have come to expect at a moment's notice. People will have to rely on each other for help in order to meet their immediate life saving and life sustaining needs. One also expects that under these kinds of conditions, family members, fellow employees, and neighbors will spontaneously try to help each other. This was the case following many earthquakes where untrained, spontaneous volunteers saved many people.

If we can predict that emergency services will not meet immediate needs following a major disaster, especially if there is no warning as in an earthquake, and people will spontaneously volunteer, what can government do to prepare citizens for this eventuality? First, present citizens the facts about what to expect following a major disaster in terms of immediate services. Second, give the message about their responsibility for mitigation and preparedness. Third, train them in needed life saving skills with emphasis on decision making skills, rescuer safety, and doing the greatest good for the greatest number. Fourth, organize immediate help to victims until firefighting and medical services arrive. There is evidence that public participation can heighten awareness, which in turn can lead to basic mitigation measures being taken at the community level. In order to prevent and mitigate the damages, not only government and disaster-related agencies but also citizens should implement disaster prevention activities voluntarily and work in the spirit of cooperation in the region. These activities can be expected to produce more effective results if the citizens act as a body and systematically.

(2) Approaches

A. Formation of community self-reliant disaster prevention groups and reinforcement of the existing community groups/NGOs involving activities of disaster prevention

The appropriate and prompt actions by citizen groups formed by local people are the nucleus of power of regional disaster prevention. For this purpose, firstly, the existing community groups can be utilized for disaster prevention and responses. Also, among many groups consisting of members with same interest and benefit, such as groups of youth, women, mothers, the elderly, welfare, patrol for security, etc. can be considered. The retired staff of disaster-related organizations such as fire department and police department who are members of the community can be utilized as leaders for the purpose of disaster management. However, they should be flexible and loosely networked from the viewpoint of disaster. Their relationship with each other can be reinforced through the daily activities including disaster prevention and once in case of disaster, there can be mutual cooperation. They share the awareness of protecting the area but each group is independent. If the organization is fixed with a tight structure, the staff and equipment will be useless in normal condition. Further, voluntary NGOs working in the community can be involved for the disaster activities. They should cooperate with private sector (industries, business offices, companies, etc.) to receive financial and technical support. If there is no such group in the community, forming new self-reliant groups for disaster prevention should

be considered. The group activities can be strengthened through formation and distribution of guidebook including manuals for fire fighting, training of leaders, workshops, discussion-meetings, film showing, technical guidance of various drills, etc.

a) The points to be considered in case of formation of the groups

- Basically the existing local community groups are utilized. If these groups are large as a unit of disaster activities, they can be divided into smaller groups (especially, in urban area, self-governing association in apartments and condominiums should participate)
- Considering the population structure in day and night times in the region, the groups should be organized not to disturb the activities even in day and night times and holidays and working days.
- Based on the discussion with businesses in the region, the disaster groups in the business sector should be positioned as self-reliant groups and cooperation with them should be promoted.
- Participation of women is one of the important factors. Some communities have many men folk working outside and only women, children and the elderly are left in the daytime. In this case, the groups can be consisted of women and other inhabitants who stay at home. It is likely that women know the community and families well and can contribute to secure the area.
- Countermeasures considering local conditions should be prepared and provided.
- Partial with strong locality and excessive utilization of experts and experienced should be avoided.

Disaster prevention alone cannot be used as motivation; it is necessary to encourage the people to create a region with comfortable and safe communities that they themselves created through their activities. Disaster prevention should be a part of the daily community activities. The government should not force the formation of the groups. The groups should be created and operated through many discussions among the local people. The groups are not necessarily uniform or standardized but original/unique in each locality based on its characteristics.

b) Activities of the groups

Participants of the groups should prepare their own rules and disaster action plan and implement the activities based on the discussion with local government.

An example of contents of the disaster action plan

- Structure of the group and the assignments of each section
- Dissemination of disaster knowledge
- Disaster drills
- Information collection and conveyance

- Fire prevention and fire fighting at early stage
- Rescue and relief
- Guide of evacuation and refuge life
- Preparation of food and water supply
- Preparation and maintenance of equipment and tools for disaster
- Preparation of safety map and action programs based on the map

Table 5.6.2 Roles of Self-reliant Groups for Disaster Prevention

Normal Condition	- Dissemination and increase of disaster-related knowledge and prevention of fire - Implementation of drills on fire fighting at early stage, evacuation, rescue, first aid - Accumulation and maintenance of equipment for fire fighting, first aid kits, other tools - Understanding of the disaster-weak(infants, disabled, elderly) in the region - Understanding the dangerous area and points in the region - Clarification of role of the groups and formation of information system - Confirmation of evacuation and medical relief facilities places - Communication with disaster-related agencies and neighboring self-reliant groups
Emergency	- Implementation of fire fighting at early stage - Implementation and cooperation of rescue and relief - Collection of information on damages in the region, communication to the inhabitants on evacuation, report and request to the disaster-related agencies - Security of the disaster-weak - Implementation of collective evacuation - Supply of food relief and cooperation with distribution of relief goods

Preparation of community safety file/map

In leadership of the self-reliant groups, regional groups and others concerned should check, diagnose and understand their substances and issues. This information should be maintained and utilized for emergency response and its preparation, etc.

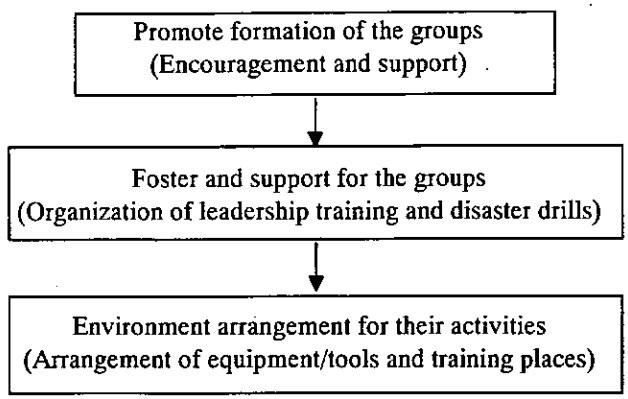
(Items to be covered in the file)

- Groups and activities related to safety and relief
- Human resources, facilities and equipment, etc. related to safety and relief
- The disaster weak and dangerous places, etc.

Based on the above file/map, concrete and detailed measures should be compiled and formed as action program to realize a safe community.

c) Role of the government in formulation and improvement of the groups

Government in each locality should play the roles depicted below.



Local government should try to establish a cooperation system with related agencies and financial support for new groups in order to promote self-reliant disaster groups. Local government should conduct the following activities:

- Establishment of committee on promotion of the group formation
- Preparation of self-reliant group formation plan
- Establishment of model groups
- Preparation and distribution of materials for enlightenment
- Training for core leaders and other leaders of the group
- Organization of various workshops, lectures, round-table conference, etc.
- Individual guidance and advise to each community
- Drills and training for each community
- Award of best self-reliant groups and leaders
- Financial support for equipment and tools

Additionally, the general public should be enlightened on the importance and roles of the groups in order to increase the number of groups and their members. In the formation of the groups, following areas should be focused:

- High-populated area
- Disaster-prone areas with high rate of inhabitants affected
- Concentrated area of fragile houses and dangerous facilities
- Area lacking fire fighting and water control facilities and activities
- Area with disaster experience of large damages

B. Foster leaders for disaster prevention

In order to make the community and self-reliant groups act vividly and function effectively for disaster, leaders are necessary to direct and conduct the people. Leaders will encourage inhabitants in the community and be at the head of prompt and appropriate action in case of disaster. Leaders should be a member of the community and provided with basic information and skill for disaster. Appropriate persons for leaders should be found among the participants to various training, seminar and workshops related to disaster prevention and trained as local leaders.

The local government should organize courses for disaster leaders. The candidates will learn the necessity of regional disaster prevention, basic fire fighting, rescue and relief and lifesaving procedures as well as formation of personal network. Leaders should be liaised with CLE, voluntary groups and other governmental offices, and private sector.

C. Formation of network for mutual help and public help

Figure in Appendix 5.6.1 shows the ideal relationship among the concerned parties for disaster prevention. Soon after the disaster occurrence, such case can be predicted that systematic emergency responses by related agencies are difficult. Also, there are many disaster weak such as the elderly, disabled and infants who need support and assistance. In this condition, cooperation among local people and businesses in the region is strongly needed. In order to promote this kind of cooperation in the big city, the traditional network should be disclosed and inhabitants, neighborhood association, citizen groups, industries, schools, volunteers, NGOs and other various groups should work together. For this purpose, Cundinamarca government prefecture and Bogotá city are appropriate organizations and which can take initiative. They should consider the coordination and cooperation for regional disaster prevention and formulate basic guideline for promotion of the cooperation. In accordance with this basic guideline, each lower level should establish a mutual support system based on the local condition following an agreement, for example.

- In conjunction with the foregoing cooperation of the concerned parties, there are several factors, which affect good understanding and cooperation between governments and communities. These include the following:
- In addition to knowing what government planned to do to assist it in time of disaster, the community should also have at least a broad understanding of the scope and limitations of government responsibility.
- The government and the community must act together to overcome the crisis, which arise from disaster, and to ensure a rapid return to normal conditions.
- The community needs to understand and be able to implement certain measures of self-preparedness when required to do so.
- Similarly, it is important for the community to understand the government's problems in providing post-impact relief, especially the difficulties in accurately establishing immediate needs.
- It is usually in the community's own interests to cooperate, to the maximum extent possible, with the government in disaster management programs.
- For its part, the government needs to understand and take into account the fact that, under disaster conditions, the public is usually affected by shock, loss and other trauma, and needs treating accordingly.

5.6.2 Education Plan

1) Objectives

It is widely accepted that the broad objectives of training are to teach people to carry out specific tasks based upon accepted methodology. Education, on the other hand, is more concerned with the development of mental capacity and thus with people's attitudes. Basic aim of disaster education is to promote disaster prevention literacy. From a disaster management viewpoint, therefore, there is benefit in contributing to public education, as far as possible, in support of training programs. This contribution could also be seen as furthering public awareness. It is suggested, therefore, that national and local authorities concerned with disaster management training, and associated public education, should take advantage of media and other opportunities to apprise the public of current and proposed disaster-related activities. Assistance in educating the public to understand the benefits of long-term mitigation should be regarded as a valid and productive objective for disaster management. In this regard, program of disaster education in schools, in society (community) and for the government staff in charge of disaster management can obviously play an important part. The following plan suggests and guides the appropriate direction and measures for disaster education in Bogotá City Area.

2) Education for Disaster-related Staff

(1) Education for government staff

A. Necessities of government staff in charge of disaster management

In order to secure the smooth and effective implementation of countermeasures for emergency, the governmental staff should be trained and educated. The staff should conduct activities for enlightening measures to be implemented by the citizens. However, there are only a few who can understand the systematic disaster measures well as a whole and deliver them to the local people in plain and appropriate language. Therefore, the government staff themselves should increase grounding for disaster prevention.

There are 2 problems pertaining to government staff for disaster management. One, the number of the government staff in charge of disaster prevention and emergency responses is not enough at all levels. In order to overcome this problem, existing staff should be trained to increase awareness and enable them to become experts. Additionally, the promising experts should be produced through education in university and vocational/technical schools. And two, the existing staff in charge of disaster prevention have insufficient technical skill and fail to recognize their responsibility. They should be trained in order to increase their skill and awareness.

The academic knowledge obtained from the academic research and scientific investigation conducted by consultants, researchers and experts, in universities and institutes, should be

returned to the government and the general public in order to use for mitigation of disaster. Public lectures on this topic in university can be considered.

For governmental staff to carry out their work, they should be trained to promote countermeasures for disaster and emergency and disaster management activities in the region, and to acquire the necessary knowledge and attitudes through various ways. The specific requirements of the staff are:

- Basic information and knowledge on different kinds of disaster
- Information of possible disasters and estimated damages and level of crisis
- Regulations and plans related to disaster
- Activities to be conducted in case of disaster
- Role of staff (System of gathering and assignment)
- Existence of a warning declaration and the following measures and provision of information
- Countermeasures to be taken in each family and community, and formation and enforcement of self-reliant groups for disaster prevention
- Issue and other necessary items in disaster prevention measures

The above-mentioned requirements depend on position and responsibilities. However, they cannot be implemented only by technical knowledge of engineering, sociology, science, etc. in schools and fragmentary experiences in the field. In the existing education system, special courses in universities can cover research and technique, and skill can be acquired in specific colleges and technical schools, etc. However, there is no facility and course that can provide cross-sectoral technique and skills in Bogotá. Therefore, the coordination and cooperation of all disaster-related organizations and facilities is desirable, where interdisciplinary research, technique and skills can be acquired and trained.

In order to achieve these training fields, the following categorized staff should be produced.

Table 5.6.3 Necessary Staff to be Developed

Field for Human Resource Development	Necessary Staff
1. Operation and management of information system on disaster information	GIS engineer Information engineer Risk analyst
2. Engineering of each kind of disaster management	- Engineers in charge of flood, landslide, earthquake, chemical, lifeline, etc.
3. Administration for disaster management - Planning, monitoring and evaluation of the plan and programs	Planner Administrator
4. Education, training and public relations - Formation of community groups, coordination with NGOs and volunteers - Advise for formation and revision of disaster management plan in office and region and training	Specialists for training, education and enlightenment Specialists in charge of community development Public information coordinators
5. Emergency responses	- Red Cross, Civil Defense, Health Department, Police Department, Fire Department, etc.

B. Measures

- Training and education on each specific field
- Seminar, workshop, forum on the topics
- Simulation, drills
- Publications (manual, guide, etc.)

a) Contents of Training and Workshops

Disaster management training

Training for existing or potential managers in order to equip them for disaster-related tasks as specialists, and to orient them on various aspects of crisis management.

Skills training

Training for those persons who may be required to undergo duties in:

- Emergency operations,
- Rescue,
- First aid,
- Emergency feeding and welfare,
- Communications,
- Needs and damages assessment.

In some cases, they may need to be trained as auxiliaries to support existing emergency services (e.g. for auxiliary rescue teams acting in support of the police and fire authorities).

Coordination training

Training for coordinated disaster management action is likely to be required for all key persons in emergency services, and government departments and agencies. As an adjunct to this training,

the services and the organizations themselves need periodic practice in coordinated action, usually in the form of combined exercises.

Workshops and seminars

These will cover:

- Specialized subjects such as prevention and mitigation measures,
- Special briefings of technical and academic studies,
- Annual preparedness reviews.

b) Points for training programs

Responsibility

The implementation of training programs is obviously influenced by the availability of suitable institutional facilities/equipment, materials and staff. On this respect, it is usually worth considering the following factors:

- It is advocated that responsibility for training must be clearly defined within the overall training policy. It is probably best to place this responsibility with the Regional and District Education Committees. The disaster management sections in Cundinamarca and Bogotá governments should be given the responsibility for overseeing day-to-day training matters.
- Members of the committees and sections should receive training at a suitable disaster management establishment. If such training could include institutional techniques, this is advantageous.
- Local disaster-experienced officials and the resources of government sections in charge of training should be utilized to assist in formulating and implementing training programs. Also, there is a good deal of instructional expertise within Police, Civil Defense, academic, Red Cross, religious, welfare and similar resources, and the utilization of this expertise is not only invaluable from a purely training viewpoint, but also from a disaster management coordination aspect. Full use of these local personnel resources can go a good way to offsetting the shortage of suitable trainers. For instance, the graduates of a series of disaster management courses for government officials formed themselves into an association of trainers.

Monitoring and Review

Whilst the four types of training requirements mentioned above are likely to comprise the core activities, other possibilities should not be overlooked. In practice, training requirements tend to fluctuate considerably, the emphasis on some activities fades, whilst the need for other activities increases. Thus training programs need careful monitoring, with adjustment being applied as necessary. It is therefore advisable to review the contents of training programs on a regular basis.

Depending on the size and nature of such programs, this might be done annually or biennially. If a training program is being introduced for the first time, it is useful to run it over a pilot period, after which it should be evaluated as a guide for the future.

The following ways should be initialized for disaster education.

C. Distribution of manual for disaster

This manual will be prepared and distributed by Cundinamarca and Bogotá governments to their staff, so that they can understand what actions are required in disaster response. The points to be included in the manual are as follows:

- Gathering in early stage
- Information collection during the staff gathering
- Rescue and first aid
- Fire fighting in early stage
- Guidance of evacuation
- Establishment and operation of refugee camps/shelters
- Compilation of information on disasters
- Public relations activities
- Other necessary matters

D. Implementation of drills and simulation on the spot, field survey and observation

Toward the local staff in charge of disaster, the drills and simulation on the spot, and supposed emergency activities should be conducted individually and collectively by agencies. Regional and District Operation Committees shall take initiative for this activity, which includes:

- Disaster prevention measures in each related organization and their assigned tasks;
- Mobilization of the staff and confirmation of their roles in case of disaster;
- Communication system among related agencies and information activities;
- Application of related laws and regulations; and
- Damage estimation and evacuation ways (routes and refuge).

E. Training sessions, lectures, workshops, seminars, etc.

Researchers and experts, and staff in the disaster-related agencies will be invited, as lecturers or leaders, and training and lecture sessions shall be organized. The items to be included are:

- Kinds and characteristics of disasters;
- Forecast of disaster and weather conditions;
- Contents of laws and regulations related to disaster;
- Know-how, measures and rules in case of disaster;
- Contents of the disaster plan;
- Past disaster cases and issues on disaster measures;

- Knowledge of living security in case of rehabilitation; and
- Results of academic and technical studies and researches.

F. Courses for specialists of disaster management

Between researchers and the field staff of the government, between the government and the local people, there are still gaps to be overcome. Therefore, it is suggested that the Cundinamarca governments and Bogotá should coordinate to open the courses for governmental staff in charge of disaster in order to enhance the capacity of utilization of academic and scientific researches and studies for practical disaster management, and make them disaster specialists. The aims of the courses are as follows:

- To consider how to interface the researches of disaster with disaster prevention and damage mitigation;
- To review how the existing researches contribute to disaster prevention;
- To be informed how the field side can judge the opinions and comments by scientists;
- To consider how to take countermeasures from the information supplied to local government; and
- To contemplate a system that translates the results of researches into understandable and usable format and feed this information to the general public through publication, workshops and drills, etc.

G. Education for other related agencies

The disaster-related agencies such as Fire Department, Police Department, Health Department, etc. should conduct in-house training for their respective staff in cooperation with Red Cross, Civil Defense and private sector.

(2) Education for educational staff

A. Training of teachers and school staff

It is essential that school teachers and staff should be trained. They are not only those who are in charge of disaster prevention in school but also those who teach subjects that can be related to disaster. Additionally, some schools have possibilities to be used as refuge in the event of a disaster. Since, in this case, the roles of schoolteachers and staff will become very important, they should be prepared for this situation.

a) Appropriate means

- To continue and improve training courses already provided by DPAE
- To provide opportunities for participation to various training courses offered by other agencies such as Civil Defense, Red Cross, Fire Department, etc.
- To distribute pamphlets, leaflets, posters, manual, guide on the topics

- To show videos on the related topics
- To organize workshops, seminars, symposium, lectures, discussion meetings, drills, etc.

b) Contents to be provided

- General knowledge of disasters
- Countermeasures in case of emergency
- Information on the area with high risk and possibilities in the region
- Knowledge of fire fighting, rescue, relief and first aid
- Ways of acquisition of disaster information
- Information on refuge, evacuation route, and other evacuation measures
- Security of students and communication with their families
- Mental care of the students after a disaster

B. Activation and utilization of regional and district education committees, board of education and teachers' union

The Education Committee in coordination with Secretariat of Education should be activated for the following tasks. In addition to this, it is proposed that the Board of Education and teachers' unions and associations should be vitalized for disaster education in cooperation with Education Committees. The tasks they have to carry out are as follows:

- Definition of the concept of disaster education
- Formation of disaster education program
- Action plans by each Committee member in short, medium and long terms
- Recognition and reinforcement of roles and advantages of each member agency
- Increase of awareness among the members
- Centralization and unification of the related information
- Evaluation and utilization of teaching aids, manuals and guides already published and formation of guidelines for educational materials by newly set up evaluation committee
- Preparation of new educational materials based on the guideline
- Preparation of school disaster manual to become a basis of school emergency plan and annual teaching plan for disaster education

School disaster manual can have the following structure:

- Activities to be prepared for disaster
- Responses in case of disaster
- Reopening of educational activities after disaster
- Responses as refuge in case of disaster

In order to implement these, the members also should participate in training, workshop, seminars and other available ways.

3) School Education

(1) Concept of school education for disaster prevention

The ability of the children should be harnessed and increased through education, which will enable them to understand the mechanism of natural disaster, natural environment and disaster experiences in the region and the system of disaster prevention and emergency responses. It will also help them recognize well the crisis in case of emergency, prepare for the disaster daily and act spontaneously for their own security following their appropriate judgment.

The aims of the education for disaster in general are:

- To recognize possibilities of disaster, to make daily preparedness, and to act timely and in an effective manner for their own security based on their appropriate judgment in accordance with the conditions,
- To help actively in securing the other people, groups and region during and after the disaster, and
- To understand not only the mechanism of natural disaster occurrence but also the basic and necessary information of regional natural environment, disaster and its prevention.

In order to achieve the above 3 aims, education for disaster should be implemented through a whole package of educational activities in school systematically with a definite plan, in conformity with the conditions of each school and local society in the region, development level and experience of the students, clearing the contents with priority in the curriculum.

(2) Curriculum

Disaster education curriculum in schools should be established. The Education Committee should determine the program and contents. Nine (9) subjects in the National Education System in Prevention of Emergency and Disaster should be utilized with some teaching aids. Additionally, it is proposed that model schools should be assigned in order to experiment with the proposed curriculum as a pilot project.

(3) Extracurricular activities

In order to supplement the curriculum, activities outside the curriculum are necessary. Example activities to be considered are as follows:

- Visit and experience work and activities in fire stations, Red Cross, Civil Defense, etc.
- Voluntary activities in the region where the school and students' houses locate
- Drills of evacuation, fire fighting, rescue and first aid
- Presentation of the learning and study results to the community in the region
- Participation to activities in Disaster Prevention Day
- Formation of school brigade of disaster prevention and its action plan

The school children from 7 to 12 years old have been targeted by DPAE through summer vacation activities. This program should be continued and expanded to the children over 12 years old. A potential group that has not been accessed and operated yet for disaster education is parents and teachers associations. Considering that most of the schools, whether they are public or private, have this kind of organization, some coordinated activities should be promoted including workshops and joint drills of students, their parents and teachers.

(4) Preparation of annual teaching plan in school

Each school will promote disaster education, preparing a teaching plan to clarify the disaster education in the annual teaching schedule. The plan can contain the following items but the characteristics of each school should be considered:

- Time schedule
- Target classes and achievement
- Subjects to be utilized and approaches
- Kind and method of teaching aids used and other education materials

(5) Preparation of school disaster management plan by school

Defining the responsibilities and available services which can be expected during times of emergency will help protect the lives of students and staff and permit prompt measures to safeguard property and maintain educational activities. The disaster management plan incorporates the above goals by:

- Prescribing authority, responsibility, functions, and operations of the school disaster management committee,
- Coordinating emergency operations with those of other agencies,
- Developing mutual aid and other support agreements with appropriate local agencies,
- Developing procedures to ensure a reasonable state of disaster preparedness, and
- Developing disaster-proof structure for school facilities and equipment.
- There is need for continued review and upgrading of the plan to reflect changes in the school environment. The school principal should develop the school disaster management plan including preparedness and emergency responses. Also, a committee on disaster management should be established in school, a sample structure of which is shown in Table 5.6.4 below. Committee members will have specific roles in response and recovery activities.

Table 5.6.4 Structure of Disaster Management in School

Condition	Organization (Chief)	Major Role	Member
Normal	Committee on Disaster Management (Principal)	- Discussion and planning of disaster prevention system - Annual plan of disaster prevention - Survey and guidance for security - Communication and coordination with external agencies, Parents Association and local self-reliant group of disaster prevention - Education plan for disaster prevention - Coordination and discussion for operation of refuge - Assignment of educational staff to gather in case of emergency - Emergency plan for educational staff to gather in case of emergency	- Vice-principal - Head of school affairs - Head of disaster prevention - Teacher in charge of curriculum - Teachers consultant - Teacher in charge of health - Head of each grade - Dietician, etc.
Emergency	Task Force on Emergency Responses (Principal)	- Establishment of task force on emergency responses and command and unification - Information analysis and response decisions - Plan of 24-hour mobilization of operative educational staff - Confirmation of roles of all educational staff - Supplement of absent staff - Organization of voluntary students - Security check of facilities and equipment for prevention of the secondary disaster - Measure of operation of refuge - Measures for reopening of classes	

(6) Courses of disaster management in university

In order to create specialists of disaster management who will work in government and private sectors, special courses related to disaster management should be established in universities. The program should be prepared by Education Committee and applied to some model universities as a pilot project. Courses should be multidisciplinary and practical, which aims at increasing awareness of disaster prevention and technical knowledge and skills including on-the-job training in the disaster related organizations. Therefore, not only young students but also governmental staff and private employees in active service can attend the courses.

4) Social Education

(1) Concept of social education for disaster prevention

Leadership at community or local level is a very significant factor in disaster management. Since the general public is composed of various kinds of people, it is difficult to carry out education and enlightenment for awareness of disaster if the public is considered as being all of equal level. Where the frequency of disaster is low and the practical opportunities for disaster activities are

few, people's awareness is low and the role of education and training is very important. The present training, drill and courses for volunteer leaders are likely to focus on activities soon after the disaster, however the most important stage in need of citizen power is the promotion of measures preventing and mitigating the future disaster. In order to utilize the citizen's power, more training and education should be arranged for the whole stages from prevention to the recovery. Based on the concept "protect you own life", the disaster-related organizations should disseminate thoroughly the idea of self-reliance in case of disaster, such as promotion and encouragement of actively dealing with disaster in the region, home and work places, etc. even in normal condition. The general public, i.e., those in the offices, industries and homes, should be provided with knowledge of disaster prevention in cooperation with related agencies and groups at any time appropriate opportunities present themselves.

The aims of social education are:

- To disseminate knowledge of disaster,
- To increase awareness of disaster,
- To increase ideas and skill of disaster management, and
- To establish a local disaster prevention system.

If the administrative leadership/guidance is too strong, however, the communities will decrease their voluntary activities and increase dependency on the government. The effective approaches to encourage community interest and participation should be considered carefully. Additionally, the delicate leadership and instruction by the government should be required in order to continue inhabitants' daily activities for disaster prevention especially in time of rare disasters.

(2) Contents of the disaster knowledge to be conveyed

The disaster knowledge should cover prevention, emergency measures and rehabilitation. For example:

- Disaster countermeasures in the area
- Knowledge of disaster and past disasters
- Daily exercise of prudence and preparedness for disaster
- Disaster risks and possibilities in the area
- Check of houses and furniture, etc
- Communication system among family members
- Prevention of fire
- First aid
- Evacuation ways (routes and refuge)
- Stock of food, water, and goods for 3 days after disaster
- Confirmation of goods to be taken out in case of emergency (valuables, portable radio, flashlight, clothes, first aid kits, foods, etc.)

- Formation of self-reliant groups
- Consideration of the disaster-weak
- Participation in voluntary activities
- Knowledge in case of emergency
- Action to be taken in disaster
- Prevention of fire and fire fighting at the early stage
- Understanding of damage conditions around the houses and the region
- Rescue activities
- Information collection by television and radio
- Necessary measures in evacuation
- Behaviors in refugee camps/shelters
- Activities by self-reliant groups
- Attitudes during driving and traveling

(3) Approaches

A. Processes to be educated

There can be three categories of the participation level of the local people to the activities for disaster prevention. They are as follows:

a) Step 1: Recognition Level

For the general public, the target should be set and guided in a way that they can always check their own town from the safety aspect and evaluate through education and enlightenment.

b) Step 2: Daily activities level

There is disaster prevention in family, acquisition of technique of disaster prevention, and participation to the creation of a safe community. However, in order to maintain and increase the participation rate to the training and drills, the daily life and disaster prevention should be connected closely and effectively.

c) Step 3: Activities in case of emergency

The appropriate information collection system should be established. The citizens should be trained as information and assistance supply sources. The citizens should be organized as self-reliant groups for disaster prevention. In future, voluntary activities should be systematized in order to be ready to gather for necessary activities.

B. Target groups

Target groups for social education can be local inhabitants in the region. Sometimes governmental staff, employers and employees in private sector, educational staff, and journalists

can be included as members of society. The community organization is the tail end of information resource channel from government to the inhabitants and can be used as self-reliant group for disaster prevention. The level of relationship and local activities among the inhabitants and leadership can produce a different level of emergency responses. Therefore at the beginning of the formation of the groups, the best way is the utilization of the existing community groups with strong leadership. There might be possibilities in groups of women, mothers, self-patrol, etc. JAC and JAL can be also considered with support of CLE at locality level. Local active leaders such as local government staff, grass-roots voluntary groups with close relationship with the region, and local private industries should be involved.

C. Means for education

In order to disseminate appropriate information and knowledge related to disaster, the most effective and practical media should be utilized. They include the following:

- Newspaper, television, radio, etc.
- Public relations paper, pamphlet (poster, leaflet, handbill, etc.) and other publications
- Movie, slide, video
- Standing sign board, banner
- Lecture session, training, workshop, seminar, symposium, forum, etc.
- Competition of slogans, paintings, compositions, posters, etc. among school children, students and the general public
- Utilization of Day of Disaster Prevention and Attention (campaign and drills)
- Formation of community safety map
- Formation of self-reliant groups of disaster prevention by community

The community safety map showing danger and risks and facilities and resources necessary in case of disaster in the region might be prepared and presented or distributed to each household in order to make easier formation of an accurate disaster plan. Also, it can make the individual activities of disaster prevention quick and appropriate.

In order to motivate and mobilize the people for constructing a self-reliant, safe community, a competition could be launched to award the best in the three categories given below. The organizers might be members of the Education Committee with support from the Cundinamarca and Bogotá government.

- Objects: Facilities in the community taking into consideration the viewpoint of disaster management, such as road, park, building, trees, etc.
- Activities: Increase of disaster awareness, enlightenment, such as formation of safety map, self-reliant organization of disaster prevention in the region

- Persons: Leaders who take initiative of disaster drills, practical educational training, workshops, courses, seminars to increase people's awareness and capacity for disaster prevention

The self-reliant groups for disaster prevention should be formed using existing community groups with the following expected activities. The leaders and members should be trained to implement their activities effectively.

Table 5.6.5 Expected Activities for Self-reliant Groups of Disaster Prevention

Normal Condition	Enforcement of organization Dissemination of information and knowledge regarding disaster Formation of activity manual Equipment of necessary tools
Emergency Case	Collection and distribution of information Prevention of fire and fire fighting at early stage Rescue and relief of the injured Guidance of evacuation of the inhabitants Provision of food and water

Table 5.6.6 Training of Self-reliant Groups

Name of Training	Implementation Agency	Target	Objectives
Leaders Training	Governments of Cundinamarca and Bogotá	Core leaders of the groups	- To increase knowledge and skills of disaster prevention - To activate the groups - To exchange information of activities - To foster regional leaders with broad views
Members Training	Governments of Cundinamarca and Bogotá	Main members of the groups	- To acquire knowledge and skills of disaster prevention - To enlighten and enforce awareness and measures among groups and local people

(4) Formulation of disaster prevention plan by community

In order for inhabitants to protect their own community, the community disaster prevention plan should be prepared. The preparation work should be conducted led by self-reliant groups and/or community groups. Points to be considered are as follows:

- Plan should be utilized for practical work for disaster countermeasures and preparation itself is not the purpose.
- The geographical condition of the region, and estimated damages should be taken into consideration. In this case, experts in civil engineering and architecture should be consulted.
- The characteristics of the community (advantages, disadvantages, uniqueness, constraints, etc.) should be understood and the system to cover and supplement these points should be established. In addition, at all stages from the disaster occurrence to relief activities in the refuge (fire fighting, life-saving, relief, rescue), role of players should be defined.

- Especially, it should be recognized that communities implement activities during the time soon after the occurrence until the arrival of fire fighting and medical services.
- The information on disaster should be delivered to the inhabitants appropriately and promptly.

The structure and items to be included into the community disaster prevention plan can be as follows:

- Introduction
- Outline and Characteristics of the Region
  a) Natural Conditions
  b) Social Conditions
- Disaster Prevention Plan (for Earthquake)
  a) Earthquake force
  b) Estimated Damage
  c) Groundings and Directions for Disaster Prevention
  d) System of Disaster Prevention in Normal Condition
  e) System of Disaster Responses in Case of Emergency
  f) Security in Case of Emergency
- Disaster Prevention Plan (for Flood, if necessary)
- Disaster Prevention Plan (for Industrial Disaster, if necessary)
- Disaster Prevention Plan (for Landslide, if necessary)
- Storage Plan
- Issue for Future
- Conclusion

5.7 Disaster Management Information System

5.7.1 General

"Disaster Management Information System (DMIS)" is the system to support the functions of DMA (Disaster Management Agency), and the one of the most effective tool in decreasing the damage of disasters by giving the necessary information in time.

DMIS will be composed five independent systems with the functions mentioned as follows:

1) **Information Collection and Transmission System (CTS)**

Collecting hydrological and meteorological information and transmitting to DMA

Collecting and transmitting disaster (damage) information to DMA

2) **Database System (DB)**

Storing information related to disasters as a database using GIS

3) **Information Processing System (PS)**

Processing information for decision-support in case of disaster, research and study, formulation of disaster mitigation plan, etc.

4) **Decision-support System (DSS)**

Supporting decision by automated alert using pre-set criteria

5) **Information Distribution System (IDS)**

Distributing the monitored and processed information, announcement, etc. to public and/or related agencies.

To set up DMIS, the followings have been taken into account:

- Kinds of disaster
- Emergency situation
- Information to be handled
- System to be constructed
- Organization

5.7.2 Disasters to be Correspond

The system should correspond to any kinds of disasters; however, the system proposed in this study will correspond to the following disasters, because the present study not includes other disasters.

- Earthquake
- Landslide/slope failure

- Flood
- Industrial disasters

The characteristics of each disaster from the viewpoint of construction of DMIS will be described in the following sub-sections.

1) Earthquake

The damage of earthquake will be widely spread and various types of damage will happen. Moreover, other disasters (e.g. landslide, slope failure, industrial disasters) will also have a possibility of happening caused by the earthquake. On the other hand, since it is difficult to predict the occurrence of an earthquake, the system will be mainly used after the disaster happened.

Therefore, the system for the earthquake should have a capability of handling the various kinds and the large amounts of information in the short period, and should resist against the large earthquake.

2) Landslide/slope Failure

Although the hazardous areas of landslide/slope failure spread widely in the Study Area, the landslide/slope failure will not occur in the same time except the event of heavy rainfall or earthquake. Thus, the extent of damage will usually be limited. In addition, it is possible to predict the occurrence of these kinds of disasters, especially landslide, with appropriate monitoring system.

3) Flood

The flood is mainly caused by heavy rainfall and it is possible to predict an event and to prepare a response plan before occurrence of the event using weather forecast and hydrological and hydraulic simulation system.

Since hazardous areas of flood are extended widely in the low-laying areas along the river, to mitigate the damage of flooding, the sub-system, especially CTS and IDS, should cover the whole possible inundation area.

4) Industrial Disasters

There are two causes of happening the industrial disasters. One is a failure of operation and the other is a natural disaster such as earthquake, landslide and flooding. Among these natural disasters, an earthquake is the most critical one because it is impossible to prevent the hitting of earthquake.

On the other hand the materials handling and/or storing, location, weather, etc will vary the extension of hazardous area, and the kinds of damage will also be varied. However, the extent of

hazardous area and damage can be assumed because the locations of factory/storage and kinds of materials to be handled and stored have been identified.

Because of the difficulty of prediction of the happening, the system should be constructed with the consideration of the situation after the event happening.

5.7.3 Emergency Situation

As for the disaster management, following three situations should be considered.

- Normal
- Pre-emergency
- Emergency

Since, DMIS should be corresponded to each situation appropriately, the system has three (N: Normal, P: Pre-emergency, E: Emergency) information flows (see Figure 5.7.1).

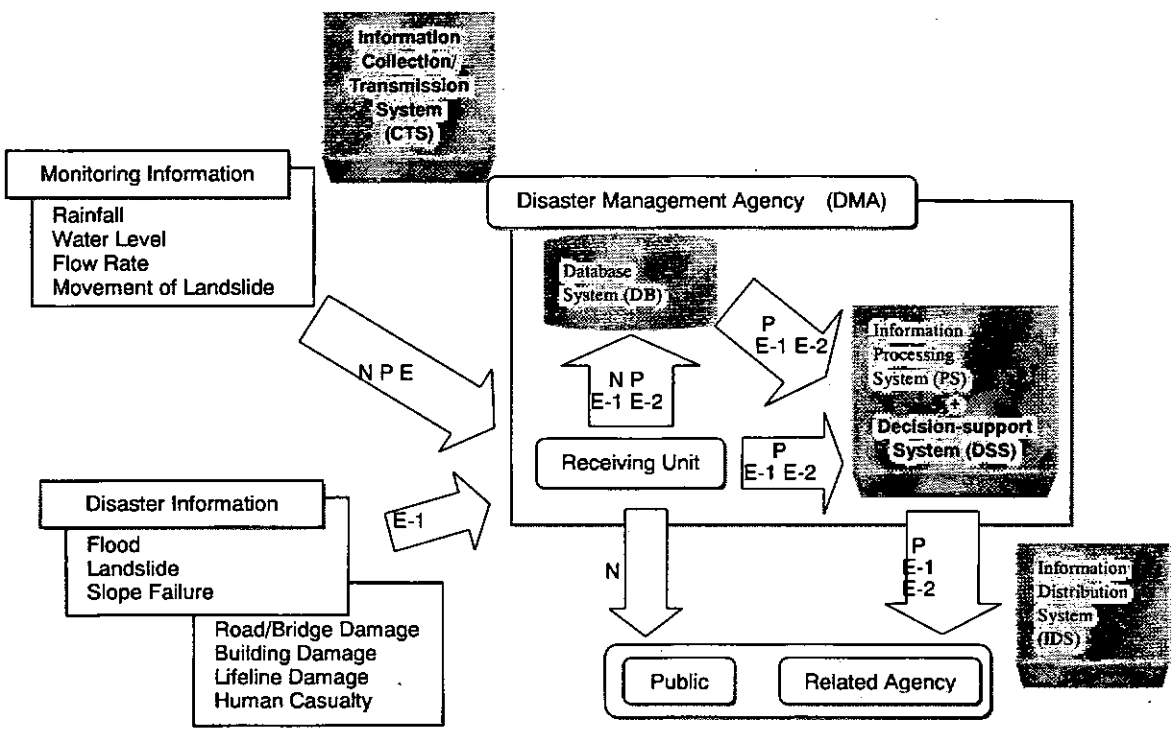


Figure 5.7.1 Flow of Information

1) Normal Situation

In the Normal Situation, the main functions of DMIS are collecting/monitoring the information related to the disasters (e.g. seismic wave, hydrological data, movement of landslide, etc.) and storing of collected information to the database.

Collected information by CTS is stored to DB (arrow with "NPE" in Figure 5.7.1). PS also processes the collected information as soon as the information reached to DMA. DMIS will

inform the officials if the monitored or processed figure extends the pre-set standards (e.g. rainfall amount, amount of movement of landslide, etc.).

2) Pre-emergency Situation

This situation is the situation that happening of disaster is predicted in near future (e.g. expecting a flood, a new movement of landslide due to the heavy rainfall, etc.). DMA should prepare appropriate corresponding plan to the disaster, and publish the warning about disasters. Therefore, the system should provide the useful information to the officials for prompt action.

In this situation, the collected information should be monitored by the officials in the real time and stored to DB as well. The information is processed by PS and is provided to the officials through DSS. Official announcements and monitored/processed information are distributed through IDS (arrow with "P" in Figure 5.7.1).

3) Emergency Situation

"Emergency" is a situation, which the disaster happens. To act promptly and properly against the disaster, it is important to unify the information and to share the same and correct one among the agencies related to emergency response.

The emergency situation can be classified into two phases of just after the event happening (Phase E-1) and the situation after a while (E-2).

In the phase E-1, the main activities of DMA are collection of information and confirmation of damage distribution. It is, therefore, CTS, and PS (arrow with "E-1" in Figure 5.7.1) will be assigned as a main function of DMIS. Using the information collected, the information stored in DB, PS and DSS, the officials prepare the information for emergency response.

In the situation of "E-2", the main activities of DMA are analyzing the information, deciding a measures which correspond to the disaster and announcement of directions to local office(s)/damaged site(s)/public through IDS (arrow "E-2" in Figure 5.7.1).

IDS includes a direct inform distribution system to public, therefore, IDS to public should have continuous distribution system using various interfaces such as mass media (e.g. TV, Radio), Internet, wireless communication, etc.

Figure 5.7.2 shows characteristics of information flow from the local office(s)/disaster site(s) to DMA and DMA to local office(s)/disaster site(s).

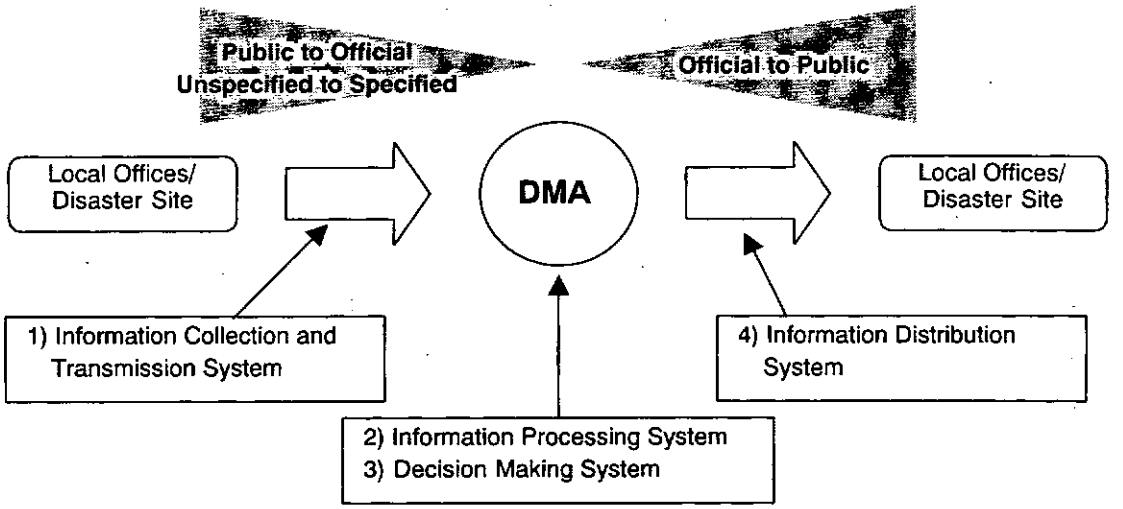


Figure 5.7.2 Characteristics of Information Flow

As shown in the figure, in the emergency situation, public (various kinds of source and way) will transmit the information to DMA. Therefore, the system should have a capability to handle large amount and various kinds of information with same format.

5.7.4 Information to be Handled

The system should handle many kinds of information, e.g. seismic wave, hydrological data, disaster information by telephone, radio (voice), digital photo/movie at site through Internet, etc. The information to be handled will change the kinds of disasters and disaster situation. The interval of acquisition and transmission of information are also changed by the type of disaster and situation. It is therefore necessary to select the suitable data transmission method by the types of information and disasters.

Table 5.7.1 shows the information to be handled on DMIS, and the interval and method suit for collection and transmission of information.

Table 5.7.1 Information to be Handled

Collection and Transmission System				
Kinds of Disaster	*Information*	*Transmission Method*	*Situation*	*Frequency*
Earthquake	Seismic wave	Telemeter (radio)	Normal	Continuous Event monitoring
Landslide	Movement of landslide mass	Telemeter	Normal	10 min. Event monitoring
			Pre-emergency	???
	Rainfall	Telemeter	Normal	10 min. Event monitoring
			Pre-emergency	10 min.
	Groundwater level	Telemeter	Normal	2 times/day
			Pre-emergency	???
Flood	Rainfall	Telemeter	Normal	10 min. Event monitoring
			Pre-emergency	1 min.
			Emergency	1 min.
	Water level	Telemeter	Normal	2 times/day
			Pre-emergency	30 min.
			Emergency	10 min.
Industrial Disaster	Accident Information	Telephone Radio	Emergency	
Common	Damage on Human	Telephone Fax Radio Internet	Emergency	
	Damage on Building			
	Damage on Infrastructure			
	Damage on Lifeline			
Distribution System				
Information	*Target Person*	*Transmission Method*	*Situation*	*Frequency*
Warning	Public	Radio Internet	Pre-emergency Emergency	
Direction	Official	Telephone Internet	Pre-emergency Emergency	
Actual Situation	Public/Official	Mass Media Board Internet	Emergency	Continuous

5.7.5 Systems to be Constructed

As described in 5.7.1, the systems to be constructed are as follows:

- Information Collection and Transmission System (CTS)
- Database System (DB)
- Information Processing (PS) / Decision-support System (DSS)
- Information Distribution System (IDS)

The sub-systems will be set up according to the purpose and disaster situation. The summary of sub-systems is shown in Table 5.7.2

Table 5.7.2 Summary of Sub-systems

Name of system	Name of Sub-system	Handling Information	Method	Situation to be Considered
Information Collection System	Monitoring System	Seismic wave Movement of Landslide Groundwater Level Rainfall Water Level Etc.	Telemeter	Normal Pre-emergency Emergency
	Damage Information System	Human Building Infrastructure Lifeline	Telephone Fax Radio Internet	Emergency
Database System	Risk Database	Risk Map on Earthquake Landslide Flooding Industrial Disaster	GIS/Relational Database	
	Damage Database	Damages on Human Building Infrastructure Lifeline	Relational Database	
	Resource Database	Resources on Firefighting Doctor/Hospital Facilities Location Etc.	GIS/Relational Database	
Information Processing System	Earthquake	Seismic Wave Earthquake Risk Database Damage Database Damage Formula		Normal Pre-emergency Emergency
	Landslide	Movement of Landslide Rainfall Groundwater Level Landslide Risk Database Damage Database		
	Flood	Rainfall Water Level Flood run-off Simulation Program Flood Risk Database Damage Database		
	Industrial Disaster	Weather Information Industrial Disaster Risk Database Damage Database		
Decision-Making System	Sub-system for Earthquake Landslide Flood Industrial Disaster			Pre-emergency Emergency
Information Distribution System	Center to sub-center	Warning Direction Etc.	Telephone Fax Radio Internet	Normal Pre-emergency Emergency
	Center to related agency	Information		
	Center to public	Warning Etc.		
	Sub-center to public			

These sub-systems are independently constructed but the sub-systems are related and should be functioned as an integrated system.

5.7.6 Proposed Disaster Management Information System

1) Basic Concept

The proposed DMIS will be constructed with the basic concepts as follows:

The system should:

- be a disaster proof,
- be a system ensuring the collection and unifying the information,
- be able to transfer the information rapidly without any error,
- provide useful information to decision maker(s) as quick as possible, and
- be a system which can be utilize the experience of administration on past disasters.

2) Proposed DMIS

It is proposed that Main system of DMIS will be installed in the office of Bogotá City and managed by DMA. To share and exchange the latest information, the main system should be accessed from other related agencies by satellite system of DMIS through Internet.

The image of proposed DMIS is shown in Figures 5.7.3.

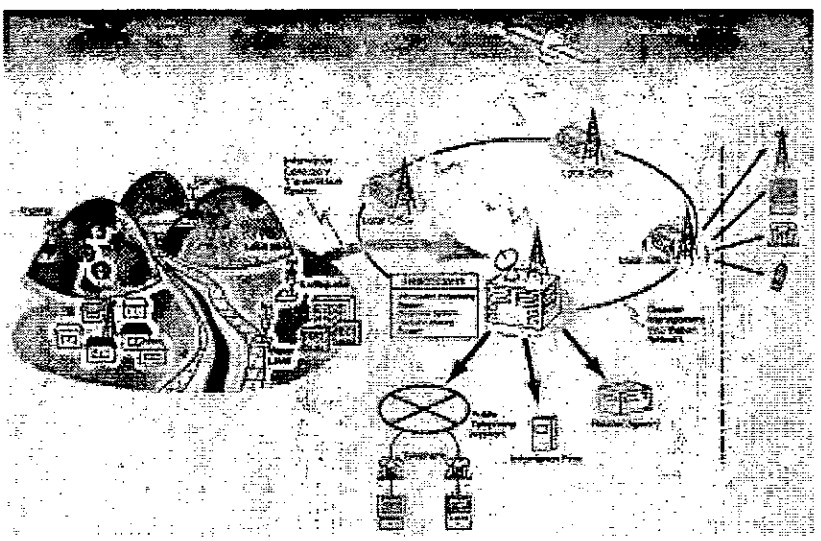


Figure 5.7.3 Image of DMIS

3) Necessary Activities

Necessary Activities to set up DMIS is as follows:

- To establish the main and sub systems of DMIS
  Including setting up simulation model, threshold, database, etc.
- To install the necessary monitoring station
- To install DMIS to related entities
- To link related entities by optical fiber network

5.8 Implementation Schedule

5.8.1 Implementation Period

The projects are planned to be implemented by 2010 considering the target year of the existing Territorial Ordering Plan (POT) and the period is planned to be divided into three terms due to the Mayor's term of the city of Bogotá as follows:

1. Short term: 2002 - 2004
2. Mid-term: 2005 - 2007
3. Long-term: 2008 - 2010

5.8.2 Implementation Schedule of Projects

Major tasks and projects of each term are planned and summarized as follows:

1) Short-term (2002 - 2004)

(1) Arrangement of government entities

- To arrange the government entities related to the Bogotá City Area, i.e. the government of Bogotá City, the Cundinamarca Government and the National government, dully to their responsibilities, and prepare their action programs for disaster prevention and emergency responses based on the Basic Plan,
- To prepare 1st Action program for the Bogotá City Area.

(2) Strengthening the urban area by improvement or strengthening strategic buildings and facilities

- To strengthen the urban areas of the Bogotá City Area by conducting seismic diagnosis studies on the strategic buildings, infrastructure and lifeline structures identifies in the Study. The strategic buildings are including emergency response centers, government buildings, hospitals, police buildings, fire-fighting stations, Civil defense buildings, Red cross buildings, school buildings. The infrastructure is consisting of bridge facilities along the major roads and the lifeline facilities include water supply, gas, electricity and Tele-communication facilities.
- To conduct the improvement or rehabilitation works of the 1st priority facilities,
- To promote strengthening or improvement of private buildings.
- To conduct preliminary design on strategic facilities like water supply tanks and open spaces required for emergency responses.
- To conduct study on infrastructure of the vulnerable areas.

(3) Enhancement of public education

- Enhancement of public awareness for seismic disaster
- Promotion of cooperation system of support inter-region.

(4) Arrangement of emergency response system

- To establish executing agencies of each emergency response functions and prepare an emergency action plan.
- To improve disaster management information system before and in a disaster.
- To study on recovery and rebuild after a disaster.
- To arrange and strengthen cooperation system.
- To prepare monitoring systems for landslide hazard areas.
- To prepare flood warning system.

(5) Implementation of landslide protection works

- Preparation of landslide protection works of 1st priority,
- Implementation of landslide protection works of 1st priority.
- Preparation of monitoring systems.

(6) Implementation of flood control works

- Preparation of river improvement works for the Rio Bogotá.
- Implementation of river improvement works for the Rio Bogotá.
- Preparation of warning systems.

(7) Conduct development studies

- To conduct a development study on the selected pilot area, conducting and preparation preliminary studies and design of major facilities, in order to promote smooth implementation of the Basic Plan.
- To prepare for other basic studies.

2) Mid-term (2005 - 2007)

(1) Arrangement of government entities

- To improve and update the executing entities.
- To review the previous plan and prepare the 2nd action program.

(2) Strengthening the urban area by improvement or strengthening strategic buildings and facilities

- To improve or strengthen strategic buildings and infrastructures of 2nd priority.
- To promote strengthening or improvement of private buildings.
- To construct strategic facilities like water supply tanks and open spaces required of 1st priority for emergency responses.
- To implement infrastructure of the vulnerable areas of 1st priority.

(3) Enhancement of public education

- To update and enhance public awareness for seismic disaster
- To strengthen the cooperation system of support inter-region

(4) Arrangement of emergency response system

- To strengthen the executing agencies of each emergency response functions and update emergency actions plan.
- To strengthen the disaster management information system before and in a disaster.
- To review and update the recovery and rebuild plan.
- To strengthen and update the cooperation system.
- To install monitoring equipment for landslide hazard areas,
- To establishment a flood warning system.

(5) Implementation of landslide protection works

- To prepare for landslide protection works of 1st priority area.
- To implement landslide works of 1st priority area.

(6) Implementation of flood control works

- To implement of river improvement works for the Rio Bogotá.
- To prepare river improvement works for tributaries.

(7) Conduct development studies

- To conduct the detailed design of the projects proposed in the pilot study.
- To prepare for other basic studies.

3) Long term (2008 - 2010)

(1) Arrangement of government entities

- To improve and update the executing entities.
- To review the previous plan and prepare the 3rd action program.

(2) Strengthening the urban area by improvement or strengthening strategic buildings and facilities

- To improve or strengthen strategic buildings and infrastructures of 3rd priority.
- To promote strengthening or improvement of private buildings.
- To construct strategic facilities like water supply tanks and open spaces required of 2nd priority for emergency responses.
- To implement infrastructure of the vulnerable areas of 2nd priority.

(3) Enhancement of public education

- To update and enhance public awareness for disasters.
- To update and strengthen the cooperation system of support inter-region.

(4) Arrangement of emergency response system

- To strengthen and update the executing agencies of each emergency response functions and update the emergency actions plan.

- To strengthen and update the disaster management information system before and in a disaster.
- To review and update the previous recovery and rebuild plan.
- To strengthen and update the cooperation system.

(5) Implementation of landslide protection works

- Implementation of landslide protection works for 2nd priority.

(6) Implementation of flood control works

- Implementation of river improvement works for the Rio Bogotá.
- Implementation of improvement of flood control structures for the Rio Tunjuero.

(7) Conduct development studies

- To implement the projects proposed in the pilot study.
- To prepare for other basic studies.

5.8.3 Implementation Agencies

The implementation agencies for the projects are different depending on the facilities. The responsible agencies are divided into the government sectors; Bogotá City, Cundinamarca Prefecture and national, privatized or private lifeline sectors; EAAB, CODENSA, EMGESA, ETB, CAPITEL, and private individuals.

In order to implement the Basic Plan it is indispensable for the Bogotá City Area to have a well-organized cooperation among the related entities and a strong leading coordinating organization.

5.8.4 Program Implementation Schedule

Study team identified proposed programs and projects for the disaster management system in the study areas. The cost of each project has estimated based on the information of existing on-going projects as well as hiring from the governmental agencies, yet some of the projects are not enough information for the cost estimation. The estimated total cost of the project is about 1,671,676 million pesos or US$ 730.3 million over the next nine years. In the short period it is expected to use 22 % of the total cost, while medium term it is to use 51.5 % of the total cost. The details of the cost flow are shown in Table 5.8.1. The project implementation schedule is summarized in Table 5.8.2.

The details of implementation plans are shown in Appendix 5.8.1.

Table 5.8.1 Cost Distribution of the Projects

Items	Cost Distribution									Total
	Short			Medium			Long			
Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Seismic Diagnosis Study of Important Buildings	927	926	30	625	626	52	1,001	1,002	152	5,340
Strengthen Important Buildings	9,232	18,316	18,342	24,713	31,229	22,118	45,363	45,364	49,627	264,303
Seismic Reinforcement of Vehicle and Ped. Bridge	6,825	6,825	57,700	57,700	57,700	57,700	57,700	-	-	302,150
Water Supply	4,805	4,805	88,420	101,580	101,580	101,380	99,680	12,200	12,450	526,900
Gas Supply system	775	575	1,110	1,110	1,130	1,130	200	200	200	6,430
Electronic Supply Systems	780	780	1,320	3,320	3,370	3,820	3,820	3,300	1,250	21,760
Telecommunication Systems	410	410	1,250	1,750	1,750	1,750	700	800	800	9,620
Urban Development	8,658	8,658	8,660	66,391	66,391	66,397	-	-	-	225,155
Earthquake Engineering	-	-	-	-	-	-	-	-	-	-
Landslide Program	830	2,471	2,471	2,364	2,364	2,375	579	580	-	14,034
Flooding Program	27,028	27,028	27,030	19,078	19,078	19,079	38,150	38,150	38,150	252,771
Industrial facility	-	-	-	-	-	-	-	-	-	-
Health Program	4,216	4,226	4,246	4,136	4,136	4,196	2,716	2,716	2,848	33,436
Education Program	-	-	-	-	-	-	-	-	-	-
Information System	1,603	1,603	1,603	1,603	1,603	1,605	-	-	-	9,620
Monitoring Program	70	66	3	3	3	3	3	3	3	157
Total	66,158	76,689	212,185	284,373	290,960	281,605	249,912	104,315	105,480	1,671,676
Toal (Time span)			355,032			856,937			459,707	

Source: Study Team

Table 5.8.2 Summary of Project Implementation

Program		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short 2002	2003	2004	Medium 2005	2006	2007	Long 2008	2009	2010
1	Improvement of Important Buildings	1-1 Seismic Diagnosis of Important Buildings	Each Governmental Organization	5,340									
		1-2 Strengthening of Important Buildings	Each Governmental Organization	264,300									
2	Improvement of Bridges	2-1 Seismic Diagnosis of Vehicular and Pedestrian Bridges	Bogota City	13,650									
		2-2 Seismic Reinforcement of Vehicular and Pedestrian Bridges	Bogota City	288,500									
3.1	Seismic Reinforcement of Water Supply Facilities	3-1 Seismic Reinforcement of Water Supply Facilities	EAAB	447,140									
		3-1-2 Provision of Emergency Water Supply Tanks	EAAB	79,760									
3.2	Seismic Reinforcement of Gas Supply Facilities	3-2-1 Seismic Diagnostic Study of Gas Supply Facilities	Natural Gas Company	770									
		3-2-2 Seismic Reinforcement of Gas Supply Facilities	Natural Gas Company	5,660									
3.3	Seismic Reinforcement of Electronic Supply Facilities	3-3 Seismic Diagnostic Study of Electronic Supply Facilities	CODENSA/EMG ESA	1,160									
		3-4 Seismic Reinforcement of Electronic Supply Facilities	CODENSA/EMG ESA	20,600									
3.4	Improvement of Telephone Facilities	3-3-1 Seismic Diagnostic Study for Telephone Facilities	ETB/CAPITEL	420									
		3-3-2 Seismic Reinforcement of Telephone Facilities	ETB/CAPITEL	9,200									
4	Urban Redevelopment of Priority Area	4-1 Urban Redevelopment of Priority Area	Bogota City	87,913									
		4-2 Road Development	Bogota City	109,862									
		4-3 Open Space Development	Bogota City	27,380									
5	Earthquake Engineering	5-1 Geophysical Study of Subsurface Structure	DPAE/ INGEOMINAS	-									
		5-2 Geotechnical Study for Site Response and Liquefaction Evaluation	DPAE/ INGEOMINAS	-									
6	Landslide	6-1 Landslide Protection Works	DPAE	14,030									
7	Flooding	7-1 Structural Measures	EAAB/ Cundinamarca	251,790									
		7-2 Non-structural Measures	EAAB/ Cundinamarca	980									
8	Industrial Facility	8-1 Handling of Hazardous Materials	DAMA/CAR	-									
9	Health Sector	9-1 Health Sector Improvement	Bogota/ Cundinamarca	33,430									
10	Education Sector	10-1 Education Program	Bogota/ Cundinamarca	-									
11	Disaster Management Information System	11-1 Establishment of Disaster Management Information System	Bogota/ Cundinamarca	9,620									
12	Monitoring Program	12-1 Establishment of Monitoring Program	DPAE	150									

Source: Study Team

5.9 Evaluation

The proposed programs in the basic plan for disaster prevention of the Bogotá Metropolitan Area are evaluated in technological, social, environmental and economic terms. The programs are evaluated from A to C based on the impact by each program.

The followings show the details of the evaluation criteria.

5.9.1 Evaluation Criteria

1) Technology Aspect

The supposed reduction of the damages by the programs is evaluated as a part of the impact from technological aspects. The seismic damages to building, infrastructure and lifeline structures estimated are as follows:

(1) Building damage

Number of heavily damaged buildings would be 421,989 (heavily damaged building in case 2) and the proposed program would reduce numbers of the damaged buildings.

(2) Infrastructure (bridge)

Number of collapsed bridges: would be 58 (high-risk bridges in case 2) and numbers of the damaged bridge would be reduced by the program.

(3) Lifeline structures

Lifeline structures of water and gas supply pipelines, electric power supply and telephone cables, would be also widely damaged and proposed to be reinforced by related public service entities.

2) Social Aspect

The expected earthquake damage includes casualty and injured personnel. Those damages are linked with the building damage. The building damage ratio is comparatively high at low estrato, which is characterized in low-income community. Therefore, human casualty and injured personnel has strong linkage to socially vulnerable population. The proposed program is assessed by reduction of casualty and injured personnel.

3) Environmental Aspect

There are many vulnerable localities from disaster prevention aspects, lacking of open spaces and proper road networks at community level. Proposed program would reduce the vulnerability and the social environmental conditions of the Study Area. Therefore, proposed program is evaluated by improvement of vulnerable urban area. as well as reduction of debris in a disaster.

4) Economic Aspect

The proposed programs have been assessed by reduction of damage costs. By reduction of the damage total damage cost would be decreased.

Table 5.9.1 Evaluation of Programs

No	Program	Expected Impacts	Evaluation Items			
			Technology	Social	Environment	Economy
1-1	Seismic diagnosis study of important buildings	Reduction of weak building for the governments and emergency response organization as well as private housings. The number of improved building is more than 400,000 in total.	A	C	C	C
1-2	Strengthen important building facilities		A	A	A	A
1-3	Improvement of Private Housing		A	A	A	A
2-1	Seismic diagnosis study of vehicular and pedestrian Bridges	Improvement of existing vehicle bridges and pedestrian bridges are required. The number of improved bridges is 58 in total.	A	C	C	C
2.2	Seismic reinforcement of vehicular and pedestrian bridges		A	B	A	A
3-1-1	Seismic reinforcement of water supply facilities	The seismic reinforcement of the water supply facilities is 13 stations.	A	C	A	C
3-1-2	Provision of emergency water supply facilities	Emergency water supply system is required in 110,800m3 in total.	A	C	A	A
3-2	Seismic reinforcement gas supply facilities	Improvements of existing gas supply facilities.	A	C	B	B
3-3	Seismic reinforcement of electronic supply facilities	Improvement of existing electronic supply facilities	A	C	B	B
3-4-1	Seismic diagnosis study for telephone facilities	Improvement of existing telephone facilities.	A	C	C	C
3-4-2	Seismic reinforcement of telephone facilities		A	C	B	B
4-1	Urban redevelopment of priority area	Improvement of vulnerable urban area. Total area is more than 7,000 ha in the study area.	B	A	A	B
4-2	Road development		B	A	B	B
4-3	Open space development		B	A	A	C
4-4	Education and enlightenment Program	Technology Improvement Secondary damage	-	-	-	-
5-1	Geophysical study of subsurface structure	Provision of more accurate information for seismic reinforcement for infrastructure and buildings.	A	C	C	C
5-2	Geotechnical study for site response and liquefaction evaluation		A	C	C	C
6	Landslide protection works	Five locations are identified for priority area.	B	A	C	C
7-1	Flooding (Structural Measures)	The proposed development includes five rivers in the study area.	A	B	C	A
7-2	Flooding (Non-structural Measures)	Warring system installation and preparation of flood map/	A	B	C	C
8	Handling of hazardous materials	Establishment of inspection system	A	B	A	C
9	Health sector improvement program	Improve health sector capacity and improvement of emergency response capacity.	C	A	C	C
10	Education program	Disaster management education for all level	-	-	-	-
11	Establishment of disaster management information system	Establishment of information system in the study area	B	A	C	B
12	Establishment of monitoring program	Establishment of warning system	B	A	C	B

Note: A: High impact
B: Medium impact
C: Low impact

Chapter 6

Conclusion and Recommendation

CHAPTER 6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion and Recommendation

For disaster prevention of the Bogotá Metropolitan Area, the National government, the city of Bogotá and the prefecture of Cundinamarca are related. The existing disaster prevention systems have been effective for landslide and floods, but for earthquakes. The related government entities are required to prepare against earthquakes. It is necessary for the related three governments to arrange the responsible entities for preparation of preparedness for disaster prevention and also emergency responses in order to cope with a seismic disaster.

Due to the results of seismic damage analyses buildings, infrastructure and lifeline structures are vulnerable to the seismic disaster, among them the vulnerability of the building structures are most urgent to meet.

The vulnerable buildings are widely distributed in the Bogotá Metropolitan Area due to the informal building construction and housing development. The Basic Plan has proposed to reduce the numbers of the weak buildings by strengthening by phased expansion till 2010. The vulnerable Localities and Municipalities in the Bogotá Metropolitan Area have been selected as a priority area for a pilot study to reduce the vulnerability of the area by developing.

The Basic Plan proposed for disaster prevention and mitigation for the Bogotá Metropolitan Area is effective in technical, economic, financial, social and environmental terms. By implementation of the proposed projects, the vulnerability of the area will be reduced.

It is concluded and recommended for the related governments of the Bogotá Metropolitan Area to take immediate actions for implementation of the following:

1) Arrangement of government organizations is necessary for preparation of the preparedness for disaster prevention of the Bogotá Metropolitan Area, and for preparation of the emergency responses before, in and after a seismic disaster, it is necessary for the city government of Bogotá, the government of Cundinamarca and the National government to take immediate actions to arrange the government entities to implement the preparedness for disaster prevention and prepare the emergency responses before, in and after a seismic disaster.

   For the purposes the coordinate agencies of Bogotá D.C. (DPAE-FOPAE), Cundinamarca (OPAD) and the National (DGPAD) shall take their responsibilities to coordinate the necessary arrangements through the District Committee, the Regional Committee and the National Committee for prevention and attention of disasters respectively.

   Also the coordinate agencies are necessary to arrange the government entities to participate in preparation of the preparedness for disaster prevention and emergency responses before,

in and after a seismic disaster, and establish a leading coordination organization for the Bogotá Metropolitan Area. Each coordinate agency is to take necessary actions to develop the human resources in order to strengthen the related organizations.

Also it is necessary for the three Governments to arrange a cooperation and support system with other Prefectures and City governments and private entities.

2) The database, information and disaster management information systems for the Bogotá Metropolitan Area are to be held in common among Bogotá D.C. (DPAE-FOPAE), Cundinamarca (OPAD) and the National (DGPAD). It is recommended for the related agencies to hold the database in common and maintained properly because the database development in the Study is a basic tool for disaster management.

3) For alleviation of the seismic damage it is most important for the Bogotá Metropolitan area to reduce numbers of weak buildings or no seismic resistant buildings by strengthening (seismic retrofitting) and also it is important to reduce numbers of informal building constructions by enhancement of public awareness. The CURADURIA is responsible to give approval of construction of new buildings in Bogotá. It is recommended for the CURADURIA to expand the capacity to meet the demand of new building constructions and also to extend the responsibility to the seismic retrofitting or strengthening projects. Also it is recommended for the government of Bogotá and Cundinamarca to introduce an authorized inspection system of the Locality office for inspection of construction works after getting the approval of the design from the CURADURIA.

4) Seismic design and construction standard for masonry buildings shall be reviewed duly based on the actual conditions. In the Bogotá Metropolitan Area there exist about 950,000 buildings, of which more than 80%are masonry buildings. In the 1999 Quindio earthquake many of the masonry buildings were collapsed. It is recommended for the Bogotá metropolitan Area to review the seismic design and construction standard for masonry buildings duly considering the building damages estimated and the assessment of the building damages in the 1999 Quindio earthquake.

5) A Disaster Management Information System (DMIS) is necessary to be developed for the Bogotá Metropolitan Area to collect disaster information, processing data, making decision and disseminating disaster information in a disaster as a management tool. It is recommended for the Bogotá Metropolitan Area to review the existing information or communication systems and to promote the development of a Disaster management Information System as a basic management tool for disaster prevention and emergency responses of the Bogotá Metropolitan Area.

6) Infrastructure and lifeline structures will be affected in a seismic disaster. It is recommended for public or service entities to prepare their emergency response plans, which consists preparedness for disaster prevention, strengthening the facilities like water

supply tanks for emergency response in a disaster due to their seismic diagnosis study based on the damages estimated, and for restoration of the damaged facilities after a disaster, including materials and equipment.

7) Public education for disaster prevention is necessary for the government staff to strengthen the government organizations and for communities to enhance the public awareness. The government organizations are recommended to be strengthened due to their responsibilities in preparedness for disaster prevention and also responsibilities in emergency responses. Also the inhabitants and communities are recommended to be enhanced of public awareness to follow the regulations related to disaster prevention in general, and for the necessity of seismic design and strengthening the building structures, though generally they do not have any penalty cords in building construction, land development and housing development. As for seismic design

8) Early execution of a pilot study is necessary to promote the Basic Plan for disaster prevention of the Bogotá Metropolitan Area. It is recommended for the pilot study on disaster prevention to include organization of local communities, emergency response facilities and restoration plan and for the pilot area to be selected from the vulnerable localities and municipalities selected from disaster prevention aspects in Bogotá and Cundinamarca. They are localities of Santa Fe, San Cristobal, Usme, Bosa, Kennedy, Suba, Rafael Uribe and Ciudad Bolivar, and municipalities of Cota and Soacha.

9) For further study the existing conditions of the Bogotá Metropolitan Area, studies required to be conducted are listed as follows:

- Development study on disaster prevention for pilot areas in the Bogotá Metropolitan Area,
- Geophysical study on Cundinamarca,
- Geotechnical study on Cundinamarca,
- Study on Water Resources and Environmental Management for the Upper Rio Bogotá,

10) This basic plan for disaster prevention shows the direction of the prevention and attention of disasters. It is recommended to promote the basic plan as follows:

- The disaster prevention organizations for the Bogotá Metropolitan Area are necessary to be arranged through each committee for prevention and attention of disaster, the city of Bogotá, the prefecture of Cundinamarca and National levels. The responsible and supporting agencies assigned by the committee are necessary to implement the disaster prevention plans and prepare for the emergency responses. Also it is necessary to arrange coordination agreements with other cities and prefectures and international agencies.
- It is indispensable to decide a leading coordination agency for the Bogotá Metropolitan Area in order to coordinate the agencies related and the implementation of projects.

- It is important for the city of Bogotá to assign DPAE as an Administrative Department considering the required coordination among the administrative organizations for planning the disaster prevention measures before, in and after a disaster, especially seismic disaster.
- It is necessary for the agencies, which are responsible for infrastructure and lifeline facilities, to conduct diagnostic studies on the proposed projects and reinforce them due to the study.
- It is necessary for the Localities of Bogotá and the 8 municipalities of Cundinamarca to prepare their disaster prevention plans and emergency responses.

Appendix

Appendix for Chapter 1

Appendix 1.6.1 Study Organization

JICA Advisory Committee

Name	Position	Institute
Mr. Masayuki WATANABE	Leader of Advisory Committee	Institute for International Cooperation
Mr. Shinya NAKAMURA	Member, Advisory Committee	Public Works Institute

Study Team

Name	Assignments
Mr. Hajime TANAKA	Team Leader
Mr. Kanao ITO	Urban Disaster Preparedness
Mr. Ichiro KOBAYASHI	Deputy Team Leader/Regional Disaster Preparedness
Mr. Yoshitaka YAMAZAKI	Earthquake Engineer
Mr. Tsunehisa TSUGAWA	Infrastructure (Building)
Mr. Itsuo NOZAWA	Infrastructure (Road, Bridge, Lifeline)
Mr. Ryo MATSUMARU	Flood Control
Mr. Kaoru SHIMA	Landslide Control
Mr. Hiroyuki SAGAMI	Chemical Disaster Prevention
Mr. Yoshinori TAKAHASHI	GIS Development/Disaster Information System 1
Mr. Bishwa Pandey	GIS Development/Disaster Information System 2
Mr. Noboru KAWASHIMA	Organization for Disaster Measures and Laws
Mr. Kazumi AKITA	Disaster Medical Treatment, Health and Sanitation
Dr. Nahoko NAKAZAWA	Enlightenment/Educational Training
Mr. Hideharu SUGAWARA	Translator
Ms. Kanako IUCHI	Coordinator/Urban Planning

Appendix 1.6.2 List of Steering Committee Members

No.	Entity	Name	
1	Ministry of Interior, National Direction of Prevention and Attention of Disasters	Eduardo José Gonzalez Angulo	Director
2	Ministry of Health	Sara Ordoñez Noriega	Minister
3	Ingeominas	Adolfo Alarcon Guzman	Director
4	Cámara de Comercio de Bogotá	Maria Carolina Barco de Botero	President
5	Administrative Department of District Planning (DAPD)	Maria Carolina Barco de Botero	Director
6	Administrative Department of Cundinamarca Planning	Luana Laverde Castañeda	Director
7	Company of Water Supply and Sewage Service of Bogotá	Astrid Alvarez Hernandez	Manager
8	Secretary of Health of Bogotá	José Cardona	Secretary
9	Secretary of Health of Cundinamarca	Alvaro Florez Bernal	Secretary
10	Fire fighting of Bogotá	Mayor Jorge Elias Salazar	Commander
11	Fire Fighting Department of Cundinamarca	Commander	
12	Red Cross of Bogotá and Cundinamarca Section	José Carlos Miranda Miranda	Director
13	Colombian Civil Defense, Bogotá Section	Coronel Gustavo Alfredo Cardozo	Director
14	Cundinamarca Civil Defense	Director	
15	University of Los Andes	Luis Eduardo Yamin	Director
16	Metropolitan Police of Bogotá	Brigadier General Jorge Enrique Linares	Director
17	Police Department of Cundinamarca	Commander	
18	Regional Autonomous Corporation	Dario Londoño Gomez	General Director
19	Administrative Department of the Environment	Julia Miranda	Director
20	Secretary of Environment Cundinamarca	Andres Barreto Pozo	Secretary
21	Direction of Prevention and Attention of Emergencies, Bogotá (DPAE)	Richard Vargas	Director
22	Office of Prevention and Attention of Disasters of Cundinamarca	Jaime Matiz Ovalle	Director
23	Regional Advisor and Competitively	Carmenza Saldias Barreneche	Advisor
24	Pan-American Organization of Health	Hernan Malaga	Director
25	Secretary of District Education	Cecilia Maria Velez	Secretary
26	Secretary of Education, Cundinamarca	Piedad Caballero Prieto	Secretary
27	Colombia National University	Victor Manuel Moncayo	Director

Appendix 1.6.3 List of Counterpart

No.	Name	Position
Bogotá		
1	Richard Vargas H	Director of DPAE
2	German D. Tapia	Institutional Technical Coordinator
3	Javier Pava	Risk Analysis Coordinator
4	Yovanna Marcela Chaves	Local Management
5	Mauricio Gallego	Analysis of Risk
6	Luis Alberto Baron	Analysis of Risk
7	Fernando Proaño	Analysis of Risk
8	Luz Francy Navarro	Local Management (CLE Puente Aranda)
9	Liliana Ramos	GIS Coordinator
10	Sandra Guerra	Planning Coordinator
11	Claudia Coca	Education Coordinator
12	Doris Suaza	Analysis of Risk
Cundinamarca		
1	Olga Isabel Palacio	Chemical Risk and Inter-Environmental Analysis
2	Maria Consuleo Castro P.	Cundinamarca POT Planning and Departmental Planning
3	Ricardo Augusto Palacios	GIS
4	William Cortes Castillo	Seism and buidings
5	Nidia Milena Garzon Public Education and Information	
6	Leonardo Hernanadez G.	Medical Coordinator of CRUC
7	Jaime Matiz	OPAD
8	Javier Morales Jacome	Secretary of Social Development, Social and Population Analyst
9	Luz Marina Gongora Rios	Secretary of Education, Education and public information
10	Daniel Montana	Secretary of Public Works, Hydrologist
11	Haydee Matiz Parzo	OPAD, Infrastructure Engineer
12	Maria Ursula Sola Parra	Director of Cundinamarca International Cooperation Office

Appendix for Chapter 2

Appendix 2.5.1 Role and Responsability of the Organization

Table 1 List of Organization for National Level

NAME	RESPONSIBILITY
National Committee for the Attention and Prevention of Disasters	1. Approval of the National Plan for the Prevention and Attention of Disasters 2. The information integrated system, as apart of the National Plan for the Prevention and Attention of Disasters: 3. Disaster situations: 4. Indicate rules for preparing specific action plans by the National office for the Attention of Disasters and the Regional and Local Committees.
National Operative Committee for Attention of Disasters	1. Definition regarding temporary lodging 2. Performance of census 3. Initial diagnostic of damages 4. Primary or basic attention of affected individuals 5. Supply of basic emergency elements, such a food, medicines, wares and similar elements. 6. Reestablishment of minimum or basic conditions for environmental sanitation 7. Emergency transportation and communications and solution of way interruption points 8. Definition, establishment and operation of alerts and alarms.
National Office for Attention of Disasters	1. Preparation of the National Plan for Prevention and Attention of Disasters 2. Information Integrated System as a part of the National Plan for Prevention and Attention of Disasters In disaster situation: 3. Prepare specific action plans for disasters situations of national character, with the cooperation of the respective Regional or Local Committees and technical entities, and in accordance with the guidelines provided by the National committee for Prevention and Attention of Disasters. 4. Submit to the consideration of the National Plan for Prevention and Attention of Disasters, the National Operative Committee for the Attention and Prevention of Disasters and the Advisory Board of the National Fund of Calamities, studies and proposal related to the exercise of their respective duties. 5. Direct and guide the activities of the National Technical Committee
Regional and Local Committee for the Prevention and Attention of Disasters	1. Guide and coordinate the activities of public entities and bodies to which support and assistance is requested for preparing, executing, following up and appraising the National Plan for Prevention and Attention of Disasters. 2. The information Integrated System, as apart of the National Plan for Prevention and Attention of Disasters: 3. disaster situations: 4. specific action plans:

Table 2 List of Organization for Local Government

Name	Responsibility
Local Governments	1. Direct, coordinate and control, by means of the chief of the respective administration, all the administrative and operative activities needed to attend of disaster at regional or local level. 2. Offer support to the National Committee for the Attention and Prevention of Disasters, the National Office for the Attention of Disasters, and the Regional and Local Committees, on the works necessary to prepare, execute, make, follow up and appraise the National Plan for the Prevention and Attention of Disasters. 3. Appoint the officials and dependence responsible of attending the duties related to the National Plan for the Attention and Prevention of Disasters, contingency and immediate attention plans in conditions of disaster, preventive plans and specific action plans. 4. Collaborate with upgrading and maintaining an Information Integrated System, in accordance with the guidelines provided by the Regional and Local Committees. 5. Observe the regulations that start governing with occasion of a declaration of disaster situations or which shall continue governing during the rehabilitation, reconstruction and development phases. 6. Provide special regulations in order to facilitate the activities related to repair and reconstruction of those buildings affected by a declared situation of disaster, and to reestablish a later fiscal control of the expense addressed to the performance of activities anticipated in an specific action plan for the attention of a situation of disaster. 7. Appraise, by means of the health secretariats, the aspects related to health, the coordination of medical actions, the transportation of victims, the classification of injured (triage) individuals, the provision of medical supplies, as well epidemiological vigilance and control. 8. Prepare the community, by means of the Education Secretariats, on the prevention, attention and recovery in situations of disaster. 9. Develop, by means of public works secretariats, activities related to transportation services, infrastructure works, damage evaluation and demolition and cleaning works. 10. Prepare by means of the Offices of Planning, the plans in harmony with the regulations and plan of prevention and attention of situation of disaster, and coordinate the respective institutions on program and budget matters in what relates to disasters.

Table 3 List of Organization for National Government

Name	Responsibility
The Military Force	1. Isolating and maintain the security in the area of the disaster, air control and identification and attention of ports and heliports.
National Police	1. Preventing and confronting disorders related to security, tranquility and public sanitation as well as collaborating in the protection of natural resources and the environment. 2. Watch for the security of the affected area, guaranteeing the protection of the life, honor and property of the affected persons. 3. Providing the collaboration and support required by public entities involved in attention and control jobs of the areas affected by the disaster. 4. Watch for the observance of the provisions given by the National Government and the other public entities and bodies in relation to the prevention, management, rehabilitation and reconstruction. 5. Collaborate with the evacuation of injured and affected people, who require an immediate assistance. 6. Assist the technical Body of the Judicial Police in the jobs of identifying corpses and preparing corpse lifting minutes 7. Determinate the strategic areas for the installation of services and aids required and offer the necessary vigilance.
Ministry of Health	In the disaster situation 1. appraising health aspects, 2. the coordination of medical actions, 3. the transportation of victims, 4. the classification of injured individuals (triage), 5. the provision of medical supplies, In the basic sanitation, 1. the medical attention in shelters, 2. nutritional vigilance, and 3. epidemiological vigilance and control.
Ministry of Public Works and Transportation	In the disaster situation 1. Provide transportation services 2. infrastructure works 3. appraisal of damages 4. demolition and cleaning works
Ministry of Education	1. Preparing the community level educational material on the prevention, attention and recovery of disaster situations.
Ministry of Communications	In disaster situations 1. Provide special measures on control and management of information 2. specific regulations on the use of communication frequencies, systems and means.
The National Department of Planning	In normal situation 1. presenting for the approval of the National Council of Economic and social Policies Copes, 2. the investment programs and projects derived from the National Plan for the Attention of Disasters, 3. to public institutions on everything related to program and budget aspects on attention and prevention of disasters.

Table 4 List of Organization for National Institution

Name	Responsibility
INGEOMINAS	1. preparing maps on potential threats 2. observing and studying the volcano in the country
Civil Defense	In disaster situation 1. search and rescue of victim 2. first aid jobs of victim 3. establish an initial classification system of injured individuals 4. the transportation of victims and 5. support security actions.
Institute of Hydrological, Meteorological and Environmental Study	1. hydro-meteorological risks analysis 2. prepare the risk map
Institute of Agricultural marketing (IDEMA)	Supply of food
National Service of Learning (SENA)	In the disaster situations 1. prepare the community level educational material for the prevention, attention and recovery.
Institute of Geography "Agustin Codazzi" (IGAC)	1. Provide maps aerial photograph for the studies and decision making
Institute of Territorial Credit (ICT) and the Mortgage Central Bank (Banco Central Hipotecario)	1. special credit programs in order to promote preventive relocation processes of human settlements, 2. define a housing policy in human settlements 3. coordinate and participate in the attention of damages resulting at the houses, community facilities and basic networks.
National Fund of Calamities	In the disaster and calamity situations 1. economic support needed for prevention, attention and recovery jobs 2. manage the contributions in money, 3. supervise the management and control of inventories at the centers of reserves for emergencies.
National Institute of Renewable Resources and Environment (INDERNA) and Regional Autonomous Cooperation	1. Environmental management
National Fund of Vicinal Ways	1. Provide the funds for the construction of works according the disaster prevention plan
National Telecommunication Company	In disaster situations 1. Provide free telecommunication services
Regional Autonomous Corporation	1. Preparation of risk analysis and vulnerability study
Civil Defense	1. Prevent and control disaster and calamity situations in their primary stage of imminent prevention and immediate attention and, when such events have been declared, it performs in the terms defined in the administrative acts of such situation declaration. 2. Cooperate in keeping internal security and maintaining national sovereignty. 3. Promote, train and organize the community for the effects of the duties provided in this article.
National Fund for Calamity	1. Offering the economic support required for the attention of declared disasters and calamities, giving priority to the production, conservation and distribution of food, medicines and provisional shelters. 2. Control the effect resulting form disasters and calamities, especially those related to the arising and spreading of epidemics. 3. Maintaining during the rehabilitation, reconstruction and development phases, and the environmental sanitation of the affected community. 4. Finance the installation and operation of information systems and equipment, suitable for the prevention, diagnosis and attention of disaster or calamity situations, especially of those included in the Seismographic National Network. 5. Take the necessary steps in order to prevent disasters or to mitigate its effects, which could consist, among other things, in insurance policies acquired from companies legally established in the Colombian territory and seeking mechanisms to cover in total or partially the cost of the respective premiums.
Consulting Broad	1. Provide the general policies for management and investment of fund resources and watch for the security, suitable management and optimum yield. 2. Watch the observance and implementation of Fund purposes 3. Indicate in accordance with the provisions in article 3rd in this decree, the destination attended in respect to the financial availability thereof, existing in each case. 4. Recommend suitable systems to attend situations of similar nature, qualified by the board itself, in accordance with the provisions in article 1st in this decree. 5. Resolve the consultations on the matters related to fund purpose or purposes presented by the National Government or the Fiduciary Company administering the fund. 6. Determinate, when the circumstances so require and taking into account the purpose or purposes of the fund, the cases in which the resources may be transferred under free and not recoverable title.

Appendix 2.5.2 Member List of the District Committee for Emergency Prevention and Attention

Table 1 Members of the National Committee

No.	Organization
1	President of the Republic (or his Delegate) Director of the Committee
2	Minister of the Interior
3	Minister of Finance and Public Credit
4	Minister of National Defense
5	Minister of Health
6	Minister of Communications
7	Minister of Transportation
8	Minister of Environment
9	Director of the National Department of Planning
10	Director of the Colombian Civil Defense
11	Director of the Colombian Red Cross Society
12	Representative of the Colombian Chamber of Construction
13	Representative of the Colombian Society of Construction Engineers
14	Director of the General Directive Office for Prevention and Attention of Disasters

Table 2 Members of the regional Committee of Cundinamarca

No.	Organization
1	Prefectural Governor President of CREPAD - Regional Committee for Prevention and Attention of Disasters of Cundinamarca
2	Commander of Military Brigade or Corps
3	Commander of the National Police
4	Commander of Corps of Fire Services
5	Director of the Secretary of Heath
6	Director of the Autonomous Regional Corporation of Cundinamarca
7	Director of the Colombian Civil Defense
8	Director of the Colombian Red Cross Society
9	Mayor of Santa Fe de Bogota Capital District
10	Two Representatives of Prefectural Governor of Cundinamarca
11	Secretary of the CREPAD - Regional Committee for Prevention and Attention of Disasters of Cundinamarca (Director of the Secretariat of Planning)

Table 3 Members of the Local Committees

No.	Organization
1	Municipal Mayor
2	Commander of Military Brigade or Corps
3	Commander of the National Police
4	Commander of Corps of Fire Services
5	Director of the Section of Health Service
6	One Representative of the Colombian Civil Defense
7	One Representative of Colombian Red Cross Society
8	Two Representatives of the Mayor of Bogotá C.D.
9	Secretary of the Local Committee for Prevention and Attention of Disasters (Director of the Local Secretariat of Planning)

Table 4 Members of the District Committee

No.	Organization
1	Mayor of Santa Fe de Bogota C.D.
2	Secretary of Government of Bogota C.D.
3	Secretary of Heath of Bogota C.D.
4	Director of Administrative Department of Planning of Bogota C.D. (Secretary of CDPAE)
5	Secretary of Finance of Bogota C.D.
6	Director of Administrative Department of Environment of Bogota C.D.
7	Director of the Directive Office of Prevention and Attention of Emergencies of the Secretariat of Government of Bogota C.D.
8	Commander of Official Corps of Fire Services of Santa Fe de Bogota
9	Director of Civil Defense in the Section of Santa Fe de Bogota
10	President of the Cundinamarca and Bogota Branch Office of Colombian Red Cross Society
11	Commander of the Metropolitan Police of Santa Fe de Bogota
12	Commander of Military Corps Existed in the Capital District
13	Mayors of Ward in Affection of Disasters
14	Manager of the Enterprise of Water Supply and Sewage Service of Bogota
15	Manager of the Enterprise of Energy of Bogota
16	Manager of Codensa Company
17	Manager of Emgesa Company
18	Manager of the Enterprise of Telecommunications of Bogotá
19	Manager of Gas Natural Company

Table 5 Members of the Local Emergencies Committee in Bogota D.C.

No.	Organization
1	Mayor of Ward
2	Representative of the Administrative Assembly of Ward
3	Advisor of the Directive Office of Prevention and Attention of Emergencies of Bogota C.D.
4	Director of Local Office of Health
5	Local Coordinator of the Administrative Department of Social Welfare of Bogota C.D.
6	President of the Association of the Assemblies of Community Actions
7	Representative of the Administrative Department of Community Actions of Bogota C.D.
8	Coordinator of Local Office of Planning
9	Delegate of the Technical and Administrative Department of Environment of Bogota C.D.
10	Coordinator of the Administrative Center of Education of Ward
11	Gas Natural Company

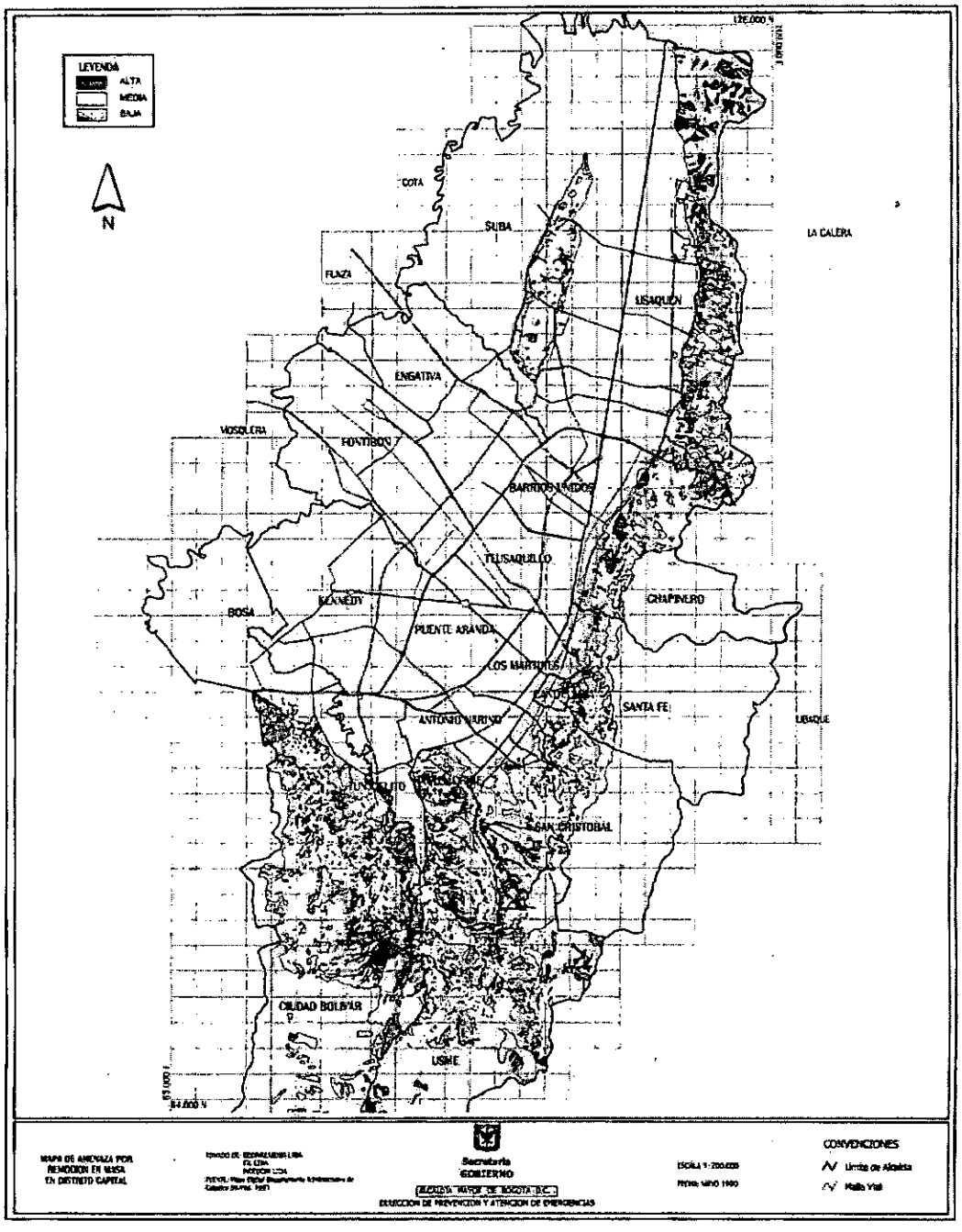
Appendix 2.5.3 Objectives of both FOPAE and DPAE

Organization	Objectives
FOPAE	• Provide the economic funding that is required for the prevention and attention of emergencies and calamities • Fund a program of prevention of disasters for the District, based on studies and inventories of risks, with emphasis on campaigns of preventive education addressed to the most vulnerable population, publishing the didactic material that may be required • Fund the preparation of a map of threats and risks for the District • Fund the installation and operation of systems and equipment of information for the prevention, diagnosis, and attention of disasters • Acquire the equipment and elements required for the prevention and attention of emergencies and assist the victims on their basic needs • In general terms, adopt the necessary measures to prevent disasters or to mitigate their effects
DPAE	• Coordinate all the actions of prevention and attention of emergencies in furtherance of the objectives of FOPAE • Promote the creation and coordinate the Local Committees of emergencies in each Location. • Develop the studies and designs for emergency attention, using new technologies and the experience in risk prevention. • Coordinate emergency prevention campaigns in the District schools, along with the Education's Secretary Office and the Community. • Promote the participation of the Community organizations in the tasks for the prevention and attention of emergencies Through the Administrative Department of Community Action and the Administrative Department of Social Welfare. • Design and establish an emergency plan of communication with the corresponding entities. • Motivate and call the private sector to participate in the programs of prevention and attention of emergencies. District Decree 657 as of 1994 • Issue, as requested by district entities, technical concepts about the existence of geological, hydraulic or electrical in different areas of the city. • Inform of the areas of high risk to the local Mayors, so that urbanizing is not allowed or police measures are executed. Copy of the technical concepts issued shall also be provided. • The same decree states the prohibition of urbanizing of properties and the provision of public services in places located in areas defined by the Direction for the Prevention and Attention of Emergencies of high-risk areas. District Decree 723 as of 1999: • Promote the adoption and the execution of Law Decree 919 as of 1989, in the corresponding issues to the District, through the Committees forming the District System. • Prepare the element of prevention and attention of emergencies of the District Development Plans and of the plan of and classification, in coordination with the District Planning Administrative Department, as stated in the National Plan for the Prevention and Attention of Disasters. • Coordinate the preparation of the plans of action for the effective handling and attention of the situations of public calamity and disaster at a district level. • Design and start the procedures and systems and for the monitoring and timely alerting of the population and as well as advising the District Government on the determination of alert status and on the measures required in each case. • Guarantee the coordination of the decisions adopted by the District Inter-Entity Committees with those of the Local Committees of Emergency. • In general terms, are functions of the Direction for the Prevention and Attention of Emergencies of the Government's Secretary Office, those who are stated on the Decree 069 as of February / 1999.

Appendix 2.5.4 Background of the Personnel of the DPAE

Professional Staff		Year of Experience					
		> 1	1 - 5	5 - 10	10 - 15	15 - 20	20 >
Anthropology	2		1	1			
		(1)	(1)				
Architect	2	(2)		2			
Biologist	1		(1)	1			
Cadastral Engineer	1			1			
				(1)			
Chemistry Engineer	1	(1)			1		
Civil Engineer	14	1	6	3	4		
		(3)	(11)				
Forest Engineer	1	(1)	1				
Geographer Engineer	3		(3)	3			
Geologist	1			1			
				(1)			
Geologist Engineer	1			1			
				(1)			
Chemistry	1		(1)			1	
Philology and Languages	2			1	1		
			(2)				
Industrial Engineer	3		1	1		1	
		(1)	(2)				
Kinder Garden Teacher	1		(1)	1			
Lawyer	6		2	1		2	1
		(2)	(3)	(1)			
Mechanic Engineer	1		1				
			(1)				
Human and Social Sciences	3		1		1	1	
			(3)				
Psychologist	2		(2)	1		1	
System Engineer	2		(2)	1		1	
Year of Experience	48	1	13	19	7	7	1
Year of Experience in DAPE	48	11	33	4			
Administrative Staff							
Administrator	5	1	2	1	1		
		(1)	(4)				
Assistant	1		1				
			(1)				
Finance	6	(1)	(5)	1	4	1	
Secretary	6		5	1			
			(5)	(1)			
Radio Operators	3		2				
			(3)	1			
Year of Experience	21	1	10	4	5	1	
Year of Experience in DAPE	21	2	18	1			

Note: () Year of experience in DPAE
Source: DPAE



Source: Homepage of DPAE

Appendix 2.6.1 Risk map of Landslide in Bogotá

Appendix 2.7.1. Characteristics of Water Supply and Sewage System in eight municipalities

Municipality	Area	Water Supply System			Sewage Service System	
		Supply Source	Supply Facility	Service Condition	Treatment Plant	Service Quality
La Calera	a. Total área: 32,875 ha b. Urban area: 68 ha c. Rural area: 32,807 ha	a. Supply from Rio EL Verjon stream (from Rio Teusaca) in Los Molinos area. Discharge: 17.1-28.5 LPS b. Another supply from Amarilla/Montanela stream (from El Verjon).Discharge: 6.6-11 LPS. c. 28% from EAAB in Veredas area and 82% of rivers.	a. There is 1 purification plants for superficial and underground water (capacity 20 LPS). b. Size of pipeline: 6-8"(main), 2-4"(other).	a. Coverage: 60% in Vereda, 82% in Los Molinos of people. b. Compensation: there is domiciliary compensation in Vereda, in Los Molinos, storage of the 25% of the mid-daily consumption (26 LPS) is required.	a. In Veredas, there is not any control of the final disposition. In Los Molinos, there are 4 principal collectors, these supply to the brooks.	a. Waste water system: In Veredas, there are individual solutions. In Los Molinos, the 80% of sewage system, 12% of the septic tank flows, 8% of superficial sewage system. b. Rainfall water system: In Veredas, in just a few sites, the CONALVIAS enterprise is carrying out the paving in the ring road. In Los Molinos, there is not a rain sewage system, neither sewers.
Cota	a. Total área: 5,344 ha b. Urban area: 143 ha. c. Rural area: 5,201 d. Water supply service: 3 aqueducts: one central, two rural "Veredas".	a. Supply from 4 wells. - Discharge: 6-14 LPS - Power: 17.4-40 HP b. Productive capacity is 28.7 LPS.c. 100% of self-supporting in city.	a. There are 3 purification plants b. .Total length of pipeline: c. Size of pipeline: 6"(main), 2-4"(other).	a. Coverage: 98%(urban). 40%(rural) of people. b. Compensation: storage volume of three combined system is enough.	a. CAR built treatment plant on riverbank of Rio Bogotá in 1981. b. Produces 13.4 LPS of waste water (old sewer system). c. New sewer system transports are divided in two pipes at well (12" and 24").	a. Sewer system is separated type. b. There is a problem of floods sporadic during rainfall seasons. c. Assumed that new sewer system built recently.
Chia	a. Total area: 8,187 ha b. Urban area: 561 ha. c. Rural area: 7,626	a. Potable water supplies from via purification plant of Tibitoc belong to EAAB (takes water from source of Rio Bogotá). b. 100% of potable water supply from EAAB for city.	a. Total length of pipeline: b. Size of pipeline: 10-30"(main) 2-8"(other)	a. Coverage: 95%of people. b. Compensation: Distribution system does not have an own storage system.	a. Total length: 31km (10-36") b. City has one treatment plant by CAR. c. Composed by a relief tank with pipeline of 24", and interceptor channels.	a. Sewer system is mixed rainfall and waters, is composed by two main systems. b. There are problems sediments and garbage of pipeline in rainfall seasons.
Funza	a. Total área: 6,599 ha b. Urban area: 369 ha. c. Rural area: 6,230	a. Supply from 1 well with purification plant and storage tank (90%). b. Potable water supplies from EAAB (10% of consumption).	a. There are 2 purification plants (max 120 LPS, usually, 50 LPS).b. Pumped station: 90HP c. Total length of pipeline: d. Size of pipeline: 6-10"of PVC (main), 2-4"of PVC (other).	a. Coverage: 96%of people. b. Compensation: storage volume system is enough comparatively.	a. Total length: 52km b. City has one treatment plant for waste water and complementary facilities by CAR. c. Treatment plant: ave. discharge of 160 LPS, max 197 LPS.	a. Sewer system is separated system except some area. b. Guali wet zone necessary to complement the main collector channels of rainfall water.
Facatativa	a. Total área: 16,149 ha b. Urban area: 379 ha. c. Rural area: 15,770	a. Superficial water from Rio Botello and Mancilla stream. b. Underground waters from 7 wells (60%). c. Superficial water collect by 4 separated small dams (40%).	a. There are 2 purification plants (capacity 280 LPS, 30 LPS). b. 2 Pumped Station: capacity 270 LPS and raw water of 310 LPS c. Total length of pipeline: d. Size of pipeline: 8-16" (main), 2-6"(other).	a. Coverage: 95%of people. b. Compensation: storage volume system is enough.	a. City has one treatment plant for waste water and complementary facilities by CAR. b. Treatment plant: ave. discharge of 187 LPS in dry time and design of 2,240 LPS. c. Complementary facilities: 3 pumping station (100 LPS), interceptor channels (16"), sand remover.	a. Sewer system is mixed rainfall and waters in old central area, which consist in rectangular channels made of bricks and covered with flagstones and brick vaults the widest. b. Because of mixed water sewer function, main conduction lines are pressurized causing inundations on the lowest areas of town.
Madrid	a. Total área: 12,036 ha b. Urban area: 636 ha. c. Rural area: 11,400	a. Superficial water from Rio Serrezuela in rainfall seasons (16%). b. Underground waters from 2 wells (24%). c. Buying water from EAAB (60%).	a. There is 1 purification plants for superficial and underground water (capacity 120 LPS, filtration limitation to 60 LPS, which is overloaded to 75 LPS). b. 2 Pumped Station: well located at purification plant (60HP), Lucitania well (65HP). c. 1 storage tank (1,600m3). d. Total length of pipeline: 69.2km e. Size of pipeline: 6-14"of PVC (main), 2-4"of PVC (other).	a. Coverage: 98%of people. b. Compensation: storage capacity is not enough. c. During rainfall seasons when the amount of superficial water is enough, the service continuity is not increased by the following reasons: 1) damages on asbestos-cement pipes by increasing pressures, 2)most of users of interior pipes not good.	a. Because there are two different drainage basins, CAR designed and constructed two waste water treatment plants. They are Madrid I and Madrid II. b. Treatment plant: capacity Madrid I, 60LPS, Madrid II, 30 LPS.	a. Sewer system is separated and/or mixed types, which is discriminated by concrete pipes, PVC pipes and grass pipes. b. The system coverage is 95%. c. Because of the separated system, there are some bad connections that introduce rainfall waters into the waste water system, making some pipelines to have pressure and overflowing the system in the check-wells.
Mosquera	a. Total área: 12,698 ha b. Urban area: 438 ha. c. Rural area: 11,260	a. Superficial water from River by using La Ramada watering system (11%, 5.4 LPS). b. Buying water from EAAB (89%, 5.4 LPS).	a. Total length of pipeline: 10km (main), 19km (other). b. 2 storage tanks of 22m3. c. Size of pipeline: 6-12"(main), 2-4"(other).	a. Coverage: 76% of people. b. Compensation: there is not compensation capacity for the main urban perimeter, and El Lucero sector is deficient.	a. For rainfall water system, there is 1 pumping station constructed by CAR at deliverance place (treatment plant or San Jose channel). b. Waste Water Treatment Plant: The plant consist in two facultative lagoons and one of maturation with their respective structures, and a pumping station (120 LPS).	a. 33.8km pipelines of separated and /or mixed sewer system. b. The system coverage is 97%. c. Some pipelines are pressured and the water overflow at the check-wells. d. These deficiencies also obey to reductions in the pipelines diameters. e. There are not a main rainfall system and in some sectors there are not any rainfall system at all.
Soacha	a. Total área: 17,900 ha b. Urban area: 1,800 ha. c. Rural area: 16,100 ha	a. Supply from some wells (48%) b. Buying water from EAAB (52%, 380 LPS).	a. Total length of pipeline:19.5km b. 3 storage tanks (80-100,000m3). c. Size of pipeline: 20-40"(main), 3-16"(other).	a. Information is not available yet.	a. Information is not available yet.	a. Sewer system is mixed rainfall and water. b. The system coverage is 45%. c. There exists a type of mixed sewer system which is insufficient for the waste water system and much less for the main waters.

Appendix 2.10.1

Members of the Emergency Local Committees in Bogotá D.C.

(unit: person)

District	Alcadia Local	Planeacion Local	Ejercito	Policia	Defensa Civil	Bomberos	DPAE	DABS	DAPD	DAACD	DAMA	ICBF	Personeria Local	Hospitales Slud	EAAB	GAS Natural	ASEO	ASO Juntas	JAC	JAL	CADEL	Others	Total
Usaquen	2	1	0	0	1	1	1	1	0	1	1	0	2	3	2	1	2	1	0	1	1	0	22
Chapinero	3	1	0	1	4	2	1	2	2	2	1	0	2	0	1	1	0	1	2	1	1	4	32
Santa Fe	2	1	0	1	1	1	1	1	1	1	1	0	1	2	3	1	1	1	0	1	1	4	26
San Cristobal	3	1	4	15	6	2	1	2	2	1	1	1	1	7	4	1	2	1	0	1	1	19	76
Usme	4	1	0	3	7	2	1	1	1	2	1	1	2	2	3	2	1	1	0	2	1	10	48
Tunjuelito	1	1	3	4	4	1	1	2	0	1	1	1	1	6	6	1	1	1	0	1	1	5	43
Bosa	1	1	1	6	8	1	1	1	1	2	1	1	1	6	1	0	1	1	0	2	1	7	45
Kennedy	1	0	0	1	9	1	1	1	2	1	1	1	1	1	3	1	1	1	0	1	1	5	34
Fontibon	2	1	1	1	4	2	1	2	1	2	1	1	1	3	1	1	0	1	0	1	2	6	35
Engativa	2	1	1	6	14	3	1	2	1	2	1	1	2	16	1	3	1	1	0	1	1	12	73
Suba	3	1	0	5	5	5	1	2	0	0	1	1	1	3	3	1	0	1	1	1	1	4	40
Barrios Unidos	2	1	0	1	2	1	1	1	0	0	1	1	1	1	1	1	1	1	1	3	0	4	25
Teusaquillo	2	0	0	1	0	0	1	0	1	1	1	1	1	0	1	1	1	0	0	2	1	5	20
Martires	1	0	1	3	4	3	1	1	2	1	1	0	2	2	1	1	1	0	4	6	2	8	45
Antonio Narino	1	0	0	2	4	3	1	3	0	1	0	1	1	1	1	2	0	2	1	1	1	7	33
Puente Aranda	1	1	0	0	3	1	1	1	2	1	1	1	0	2	0	1	1	1	0	0	1	8	27
Candelaria	2	1	0	4	1	2	1	1	1	1	1	1	0	2	2	1	1	1	0	1	1	2	27
Rafael Uribe U	1	1	0	4	0	3	1	2	2	2	1	1	3	3	2	0	1	2	0	4	1	7	41
Ciudad Bolivar	4	1	1	5	5	2	1	2	3	3	1	1	1	1	2	0	1	1	0	1	1	9	47
Sumapaz	1	1	0	0	0	0	1	1	0	1	1	1	1	2	0	0	0	1	3	2	1	8	25
Total	39	16	12	63	82	36	20	29	22	26	19	17	25	63	38	20	17	20	12	33	21	134	764

Source: DPAE

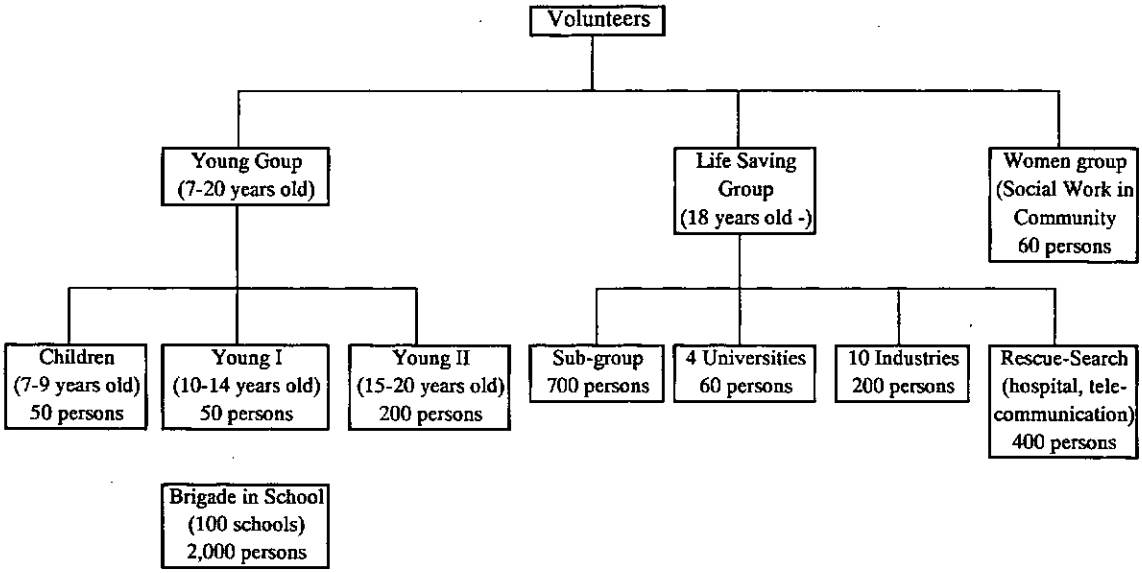
Appendix 2.10.2

Conditions of CLE

District	Comission	Office	Vehicle	Reserve Center	Contingency Plan	Risk Admin-istration Plan	Action Plan 2000	No. of Projects	Theme of Training	Budget (Peso)	Socialization Plan with DPAE
Usaquen	x	x	x		x	x	x	2	Adopatation of risk zones and risk prevention	127,296,328	x
Chapinero	x		x	x		x	x	1	Prevention of risks and attention of emergency	41,900,000	x
Santa Fe	x	x	x	x	x	x	x	1	Adopatation of risk zones and risk prevention	250,000,000	x
San Cristobal	x	x		x	x	x	x	2	Adopatation of risk zones and risk prevention	502,890,273	x
Usme	x	x	x				x	2	Adopatation of risk zones and risk prevention	160,000,000	x
Tunjuerito	x		x		x		x	2	Adopatation of risk zones and risk prevention	173,177,511	x
Boas	x		x	x	x	x	x	1	Prevention of risks and attention of emergency	40,000,000	x
Kennedy			x	x	x	x	x	1	Adopatation of risk zones/attention of affected families	45,416,414	x
Fontibon			x			x	x	1	Prevention of risks and attention of emergency	40,000,000	x
Engativa	x					x	x	2	- Prevention of risks and attention of emergency - Qualification and strengthening of institution for urban security	243,000,000	x
Suba		x		x	x		x	2	- Prevention of risks and attention of emergency - Strengthening of decentralization	293,000,000	x
Barrios Unidos	x		x	x			x	1	Prevention of risks and attention of emergency	25,000,000	x
Teusaquillo			x				x	1	- Strengthening of physical infrastructure and human resourcfes of CLE	70,000,000	
Martires			x		x		x	1	Prevention of risks and attention of emergency	30,000,000	x
Antonio Narino	x		x		x		x	1	Prevention of risks and attention of emergency	24,000,000	
Puente Aranda	x		x		x	x	x	1	Prevention of risks and attention of emergency	20,000,000	x
Candelaria	x		x		x	x	x	1	Prevention of risks and attention of emergency	20,000,000	x
Rafael Uribe Uri	x		x		x	x	x	2	Adoptation of risk zones, attention of affected families, prevention of risks and attention of emergency	383,337,000	x
Ciudad Bolivar	x	x	x		x		x	1	Prevention of risks and attention of emergency	95,000,000	x
Sunapaz			x		x		x	1	Prevention of risks and attention of emergency	75,000,000	

Source: DPAE

Appendix 2.10.3 Composition of Volunteers of Red Cross



Source: Cruz Roja

Appendix 2.10.4 Workshops Organized by DPAE in Year 2000

District	No. of Participated Barrio	Theme	No. of Participants
Usaquen	5	Landslide, Earthquake	1,046
Chapinero	4	Landslide	500
Santa Fe	5	Landslide	500
San Cristobal	8	Landslide	2,650
Usme	6	Landslide, Earthquake	2,600
Tunjuelito	4	Inundation	700
Bosa	3	Inundation	1,400
Kennedy	2	Inundation	2,200
Fontibon	1	Inundation	610
Engativa	4	Inundation	1,800
Suba	6	Landslide, Earthquake, Inundation	3,400
Barrios Unidos	All	Earthquake	530
Teusaquillo	All	Earthquake	400
Los Martires	All	Earthquake	600
Antonio Narino	All	Earthquake	300
Puente Aranda	All	Technological (Industrial) Risks	900
La Candelaria	All	Earthquake	180
Rafael Uribe U	10	Landslide	1,200
Ciudad Bolivar	11	Landslide, Earthquake	1,300
Sumapaz	All	Earthquake	500
Total			23,316

Source: DPAE

Appendix 2.10.5 School Plan for the Risk Management

Ward / Cou	Methodology	Curriculum
Usaquen	153	12
Chapinero	35	19
Santa Fe	11	10
San Cristobal	38	29
Usme	13	46
Tunjuelito	62	14
Bosa	249	60
Kennedy	91	70
Fontibon	108	22
Engativa	119	46
Suba	213	53
Barrios Unidos	36	37
Teusaquillo	6	12
Maritres	8	8
Antonio Narino	48	12
Candelaria	3	10
Puente Aranda	24	30
Rafael Uribe	38	73
Ciudad Bolivar	34	41
Sumapaz	32	10
20 Wards at the same time	134	0
Total No. of Participants	1,455	614
Total No. of Training	72	28

Source: DPAE

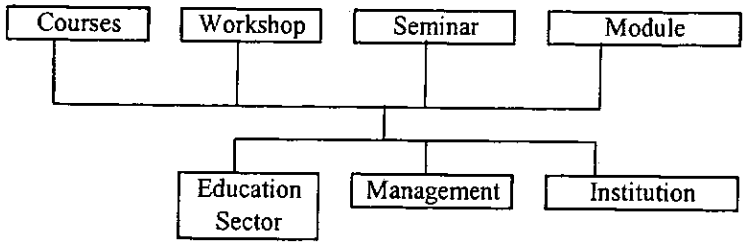
Appendix 2.10.6 Students (7-12 Years Old) Trained by DPAE on Vacation Program in November 1998

Ward	No. of Students
Usaquen	2,674
Chapinero	0
Santa Fe	900
San Cristobal	1,027
Usme	530
Tunjuelito	1,264
Bosa	1,645
Kennedy	947
Fontibon	0
Engativa	400
Suba	0
Barrios Unidos	0
Teusaquillo	0
Maritres	0
Antonio Narino	0
Candelaria	0
Puente Aranda	0
Rafael Uribe	550
Ciudad Bolivar	1,764
Sumapazs	0
Total	11,701

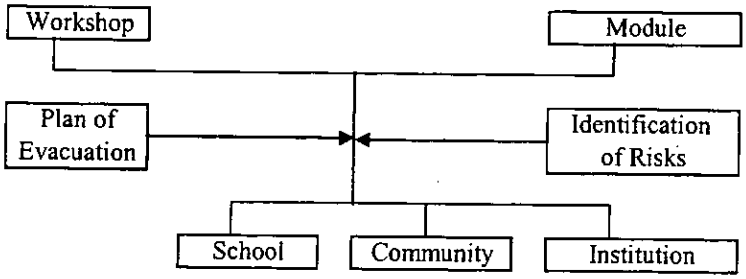
Source: DPAE

Appendix 2.10.7 Structure of Training by Cenrtro Academico of Fire Department

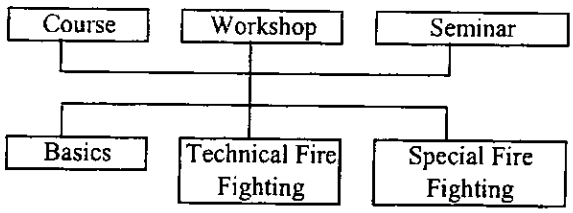
(1) External Training (Outside of Academy)



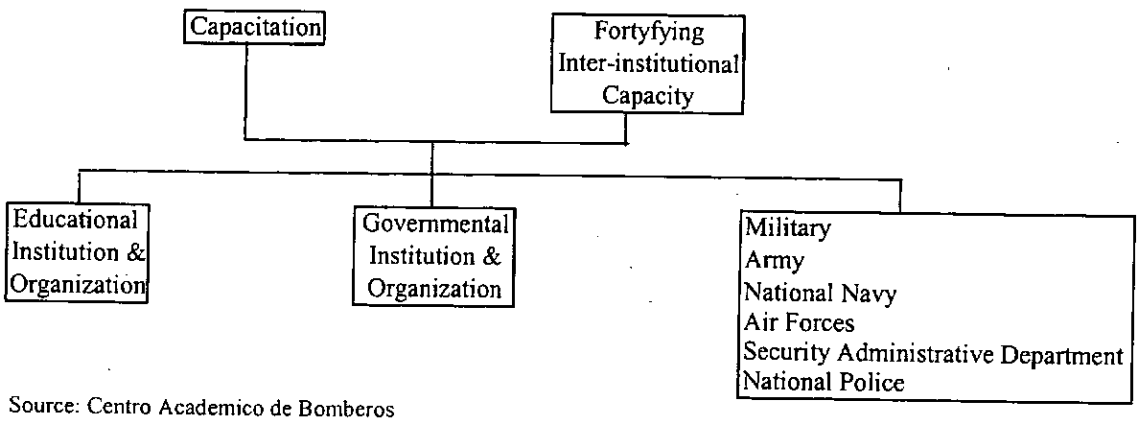
(2) External Training (through Fore Stations)



(3) Internal Training (Inside the Academy)



(4) Inter-Institutional Training



Source: Centro Academico de Bomberos

Appendix 2.10.8 Participation of the Modular by Type in 2000

Module No.	Name of Course	Total No. of Courses	Hours per Course	Total Hours for All Courses	Total No. of Participants
I	Formation of Brigades	28	3	84	531
II	Theory of Fire and Extinction	133	3	396	2,559
III	Plans of Emergency and Evacuation	28	3	84	481
IV	Use of Fire Proof Cabinet	36	3	108	569
V	Use of Portable Stairs/Ladder	13	3	39	187
VI	Prevention and Identification of Risks	24	3	72	391
VII	Basic Rescue in Fire	22	3	66	422
VIII	Trail of Claustrophobia	74	3	244	832
IX	Basic First Aid	3	3	9	59
X	Handling of Rods	1	3	3	6
XI	Rescue with Ropes	0	3	0	0
XII	Rescue of Men to Men	0	3	0	0
XIII	Rescue on Vertical Walls	0	3	0	0
Total		362		1,105	6,037

Source: Cuerpo Oficial de Bomberos, Centro Academico

Appendix 2.10.9 Training Provided by Red Cross

Internal Training		No. of Participants
No.	Topics	
1	Workshop for Monitoring Educative Brigades	60 volunteers
2	Education for Emergencie Plan	142 Civil Servants
3	Basic Module for Helping	57 volunteers
4	Basic Course in Telecommunication	18 volunteers
5	Education about SNDAD	15 Civil Servants
6	Talk about Network for Helping	22 Civil Servants
7	Workshop about Massive Events	25 volunteers
8	Workshop about Logistic in Operation	15 volunteers
9	Course for Instructors	40 volunteers
Sub-total		215 volunteers 179 Civil Servants
External Training		No. of Participants
No.	Topics	
1	Workshop on Prevention and Attention of Disaster	137
2	Definition and Organization of the Execution Plans	730
3	What to do in case of Emergency at Schools	337
4	Education of Local Committees of Emergencies	60
5	Conference of Health Sector in Tnjo	25
Sub-total		1,289 persons
Total		1,683 Persons

Source: "Un Horizonte Muy Prometedor; Balance Social 1999" Cruz Roja Colombiana

Appendix 2.10.10 Major Materials for Education, Training and Information for Prevention and Attention of Disaster

No.	Organization	Materials	Others
1	DPAE	1. Guidebook on Landslide (4,000 copies) 2. Guidebook on Inundation (6,000 copies) 3. Guidebook on Earthquake (8,000 copies) 4. Pamphlet on Mass Events (3,000 copies) 5. Pamphlet on DPAE (3,000 copies) 6. Material for "Primer Encountour of CLE" 7. Video on Earthquake (70 copies) 8. Video on Mass Events (50 copies) 9. Video on Landslide (50 copies) 10. Video on Inundation (30 copies) 11. Publication "Prevention & Attention of Emergency in Bogota, D.C./1998-2000 12. Guidebook I of Education Methodology on Prevention of Disaster After Class: Pre-school to 3rd Grade 13. Guidebook II of Education Methodology: Grade 4 to Grade 6 14. Guidebook III of Education Methodology: Grade 7 to Grade 11 15. School Plan for Risk Management: Teachers Guide I; Concept (5,000 copies) 16. School Plan for Risk Management: Teachers Guide I; Instruments and Tools for Methodology (5,000 copies) 17. School Plan for Risk Management: Students Guide 18. 3 kinds of Posters (3,000 copies) 19. TV news program on "Disaster Preparedness 20. Adversement in radio on "Forest Fire Prevention" 21. Guidebook of Prevention: Unstable Zones in Hillside in Santa Fe de Bogota"	Year 2000
2	DNPAD	1. My Friend, Wind: Prevention against Hurricanes 2. My Friend, Earth: Preparedness for Earthquake 3. My Friend, Forest: Prevention of Forest Fire 4. My Friend, Water: Prevention before Flood 5. How to Collaborate Scholl Plan into Disaster Prevention 6. Armor 11 Years: Protection of Life 7. Cantarin El Arroyo Feliz 8. Prevengamos Coloreando 9. Singing Mountain 10. Tsunami 11. Proetction of Life 12. Emergency Plan for Families 13. Prevention and Attention of Hurricanes	Year 1994
3	OPAD	1. Manual of Living Together in Temporary Dwellings 2. Guide for Design and Application of Municipal Plans of Contingency against Emergency and Disasters 3. How to live here: Manual of Consulting School Program of Disaster Prevention (2000) 4. Cortilla de la Pollologia (Book of Chicken) 5. School Plan of Emergency 6. Practical Guide for Elaboration of Municipal Plan of Cundinamarca 7. Catalogue of Environmental Disaster of Cundinamarca	
4	Fire Depertment	1. Manual Course of Firemen 2. Proposed Program for School Plan 3. Guide for Elaboration of School Plan of Emergency 4. Course of Re-training in 2001 5. Action Plan 2001 of Centro Academico 6. Secutity against Fire	
5	Red Cross	1. Manual of Disaster Prevention: Pollologia de los Disasters 2. Program of Community Educational for Disaster Prevention 3. Program of School Preparation for Diminishing Risks and Bringing Emergencies in Educational Plans 4. Plan for Family on Emergency 5. Prevention and Attention of Disaster-Inundation 6. Prevention and Attention of Disaster-Earthquake 7. Prevention and Attention of Disaster-Basic Guide 8. A Promising Horizon	- Training Center in Tabio (Cundinamarca)
6	Civil Defense	1. Conference of Desaster Prevention (1996) 2. Manual for First Aid (1985) 3. Who is and What has in Civil Defense Colombia? (2000) 4. Guide for Security Plan and Evacuation from School Establishment in case of Disaster (1985) 5. What to do in case of Disaster (1985) 6. Local Committee of Emergency 7. Civil Defense Colombia: Quarterly Magazine (1985)	- Training School in Funza (Cundinamarca)
7	Health Depantment	1. Management and Administration of Emergency and Disaster (with University of Bosque) 2. Capacitation of Emergency and Disaster in Bogota	
8	CAR	1. Prevention of Forest Fires: Guide for Preservation and Conservation Our Environment	

Appendix 2.10.11 Information of Community in Bogotá

No.	District	Major Organizations by Communities	Type of Disaster	Level of officials' interest in disaster prevention	Workshop, Training and Education by DPAE (Topic and Groups)	Possibilities for Organizations of Disaster Prevention
1	Usaquen		Landslide Inundation	Middle	JAC Mother's Community Group of Youth	Neighbourhood Brigage for emergency
2	Chapinero		Landslide	Middle	JAC	
3	Santa Fe		Landslide	High	Barrio groups	Neighbourhood Brigage for emergency
4	San Cristobal	Single mother group Elders group Youth group Cultural group	Landslide, Inundation	High	JAC	Neighbourhood Brigage for Emergency : 31 barrios have this group since 2.5 years ago. Members are still small. They were trained with district budget.
5	Usme		Landslide	Middle	Mother's Community (through ICBF) Rincon del ZEA (Through Junta de Defensa Civil) Security group JAC Teacher's and Father's Group (Through CADEL)	The Defensa Civil group has a contract with DPAE and local goverment for atention of emergency in the Rafael Uribe District.
6	Tunjuelito		Inundation	High	Mother's Community (through ICBF) Funta de Defensa Civil Security Group Health Group Brigade of Hospital Emergency JAC	none
7	Bosa		Inundation	High	JAC (Through DAACD) Funda de Civil Defense Mother's Community (through DABS, ICBF) Students (through CADEL)	Workshops for inhabitants and experts in the community begun. 2 month-project of 4 hours per course, contract with private company.
8	Kennedy		Inundation	Low	Mother's Community Committee of Users of Hospital of Kennedy	Neighbourhood Brigage for emergency
9	Fontibon		Inundation	Middle	Mother's Community	none
10	Engativa		Inundation		Mother's Community Volunteers of Civil Defense	none
11	Suba	Youth group Environment group Security group	Inundation Landslide	Middle	JAC Security Group Teachers Mother's Community	Neighbourhood Brigage for emergency
12	Barrios Unidos		none	Low	JAC	Neighbourhood Brigage for emergency
13	Teusaquillo		none	Low	JAC	none
14	Martires		none	Low		none
15	Antonio Narino	Single mother group Elders group Youth group Cultural group	none	Low		none
16	Puente Aranda		none	Low	Funta de Civil Defense	The industrial group has a brigage for technological risks
17	Candelaria		Inundation	Low	Security Group	none
18	Rafael Uribe		Landslide	Middle	JAC	none
19	Ciudad Bolivar		Landslide Inundation	Middle	Youth Group Mother's Group	none
20	Sumapaz		none	Middle		none

Source: DPAE

Appendix 2.10.12 10 Major Opinions of the Stakeholder Workshop Participants

Date	Past Participation to Workshops	Matters learned from the Past Workshops	Matters learned from This Workshop	Preferable Topics of Future Workshop
May 24	Yes: 11 persons No: 4 persons	- It is important to prevent and react before emergency. - Awareness of threat, vulnerabilitie and risks - Training and information for reaction to disaster	- Responsibilities of district entities for formation of inter-sector team - Difficult situations at evey level for preparation for the disaster - Experiences of disaster which can help increase prevention and attention of disaster - Awareness of lack of coordination and necessity of institutional coordination	- Action Plan - Strategy Plan - Training of an immediate reaction - International experience of disaster prevention - Institutional and operative coordination - Simulation - Contingency Plan
May 29	Yes: 13 persons No: 4 persons	- Primary infoamation of prevention and attention of disaste - Basic theoretical information of disaster management - Coordination of entities are necessary - People should be aware of the need of prevention - Education is needed - Monitoring of threat needs technology, but politicians think that technology is too expensive	- Dificiency of inter-institutional coordination - Awareness of other risks caused naturally - It is important for concerned entities to make dicision in case of disaster - The existence of DPAE - Sensitiveness towards the communty problems - Lack of inter-institutional information exchange and ignorance of the operation and administration of the system - Need to work together in disaster prevention - Still far away from achieving optimum results for disaster prevention - A vision of DPAE - Sharing experiences with other entities - The project of the City - Vulnerability and threat level to which community are exposed.	- Training and Workshop on emergency attention - Experience of disaster at community level - Inter-institutional coordination for risk proceeding - Community organization and local network to reduce vulnerabilities. - All related system of emergency prevention - Technical knowledge of Japanese institution - Industrial disaster - Communication by media in case of disaster - Planning of disaster prevention - Detailed presentation of educational materilas - Current regulations addressing disaster prevention, e.g. POT - Meeting of the district technical committee

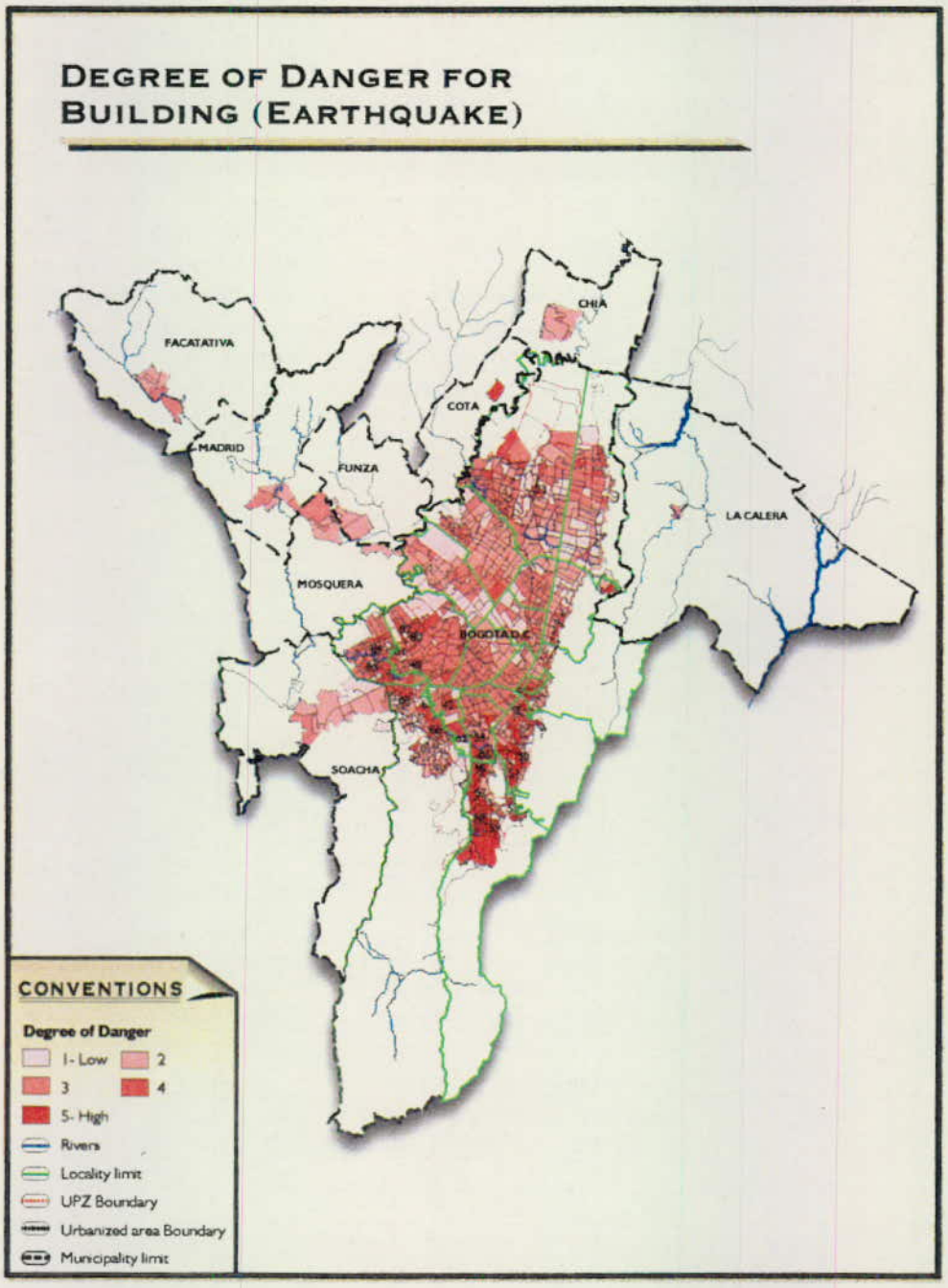
Appendix 2.10.13 Issues, Constraints, Potentials and Countermeasures

Item	Issues	Constraints	Potential	Countgermesures
A. Organization	1. Coordination of activities among concerned Agencies 2. Organizations are formed based on the regulations but no operation 3. Role of each organization as a member of committee is not clear 4. Major activities are dependent on outside agencies. 5. Evaluation structure (system) for disaster prevention measures (regular evaluation of disaster preparedness, and activity evaluation) is missing. 6. Disaster prevention policy is approved by all concerned entities or not.	1. Budget is not enough. 2. Parallel administration 3. Lack of regular full-time experts (frequent personnel changes)	1. Many organizations have already been established.	1. Regular consultation and discussion among government, private and community 2. Establishment of system of evaluation/reconsideration of disaster prevention measures 3. Establishment of permanent disaster prevention committees
B. Information	1. Distribution of the information of activities of concerned agencies is not well organized. 2. Distribution of materials produced by each agencies is not systematic. 3. Information among the organization is not well compiled. 4. Access to the information of disaster prevention by inhabitants is not easy.	1. Experience and lessons from sufferes are not utilized for the future planning. 2. Disaster history in detail cannot be handed down after ages.	1. Many materials (guidebook, video, phamphlet, manual, etc.) have been produced. 2. Colombia has experienced various disasters and received international support including Japan which has disaster experience	1. Decision of the survey items and establishment of structure to leave the detail lessons to the future 2. Establishment of system of information distribution by mass media, workshop, seminar 3. Establishment of disaster prevention center/corner where anyone can access 4. Evaluation and improvement of the materials produced by DPAE and OPAD 5. Set up a day or a week of disaster prevention and organize campaign
C. Human Resources	1. Awareness of the official staff in the concerned agencies is low. 2. Lack of leaders 3. Lack of experts 4. Lack of ecucation of disaster prevention for schools and local community 5. After the training, the follow-up activities and evaluation are not enough.	1. The number of staff is not enough.	1. Some agencies (DPAE, Red Cross, Civil Defense, etc.) have strong willingness to do their roles. 2. Some agencies have already worked with local communities. 3. Some agencies have got involeved some private sector. 4. There are international supports.	1. Increase of training, seminar, education among the related entities 2. Establishment of courses in schools 3. Training of experts with disaster prevention technique (fire distinguish, rescue, first-side, etc.) at community level
D. Facilities and Equipment	1. Lack of facilities such as disaster prevention center, training center. 2. Lack of equipment and reserves	1. Lack of budget		

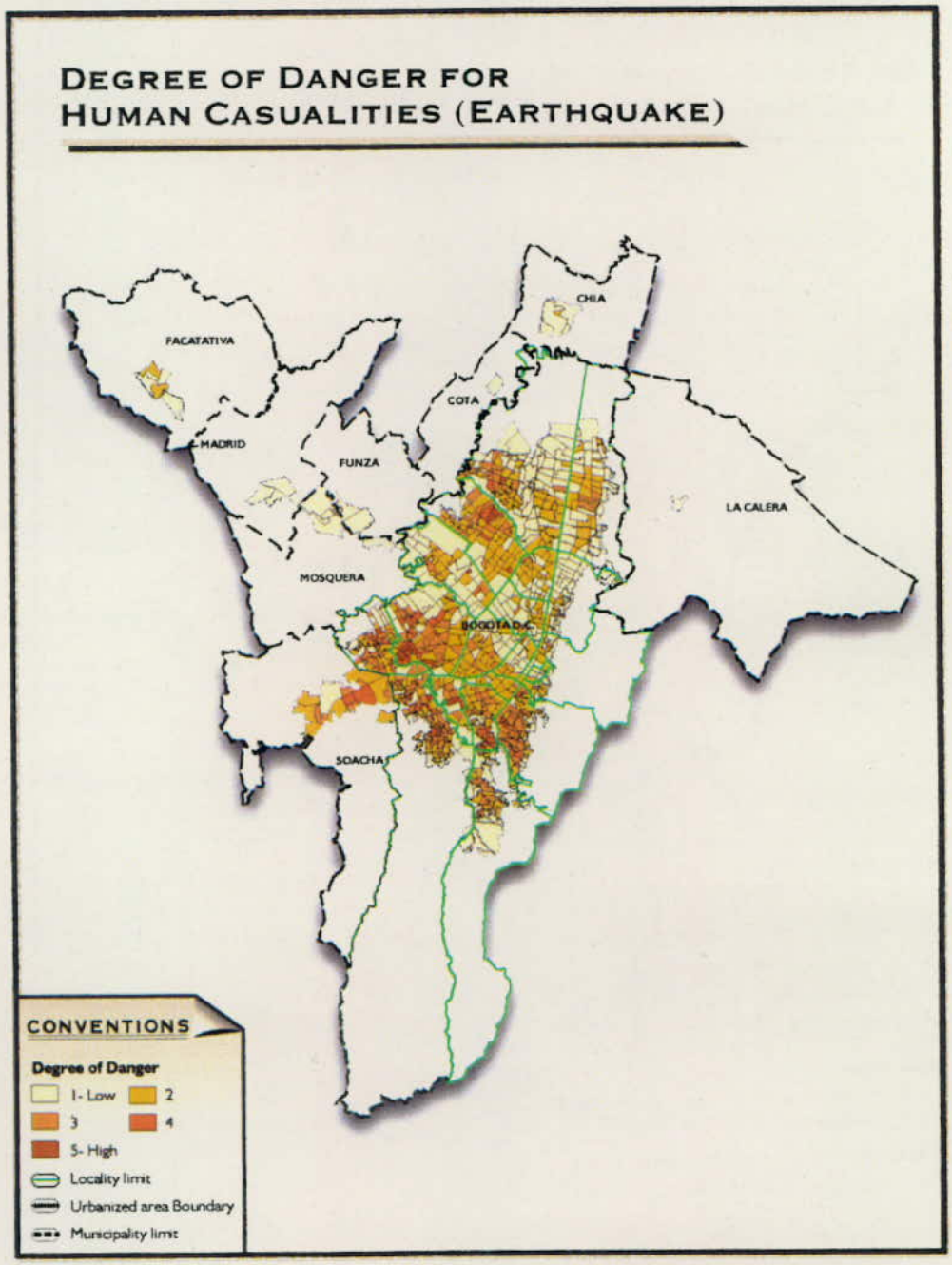
Appendix for Chapter 3

Appendix 3.3.1 Indicator for the Degree of Risk

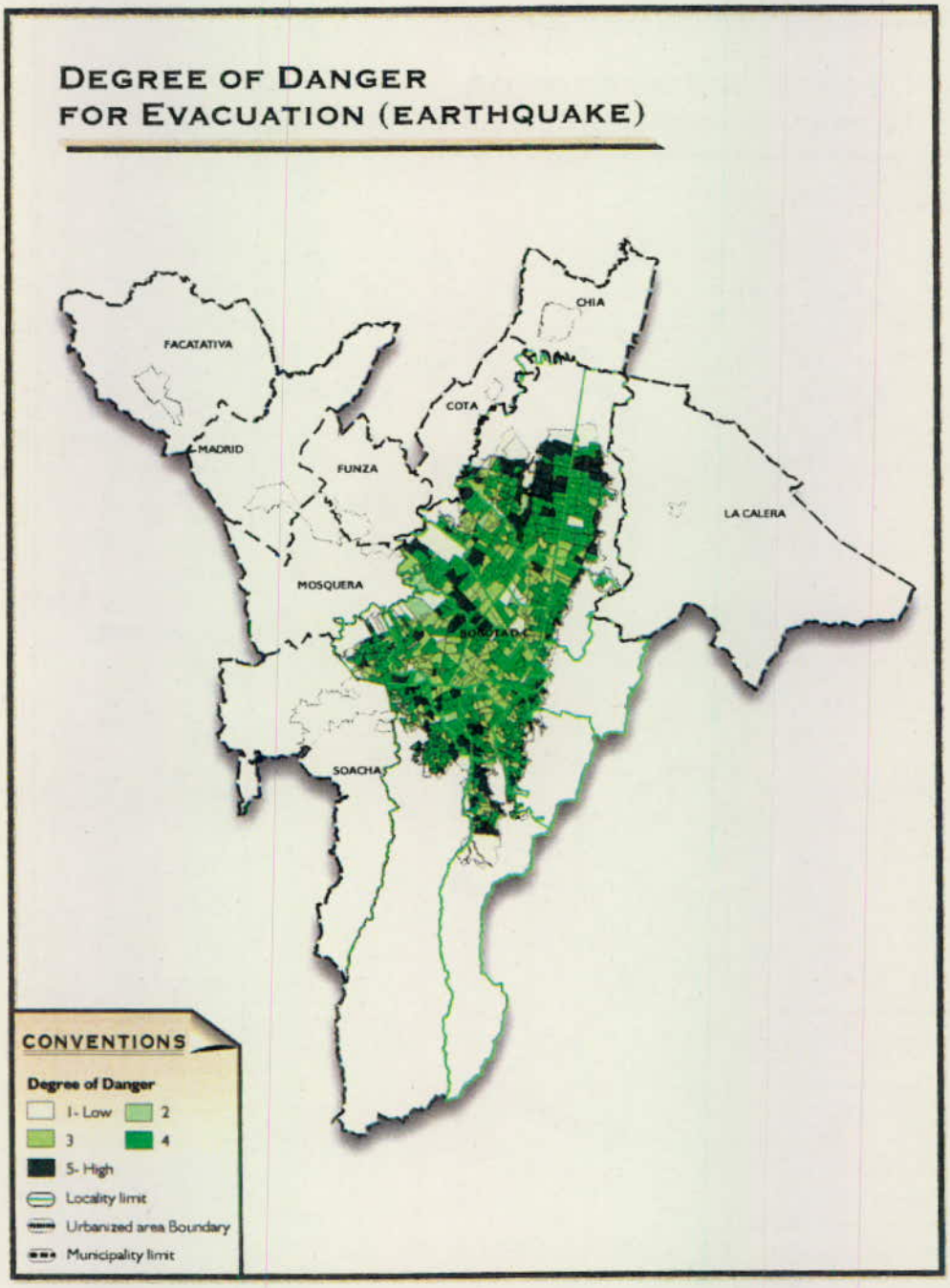
Earthquake	
Point 5	- Ratio of estimated building damage is more than 60 percent - Population density in the area is more than 450 people - Preparation ratio of open spaces (parks and roads) are less than 40% of the total area
Point 4	- Ratio of estimated building damage and population density in the area are within medium-high level (building damage: more than 40 to 60 percent, population density: more than 300 to 450 person per ha), and preparation ratio of open spaces are less than medium-low level (less than 20 to 60 percent) , or - Either one of the index is with high level and others with medium levels
Point 3	- Ratio of estimated building damage and population density in the area are within medium level (building damage: 20 to 60 percent, population density: 150 to 450 person per ha), and preparation ratio of open spaces are within medium level (40 to 80 percent) , or - Either one of the index is with medium-high level and others with low levels.
Point 2	- Ratio of estimated building damage and population density in the area are within medium-low level (building damage: 0 to 40 percent, population density: 0 to 300 person per ha), and preparation ratio of open spaces are within medium-high level (60 to 100 percent) , or - Either one of the index is with medium level and others with low levels.
Point 1	- Ratio of estimated building damage is less than 20 percent. - Population density in the area is less than 150 people per ha. - Preparation ratio of open spaces (parks and roads) are more than 80% of the total area
Landslide	
Point 5	- High occupancy rate of risk proved area 80 to 100 % of total area
Point 4	- Medium- high occupancy rate of risk proved area 60 to 80 % of total area
Point 3	- Medium occupancy rate of risk proved area 40 to 60 % of total area
Point 2	- Medium-low occupancy rate of risk proved area 20 to 40 % of total area
Point 1	- Low occupancy rate of risk proved area 0 to 20 % of total area
Flood	
Point 5	- High number of affected building probability and affected population probability
Point 4	- Medium-high number of affected building probability and affected population, or - Either one of the index is low and the other is high
Point 3	- Medium number of affected building probability and affected population, or - Either one of the index is low and the other is medium-high, or - Either one of the index is medium-low and other is high
Point 2	- Medium-low number of affected building probability and affected population, or - Either one of the index is low and the other is medium
Point 1	Low number of affected building probability - Low number of affected population probability
Industrial Disaster	
Point 5	- High rate of fire breakout rate
Point 4	- Medium-high rate of fire breakout rate
Point 3	- Medium rate of fire breakout rate
Point 2	- Medium-low rate of fire breakout rate
Point 1	- Low rate of fire breakout rate



Appendix 3.3.2 Degree of Danger for Building



Appendix 3.3.3 Degree of Danger for Human Casualty



Appendix 3.3.4 Degree of Danger for Evacuation

Appendix for Chapter 4

APPENDIX 4.2.1 ON SELECTION OF SCENARIO EARTHQUAKE

1. SCENARIO EARTHQUAKE IN SEISMIC MICRO ZONING STUDY

In general, seismic micro zoning study is made to quantitatively estimate the damage and deficiencies after major earthquake, for the purpose of establishing effective disaster mitigation measures.

The seismic micro zoning study first defines fault model for scenario earthquakes. The parameters of scenario earthquake are defined from historical earthquake records, fault studies. The most probable and the most influential earthquakes are selected for scenario earthquake.

2. EXISTING SEISMIC CODE AND SEISMIC MICRO ZONING STUDY IN COLOMBIA

a) National seismic macro zoning and seismic code

In Colombia, seismic macro zoning study has been completed in 1996 to establish seismic hazard evaluation at national level using database of active faults, historical records, and instrumental records of earthquake. The study mentions 0.2g is expected base acceleration for 475 years return period at Bogotá and eight municipalities.

b) Base acceleration used in MZSB97

Existing seismic micro zoning study for Bogotá completed in 1997 deals three scenario earthquakes. Among them, the parameters for near scenario earthquake is defined as magnitude 6.4, the distance from Bogotá to the fault as 20km, and base acceleration as 0.2g.

c) Limitations of existing study

The existing study deals only in Bogotá, and base acceleration is assumed to be 0.2g in whole Bogotá.

3. ESTIMATION OF BASE ACCELERATION IN THIS STUDY

a) Detailed Procedure of calculation

This study needs to deal Bogotá and eight municipalities. To calculate more realistic ground motion for an area larger than existing study, it is necessary to incorporate the decay of acceleration at base along with the distance from fault. For this reason, specific fault location is assumed, and then attenuation of base acceleration is incorporated.

Among faults listed in MZSB97 as shown in Table 1, fault with higher activity rate and higher magnitude is selected for scenario earthquake.

This study maintains several parameters as assumed in the existing study in more specific manner. They are: magnitude as 6.4, the closest distance from center of Bogotá to the ruptured segment of fault as 20km, base acceleration at the center of Bogotá as 0.2g.

b) Detailed procedure of scenario earthquake selection for case-1 and case-2

The existing study lists two active faults within the radius of 50km from Bogotá, No. 6 and No. 7. Two faults have almost same parameters as a whole, maximum probable magnitude, length, and activity rate. The difference between two faults are distance. The fault No. 6 contains a segment with high and moderate, while the fault No. 7 contains segment with activity rate of moderate and low. Therefore, fault No. 6 was selected as a scenario earthquake. The length of rupture segment is defined as 10 km, which is taken from total length of active segment, and the assumed rupture length is reasonable for a class of earthquake with assumed magnitude.

The scenario earthquake for case-2 is selected from list of faults as shown in Table 2 by same principle as in case-1. There are other faults that have larger magnitude than No.27. However, they are not used because they are much distant than No. 27 fault to study area, so that base acceleration is less than that by fault No. 27 due to the attenuation.

4. LIMITATIONS AND RECOMMENDATIONS

The parameters used in this study are based on the assumption in existing study, which is based on the site recognition. Trench study or geophysical study to evaluate fault activity rate is recommended to improve the accuracy in probability estimation for scenario earthquake.

Table 1 Detailed List of Faults for Case-1 Scenario Earthquake

No.	Name of Fault	Longitude (km)	Longitude with Neotechtonic Features (km)				Activity Rate	Data Quality	Fault Type	Maximum Probable	Distance from Bogot
			High (km)	Medium	Low (km)	Total (km)					
1(-)	Bogota	50			10	10	L	C(?)	I	6.4	3
2(+)	Ubaque	15			4	4	L	C	I	6.0	20
3(+)	Sabaneta	15		1	2	3	L-VL	C	I	5.7	40
4(+)	Corraleja	10			3	3	VL	C	I	5.8	45
5(+)	Fusagasuga	10			5	5	VL	C	I	6.0	40
6(*)	La Cajita	35	5		5	10	M	B	ID	6.4	30
7(+)	Rio Tunjuelito	35		5	5	10	M	B	I	6.4	25
8(+)	Facatativa S-W	10		2	2	4	L	C	SI	5.8	40
9(+)	El Meson	20		2	3	5	L	C	SI	6.1	25
10(+)	Soacha	10		3		3	L	B	IS	5.8	15
11(+)	Usaquen	30(?)			5	5	L	C	S	6.0	15

Note: (-): Active Fault; (+): Potentially Active Fault; (*):Fault of Uncertain Activity
H: High; M: Medium; L: Low; VL: Very Low
A: Good; B: Acceptable; C:Insufficient
I: Inverse; N: Normal; D: Dextal; S: Sinistral

Source: Microzonificacion Sismica de Sabta Fe de Bogota, INGEOMINAS (1997)

Table 2 Detailed List of Faults for Case-2 Scenario Earthquake

Faul System	No.	Name of Fault	Longitude (km)	Longitude with Neotechtonic Features (km)				Activity Rate	Data Quality	Fault Type	Maximum Probable	Distance from Bogota
				High (km)	Medium	Low (km)	Total (km)					
Romeral	1(*)	Armenia	60	3	10	9	22	H-M	B	ID	6.8	180
	2(-)	Manizales	40							I?	6.5	165
	3(*)	Montenegro	45	10	10		20	H-M	C	ID	6.7	190
Palestina	4(*)	Palestina	60					M-L		IS?	7.0	180
Chapeton - Pericos	5(+)	Chapeton	25			5	5	M-L	B	ID	6.0	125
Cucuana Río Bogota	6(+)	Cucuana	55		8	14	22	M	B	D	6.7	170
	7(+)	Cucuana Este	55			5	5	M-L	B	D	6.5	115
Ibague	8(*)	Cocora	60	8	25		33	M	B	D	6.9	160
	9(*)	Ibague	45	35	5		40	H	A	D	7.0	110
	10(+)	Piedras	20		6	8	14	M	B	DI	6.4	85
Viani	11(-)	Viani	40		2	8	10	L	C	D	6.5	75
Samaria - La Colorada	12(+)	El Choho	30		5	1	6	L	C	ID	6.2	190
	13(*)	Doima	35	5	9	2	16	H	B	ID	6.7	115
Magdalena	14(+)	Mulatos	60			20	20	M-L	B	I	6.7	110
	15(+)	Honda Sur	45		9	7	16	M-L	B	I	6.7	90
	16(+)	Honda Narte	70			5	5	L-VL	B	IS?	6.1	125
	17(+)	Cambras	70			5	5	L	C	IS?	6.2	130
	18(+)	Cambao Norte	60			3	3	VL	B	I	6.0	90
	19(*)	Cambao Sur	20	3			3	M	B	ID	6.2	75
	20(+)	Alto del trigo	90			6	6	VL	C	ID	6.2	80
	21(+)	Bituima Norte	60		10	2	12	L	B	IS?	6.3	80
	22(+)	Bituima Sur	30			7	7	L	C	I	6.2	70
Noroeste	23(*)	El Palmar	20	1	8		9	M	B	S	6.2	100
Servita - Santa Maria	24	Colepato	40(*)		18		18	M	B	I	6.7	70
	25	Servita	60(*)		26		26	H-M	B	I	6.9	65
	26	Santa - Maria	90(+)			15	15	L	C	I	6.8	100
	27	Guayuriba	60(*)	11	18		29	H	B	ID	7.0	80
	28	Lengupa	65(+)		3	6	9	L	C	I	6.6	105
	29	Colonia	50(+)		10		10	L	B	I	6.5	80
	30	Acacias	30(*)	4	9		13	M	B	I	6.6	80
	31	Tesallia	75(+)		7	15	22	M	C	I	6.8	95
Guaicaramo	32	Cumaral	25(*)	7			7	H	B	I	6.3	80
	33	Guaicaramo Centro	80(*)	24	20		44	H	B	ID	7.2	135
	34	Guaicaramo Sur	65(*)	3	5		8	M	B	I	7.1	90
	35	Guaicaramo Norte	50(+)		8	3	11	M	C	I	6.8	200
	36	Guaicaramo W	35(+)		8		8	M	B	I	6.5	135
	37	Pajarito	60(*)	5	9		14	M	C	ID	6.7	200
Yopal	38	Yopal	65(*)	12	12		24	H	B	I	7.1	195
	39	San Pedro	80(*)		38		38	H	B	I	7.2	145
	40	Upamera	20(+)		10		10	M-L	B	IS(?)	6.4	160
Zona Axial	41	Boyaca	80(+)		3	2	5	L-VL	C	I	6.3	200
	42	San Francisco	15(+)			1	1	L-VL	C	I	5.3	150
	43	Soapaga	100(+)		4	3	7	L-VL	C	I	6.5	180

Note: (-): Active Fault
(+): Potentially Active Fault
(*):Fault of Uncertain Activity

H: High
M: Medium
L: Low
VL: Very Low

A: Good
B: Acceptable
C:Insufficient

I: Inverse
N: Normal
D: Dextal
S: Sinistral

Source: Microzonificacion Sismica de Sabta Fe de Bogota, INGEOMINAS (1997)

APPENDIX 4.2.2 PROCEDURES AND LIMITATION IN THE EVALUATION OF AMPLIFICATION BY SUBSOIL

1. DETAILED PROCEDURES IN THIS STUDY

1) The study team obtained transfer function in subsurface geology (curve that represents period of input ground motion versus amplification of ground motion) calculated at 57 points based on boring data within Bogotá for different level of input ground motion at base acceleration. The obtained curve contains predominant period of ground amplification up to ten seconds.
2) The numerical ground models such as thickness, shear wave velocity, density of each soil stratum used for calculation, were not fully available. The numerical model partly available contains approximation of upper subsurface, but lacks information on deeper stratum to sufficiently explain the mechanism of long predominant period.
3) The study team also obtained three different seismic waveform records as input motion. They have different frequency content, duration, and maximum amplitude, recorded similar condition as respective scenario earthquake.
4) Strong motion at ground surface is calculated using three input waveforms for scenario earthquakes by three different input levels (0.05g, 0.1g, 0.2g) at 57 points.
5) Amplification factor, defined by peak ground acceleration divided by input acceleration level, is calculated at 57 points for three input levels by three scenario cases. Amplification factors are averaged by geo technical zones.
6) Base acceleration for three scenario cases are calculated by attenuation formulae at the center of each micro zone. The closest distance to the fault segment is used for the distance in attenuation equation.
7) Peak ground acceleration is calculated by multiplying base acceleration by averaged amplification factor, defined by geo technical classification, scenario earthquake, and input base acceleration.
8) For micro zones outside Bogotá that lacks geotechnical information, same values of averaged amplification factor are applied as in Bogotá, depending on the geotechnical zone, scenario case, and base acceleration.

The advantage of this method lies in the fact that it can reflect the difference in frequency content of different scenario earthquakes, and spatial difference in base acceleration. Moreover, this method can be uniformly applied to Bogotá and surrounding municipalities.

In case-1, three geotechnical zones demonstrate amplification factor less than one, but such phenomena are observed in real records as the result of non-linear effect of soil during large earthquake.

Table 1 Averaged Amplification Factors by Geotechnical zone

		Scenario case and base acceleration level								
		Case 1			Case 2			Case 3		
Geotechnical zone	Name	0.05g	0.10g	0.20g	0.05g	0.10g	0.20g	0.05g	0.10g	0.20g
1	Sedimentary rocks	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	Residual, piedmont	2.60	2.38	2.12	2.49	2.40	2.25	2.42	2.37	2.29
3	Lake deposit A	1.69	1.27	0.81	3.17	2.69	2.05	3.28	2.84	2.26
4	Lake deposit B	1.32	0.99	0.66	2.54	2.18	1.67	2.84	2.46	2.00
5	Terrace and cone	2.05	1.73	1.34	2.71	2.58	2.27	2.85	2.58	2.32
6	Riverbed and wetland	1.33	1.01	0.62	1.81	1.67	1.44	2.26	1.89	1.45

Source: JICA Study Team

2. SIMPLIFIED METHODS PROPOSED IN JAPAN

Simplified methods to estimate relative ground amplification factor is proposed in Japan as shown in Table 2, in case detailed information on dynamic properties of the ground is not available. These methods are based on ground data in Japan, and classification is made on different points of view. For example, Shima's classification is made from the viewpoint of geology, while Midorikawa's classification is made from the viewpoint of the age in geological unit, thus these method cannot be directly applicable in this study. Besides, these methods only shows relative amplification factor for any case, and does not take into account the difference in frequency content or intensity of strong ground motion.

Table 2 Simplified methods to estimate relative ground amplification factor

Geological unit	Relative amplification factor
Peat	1.6
Humus soil	1.4
Clay	1.3
Loam	1.0
sand	0.9

Shima (1978)

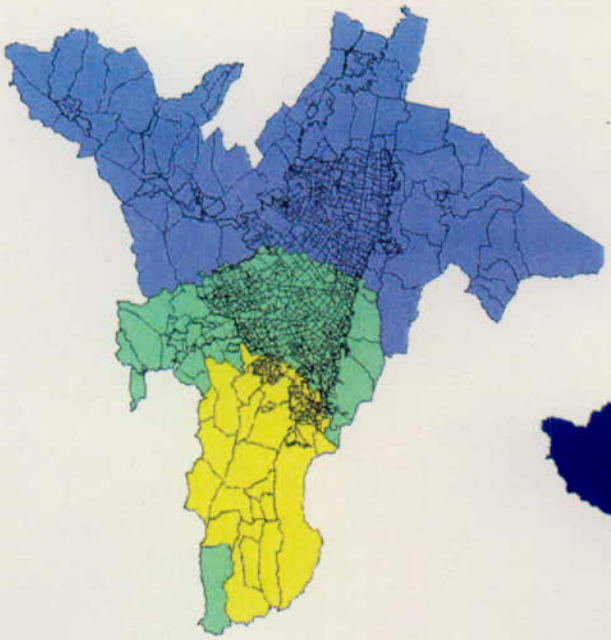
Geological unit	Relative amplification factor
Holocene	3.0
Pleistocene	2.1
Quarternary volcanic rocks	1.6
Miocene	1.5
Pre-Tertiary	1.0

Midorikawa (1987)

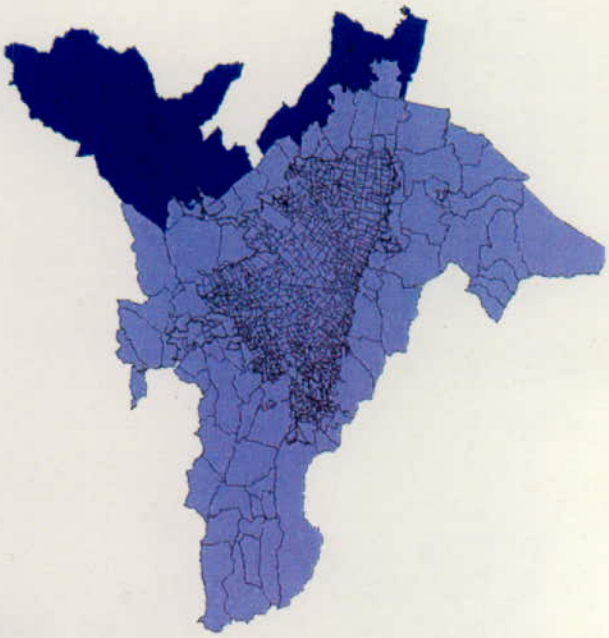
Source: "Manual for Zonation on Seismic Geotechnical Hazards" by International Society for Soil Mechanics and Foundation Engineering (1993)

3. LIMITATION OF EXISTING STUDY AND RECOMMENDATIONS

Above all, numerical ground model used to calculate amplification curve was not fully available. The available information suggests that it is assumed in calculation of soil response that deep stratum will be excited in case of large earthquake. However, dynamic properties of deep stratum are not well studied, and such records are not . Though detailed geotechnical boring data was available in Bogotá, collected borings in municipalities in Cundinamarca lacks such data, and maximum depth was limited to 30m. It is recommended that dynamic properties of subsoil should be studied to improve the reliability of the geotechnical model.



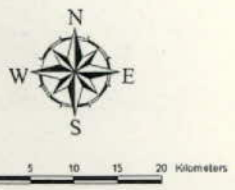
La Cajita Fault Model



Guayuriba Fault Model



Subduction Model

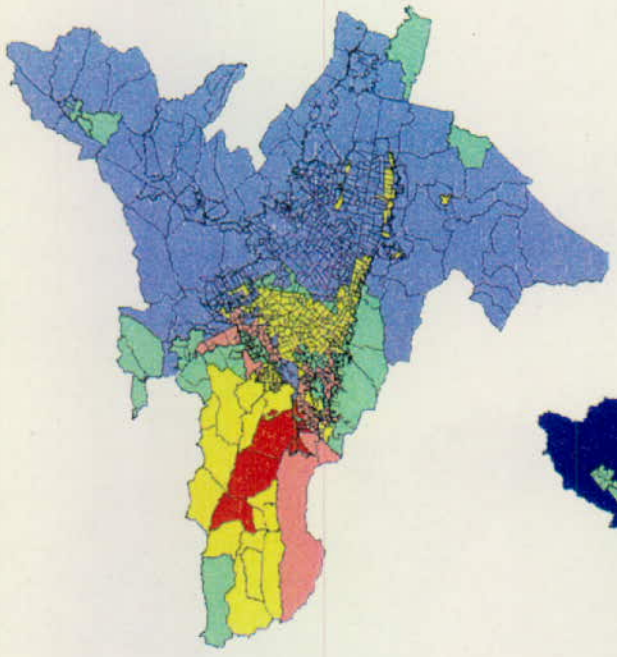


LEGEND

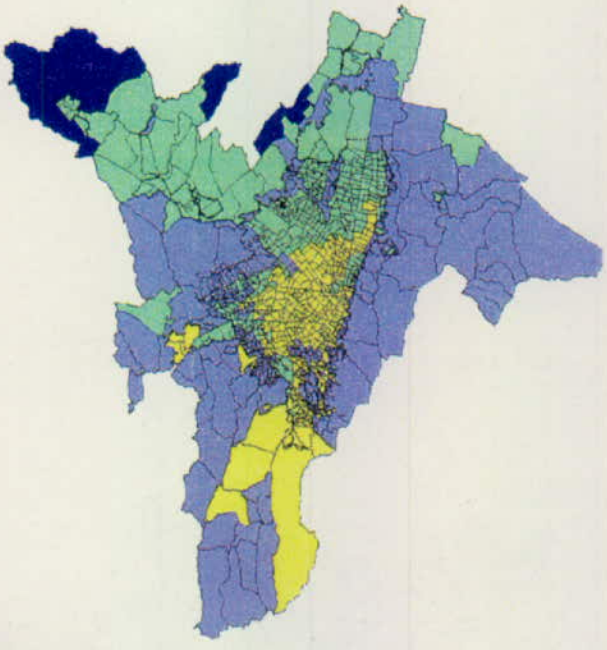
Basement Acceleration (g)

- 0.7 - 1
- 0.5 - 0.7
- 0.3 - 0.5
- 0.2 - 0.3
- 0.1 - 0.2
- 0 - 0.1

Appendix 4.2.3	Basement Acceleration



La Cajita Fault Model



Guayuriba Fault Model



Subduction Model





LEGEND

Peak Ground Acceleration (g)

- 0.7 - 1
- 0.5 - 0.7
- 0.3 - 0.5
- 0.2 - 0.3
- 0.1 - 0.2
- 0 - 0.1

Appendix 4.2.4	Peak Ground Acceleration Distribution

Appendix 4.2.5 Modified Mercalli Intensity Description

MMI	PGA (gal)	Description of shaking Severity	Full Description
I.	2		Not felt. Marginal and long period effects of large earthquakes
II	4		Felt by persons at rest, on upper floors, or favorably placed.
III.	8		Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake
IV	16		Hanging objects swing. Vibration like passing of heavy trucks, or sensation of a jet like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls an frame creak.
V.	33	Light	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing close, open. Shutters, picture move. Pendulum clocks stop, star, change rate.
VI	65	Moderate	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, etc, off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school): Trees, bushes shaken (visibly, or heard to rustle).
VII	130	Strong	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
VIII	259	Very Strong	Steering of motor cars affected. Damage to masonry C; partial collapsed. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	518	Violent	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapsed; masonry B seriously damaged. (General damage to foundations). Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters.
X	1033	Very Violent	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly
XI			Rails bent greatly. Underground pipelines completely out of service.
XII			Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Source: Richter, C.F., 1958. Elementary Seismology. (PGA correspondence is calculated using Trifunac & Brady's formula.)

APPENDIX 4.2.6

METHODS TO ESTIMATE LIFELINE INFRASTRUCTURES DISTRIBUTION

1. INTRODUCTION

The information of the existing lifeline distribution systems was used for seismic damage estimation on the lifeline by the JICA Study team in 2001. However, the most of data for the existing lifeline systems were incomplete and not sufficient to estimate realistic impacts of the earthquake on the cities. Therefore, the missing parts of the information of the cities' systems were estimated based on the existing data and available information. Methods to estimate lifeline distribution systems are described in this section.

2. OBJECTS OF ESTIMATION

The objects to be estimated are distribution networks of lifelines: water supply pipe network, natural gas supply pipe network, electric supply wire network and telephone wire network. Table 1 shows the specification of the networks.

Table 1. Specifications of Concerned Lifelines Networks

Types of lifeline networks	Specifications	Sources of Information
Water supply	Water supply pipes with 1 to 78 inch diameters. The lines between buildings and the networks are not included. In Cundinamarca, only urban area is the Study's object since information on its rural area is not available.	EAAB
Natural gas supply	Low-pressure (60psi) natural gas supply network. In Cundinamarca, only Chia and Soacha have natural gas supply system	Gas Natural
Electric supply	11kv electric supply wire network.	Codensa
Telecommunication	Telephone wire network. Wires connecting between poles and houses are not included.	ETB & Capitel

3. SUMMARY THE ORIGINAL DATA

The original data and their reliability are summarized in Table 2. Accuracies of estimated locations of the lifeline networks depend on the format and quality of the original data. Table 3 indicates the accuracies of the information and the estimations on the lifeline networks for different data type.

Table 2 Summary of Original Data for the Estimation

Area		Water	Gas	Electricity	Telephone	
		EAAB	Gas Natural	Codensa	ETB	CAPITEL
Bogotá	urban	GN	IV	PN,FT	GD&IV	GN
	rural	GN	IV	PN,FT	GD&IV	GN
Chia	urban	CN	N	N	N	---
	rural	CN	N	N	N	---
Cota	urban	CN	---	PN	N	---
	rural	N	---	PN	N	---
Facatativa	urban	CN	---	N	N	---
	rural	N	---	N	N	---
Funza	urban	CN	---	PN	N	---
	rural	N	---	PN	N	---
La Calera	urban	CN	---	N	N	---
	rural	N	---	N	N	---
Madrid	urban	CN	---	N	N	---
	rural	N	---	N	N	---
Mosquera	urban	CN	---	PN	N	---
	rural	N	---	PN	N	---
Soacha	urban	GN	IV	PN	GD&IV	GN
	rural	GN	IV	PN&N	N	---

Table 3. Legend and Accuracy of Estimation

Legend	Form of information	Accuracy of estimation
GN	GIS Network data	High
GD	GIS data	High
CN	CAD drawing Network data	High
PN	Printed Network data	Middle
FT	Figure table	Middle
IV	Information on figure by interview	Middle
N	No information available	Low
---	Network does not exist	

4. METHODOLOGY OF DISRIBUTION ESTIMATION

In this section, details of the original data and the methodologies of the estimation are explained for the lifelines.

4.1 Water Supply Network

4.1.1 Object of Study

The pipes with diameters between 1 and 78 inches are the sole object for the water distribution network estimate. The water supply lines between the main distribution pipe network and houses and/or buildings are not concerned.

4.1.2 Status of the Original Data

The original data contains information on topology, diameter and material of the distribution pipes in the most of urban areas covered for the Study. There was no

information available for the urban areas in Cota and Facatativa. Information on all of the rural areas in Cundinamarca was not available either.

Table 4. Details of the Original Data of Water Supply Networks

Area		Type of Data	Information		Figure
			Diameter	Material	
Bogotá	urban	GIS	O	O	Figure 1
	rural	GIS	O	O	
Chia	urban	CAD	O	O	Figure 2
	rural	CAD	O	O	
Cota	urban	CAD	O	X	Figure 3
	rural	---	---	---	---
Facatativa	urban	CAD	O	X	Figure 4, 5
	rural	---	---	---	---
Funza	urban	CAD	O	O	Figure 6
	rural	---	---	---	---
La Calera	urban	CAD	O	O	Figure 7
	rural	---	---	---	---
Madrid	urban	CAD	O	O	Figure 8
	rural	---	---	---	---
Mosquera	urban	CAD	O	O	Figure 9
	rural	---	---	---	---
Soacha	urban	GIS	O	O	Figure 1
	rural	---	---	---	---

O: Available
X: Not available

4.1.3 Method of Estimation

The quantities and quality of the original data on the water networks were adequate for the Study purpose. Therefore, it was not necessary to develop a method to make estimation

4.2 Natural Gas Supply Network

4.2.1 Main Target

Low-pressured (60psi) natural gas supply system was chosen for the Project. Such a network exists only in Bogotá, Soacha and Chia but not in the other 6 municipalities in Cundinamarca.

4.2.2 Details of the Original Data

The total lengths of the gas distribution pipeline in Bogotá and Soacha were determined based on the interviews given to the residents by Gas Natural Company. No information for the system in Chia was available. Table 5 shows the total lengths of the gas distribution systems in Bogotá and in Soacha.

Table 5 Total Lengths of the Natural Gas Networks in Bogotá and in Soacha

City	Total length of the natural gas network (m)
Bogotá	8,023,800
Soacha	584,113

4.2.3 Method of Estimation

Two assumptions are adopted to estimate the natural gas network distribution system.

Such adopted assumptions are as follows.

1. Length of network segments is proportional to the numbers of buildings within a micro-zone.
2. Average network segment length per building in Chia is the same as that in Soacha.

Figure 1 shows the flow chart of the method to estimate gas distribution network lengths.

Bogota

Averaged gas pipeline length per building in Bogota × Numbers of buildings at a micro-zone = Estimated gas pipeline length in a micro-zone of total Study area

Where

$$\text{Averaged gas pipeline length per building in Bogota} = \frac{\text{Total length of the pipelines in Bogota}}{\text{Total number of buildings in Bogota}}$$

Soacha

Averaged gas pipeline length per building in Soacha × Numbers of buildings at a micro-zone = Estimated gas pipeline length at a micro-zone in Soacha

Where

$$\text{Averaged gas pipeline length per building in Socha} = \frac{\text{Total length of the pipelines in Soacha}}{\text{Total number of buildings in Soacha}}$$

Therefore, the gas network length in Chia can be estimated as below:

Chia

Average length per buildings of Soacha × Numbers of buildings at a micro-zone in Chia = Estimated gas pipeline length at a micro-zone in Chia

Figure 1 Method of Estimation of Natural Gas Network Distribution

Table 6 below summarized the data that were used to estimate lengths of the gas supply networks.

Table 6 Summary of Figures of the Natural Gas Networks

Area	Total length of the Natural gas network (m)	Number of buildings (nos)	Average length per buildings (m/bui.)
Bogotá	8,023,800	752,593	10.66
Soacha	584,113	57,930	10.08
Chia	182,544	18,104	10.08

4.3 Electric Supply Network

4.3.1 Object of Study

Electric distribution network system with 11 kV power supply was selected for the Study. The network consists of both overhead cable and under ground cable systems. Therefore, the lengths of overhead cable and of under ground cable are estimated separately.

4.3.2 Details of the Original Data

The map of the local electric distribution system network was provided by the supplier, Codensa. Also the table for the lengths and types for both overhead and under ground cables was provided by Codensa.

4.3.3 Method of Estimation

1) Summary of the method

Several methods were adopted to estimate the electric network according to the given information. Figure16 shows the relationship between the study area and the map. From the Figure 16 the study area was divided into 3 parts Described below.

1st part: High-density network area

This area corresponds to the urban area of Bogotá. An appropriate estimation method was developed for the high-density area since it was difficult to digitize the network.

2nd part: Low-density network area

This area corresponds to all the parts of Cota, Funza, and Mosquera and some part of Chia, Madrid, Soacha, and Bogotá. The length of the network was measured by using GIS system directly.

3rd part: The area which is out of the drawing

This area corresponds to Chia, Facatativa, La Calera and some parts of rural area of Bogotá and Soacha. The drawing doses not cover all study area. Therefore correlation method, which was derived from the information of 2nd part, were adopted.

Table 7 shows the summary of the areas and the adopted methods for estimation of the electric cable distribution.

Table 7 Summary of Methods for the Electric Distribution Networks

City	urban/rural	Part	Method	Accuracy
Bogotá	urban	1st	Estimation by drawing & table	Medium
	rural	1st 3rd	Estimation by drawing & table Estimation by correlation	Medium
Chia	urban	3rd	Estimation by correlation	Low
	rural	3rd	Estimation by correlation	Low
Cota	urban	2nd	Directly measuring from the drawing	High
	rural	2nd	Directly measuring from the drawing	High
Facatativa	urban	3rd	Estimation by correlation	Low
	rural	3rd	Estimation by correlation	Low
Funza	urban	2nd	Directly measuring from the drawing	High
	rural	2nd	Directly measuring from the drawing	High
La Calera	urban	3rd	Estimation by correlation	Low
	rural	3rd	Estimation by correlation	Low
Madrid	urban	3rd	Estimation by correlation	Low
	rural	3rd	Estimation by correlation	Low
Mosquera	urban	2nd	Directly measuring from the drawing	High
	rural	2nd 3rd	Directly measuring from the drawing Estimation by correlation	Medium
Soacha	urban	2nd	Directly measuring from the drawing	High
	rural	2nd 3rd	Directly measuring from the drawing Estimation by correlation	Medium

2) Estimation method for 1st part:

The assumptions, which are adopted in the estimation for 1st part, are as follows.

1. The length of the network in a certain area is proportional to the area in a Codensa's local service zone.
2. The length of network in a area of the local service zone is proportional to the numbers of buildings in the same area.

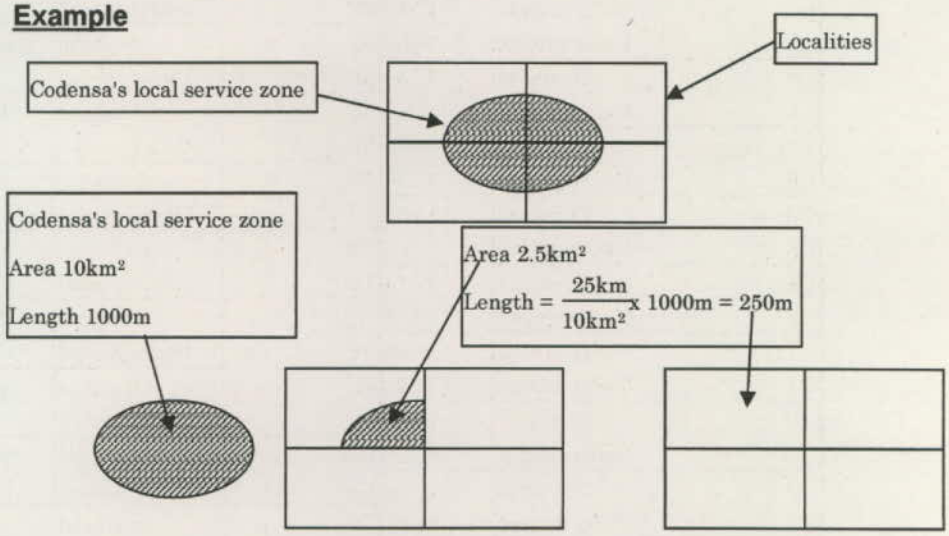
Because the network map given by the electric provider, Codensa, was available, it was difficult to trace and measure all the dense networks in 1st part. Also, the micro-zones were smaller than Codensa's local service zones. Therefore, the lengths of Codensa's local service zones were converted into localities according to area size. After the conversion, the lengths of localities were converted to micro-zones. Figure 2 shows the flowchart of the estimation method for the 1st part.

Summing up the length from the Table.8 for each Codensa's local service zone. (See Table 8)

Identifying Codensa's local service zone on GIS.

Distributing the length to localities from Codensa's local service zones according to the area.

Example



Deliver the length of electric supplying wire in the micro-zone from localities according to number of building.

Example

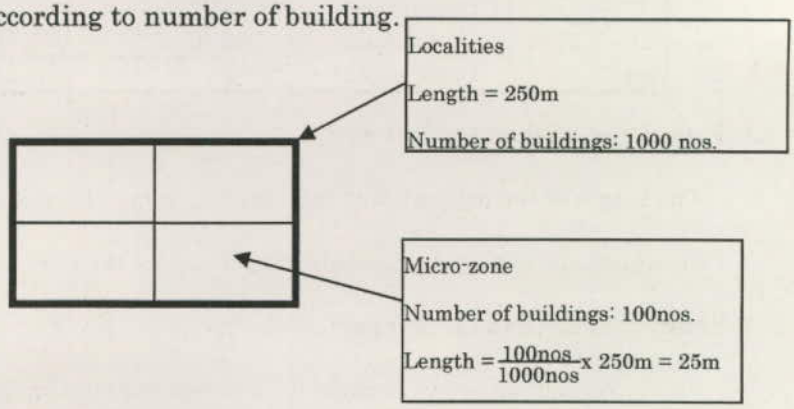


Figure 2 Flowchart of the Estimation Method for Electric Network Part 1

Table 8 Summary of length of Condensa's Local Service Area

Codensa's local service area code	Type of cable	Length (km)	Codensa's local service area code	Type of cable	Length (km)
AJ	Overhead	21.19	MZ	Overhead	135.33
AJ	Under ground	92.7	MZ	Under ground	13.28
AU	Overhead	39.03	RS	Overhead	38.6
AU	Under ground	202.27	SA	Overhead	44.97
BL	Overhead	244.28	SA	Under ground	230.12
BL	Under ground	22.48	SC	Overhead	98.67
BO	Overhead	203.47	SC	Under ground	11.1
BO	Under ground	22.08	SF	Overhead	4.56
CC	Overhead	17.69	SF	Under ground	82.82
CC	Under ground	104.2	SJ	Overhead	13.65
CN	Overhead	77.41	SJ	Under ground	25.28
CN	Under ground	68.4	SU	Overhead	165.52
CP	Overhead	82.34	SU	Under ground	28.61
CP	Under ground	17.99	T0	Overhead	188.03
CR	Overhead	11.09	T0	Under ground	70.88
CR	Under ground	58.3	TB	Overhead	125.57
CS	Overhead	22.54	TB	Under ground	56.55
CS	Under ground	97.25	TE	Overhead	204.84
CT	Overhead	54.39	TE	Under ground	20.67
CT	Under ground	162.54	TU	Overhead	141.99
CU	Overhead	14.41	TU	Under ground	24.49
CU	Under ground	48.25	UM	Overhead	349.66
FO	Overhead	183.4	UM	Under ground	9.38
FO	Under ground	86.89	US	Overhead	56.98
GG	Overhead	15.24	US	Under ground	217.47
GG	Under ground	57.06	VE	Overhead	103.81
LP	Overhead	44.23	VE	Under ground	22.7
LP	Under ground	105.72	VI	Overhead	213.7
MR	Overhead	121.59	VI	Under ground	1.3
MR	Under ground	74.79			

3) Estimation method for 2nd part

The length of the network was measured by using GIS system directly.

Overhead electric lines were only considered for the target of the estimate in this part .

4) Estimation method for 3rd part

Some correlations were assumed for estimation of the 3rd part. The correlations are based on the information of the 2nd part.

Assumptions adopted in the estimation are as follows:

1. Network in the 3rd part is overhead cable.
2. The micro-zones can be classified according to sizes and density of buildings.

3. Network length is the same as road length of a micro-zone, of which area is bigger than 25km^2 and density of building is smaller than 25nos/km^2.

Classification and correlations between the length of network and the area of a micro-zone, numbers of buildings and the density of the buildings were studied by using the data of the 2nd part. Some correlation equations were determined, of which correlation coefficients were better than 0.7.

The classification and correlation is shown in Table9.

Table 9 Classification and Correlation for the 3rd Part

Area (km^2)	Density of buildings (nos/km^2)	Correlation	Correlation coefficient
---	Higher than 1000	$L = 4915 \times A - 20.975$	0.7
Smaller than 20	Lower than 1000	$L = 1529.4 \times A + 89.43$	0.7
Bigger than 20	Lower than 1000	$L = 16.836 \times A^{1.9424}$	0.9
Bigger than 25	Lower than 25	L = Road length	----

L: length of network (m), A: area of micro-zone (km^2)

4.4 Telephone Network

4.4.1 Object of Study

In this analysis wires between pole and each building were not included. The lengths of overhead cable and under ground cable were estimated separately.

The telephone networks, which belong to ETB and CAPITEL, were the objects of the estimation. Three telephone companies (ETB, CAPITEL and EPM) have telephone cables networks in the Study area. The telephone network of EPM was not included since their information was not available.

4.4.2 Details of the original data of telephone network

Table 10 Summary of Original Data for Telephone Network

Institution	Contents	Type of data
ETB	Location of cabinets	GIS data
	Examples of primary network length of 7 ETB central stations	Printed table
	The total pole number in Bogotá & part of Soacha	interview
	Ratio between overhead cable and under ground cable	interview
CAPITEL	Over head cable network	GIS network data
	Under ground cable network	GIS network data
	Location of Poles	GIS data

The total number of ETB cabinet is 4,628. This number was counted by using GIS.

The information on ETB telephone network by interview is as follows:

1. The total pole number in Bogotá and part of Soacha, which has cabinets of given GIS data, is 120,000 nos.

2. The overhead cable to the underground cable ratio of secondary network is such that shown in Table 11

Table 11 Ratio between overhead Cable and Under Ground Cable of ETB Network

	Ratio (%)	
Type	Overhead	Under ground
Primary network	1	99
Secondary network	49	51

4.4.3 Method of Estimation

1) Summary

The original data of CAPITEL was GIS network data. Therefore it can be used directly and no estimation is required. On the other hand, estimation was necessary for ETB network.

The lengths of ETB network were estimated by using the following three methods.

1. Estimation based on the number of cabinets in a micro-zone. This method is adopted for the area where ETB cabinets are located (Figure.3).
2. Estimation based on correlation between CAPITEL network and the electric supply network. This method was adopted for the area where ETB cabinets are not located in Figure.3 and the building density is higher than 1,000nos/km^2.

   No information, which based on ETB cabinet, was available in this area. The length of electric network had been already estimated in this area. Therefore, the estimate was used. However, the length of telephone network was not same as the electric's one in the area, where the building density was higher than 1,000nos/km^2. Therefore, the correlation between CAPITEL network, of which information was high accuracy, and electric network was adopted.
3. The length of electric network was considered as the length of ETB network. This method was adopted for the area where ETB cabinets are not located in Figure3 and the building density was lower than 1,000nos/km^2.

   No information was available in this area based on the ETB cabinet data. The information based on CAPITEL network was not available either in this area since the CAPITEL network was not exist in the area low in the building density. The length of electric network had been already estimated in this area. Therefore, the length of electric network was adopted as the length of telephone network.

2) Estimation based on numbers of cabinets

Assumptions for this estimation method are as follow:

1. The average distance between two poles is 30m. This was figured out based on the information from CAPITEL.
2. The lengths of telephone lines in Bogotá and part of Soacha are proportional to the number of cabinets.
3. The average length of primary network per central station of 7 stations shown in Figure 3.
4. Primary network is underground cable.

The flowchart of estimation based on numbers of ETB cabinets is shown as below.

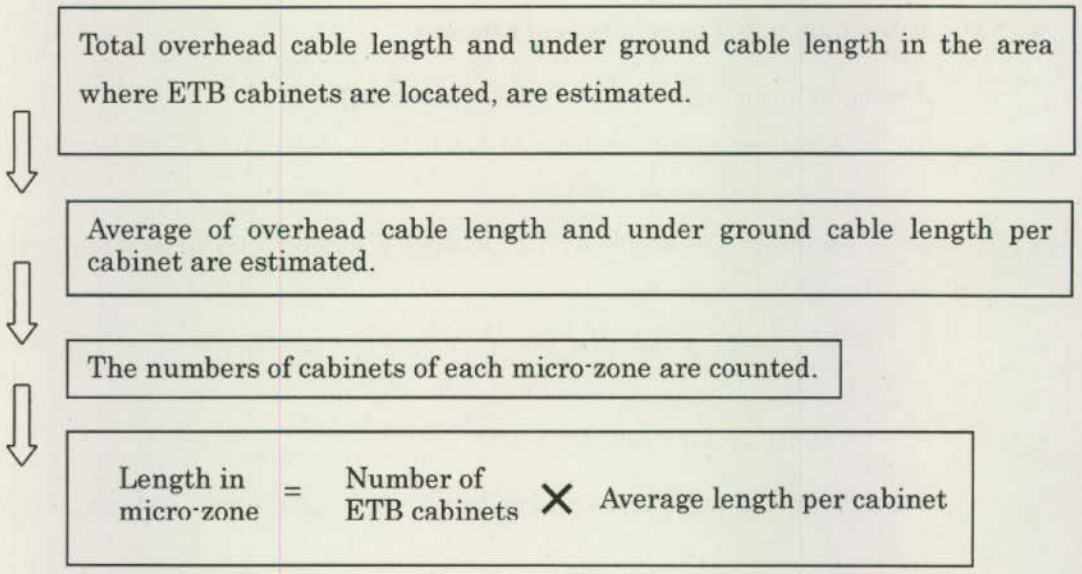


Figure 3 The flowchart of estimation based on number of ETB cabinet

The total lengths for the area where ETB cabinets were located were estimated as below.

Estimate total length of overhead cable of secondary network

Total number of poles × Average distance of between two poles of CAPITEL data

120,000 nos. × 30 m ⟹ 3,600,000m

Estimate total length of under ground cable of secondary network

$$\text{Total length of overhead cable} \times \frac{\text{Ratio of under ground cable}}{\text{Ratio of under overhead cable}}$$

$$3{,}600{,}000\text{m} \times \frac{51}{49} \Longrightarrow 3{,}746{,}939\text{ m}$$

Estimate total length of under ground cable of primary network

$$\text{Total length of 7 central stations in Table.12} \times \frac{\text{37: total number of central stations}}{\text{7: total number of central stations in Table.12}}$$

$$134{,}415\text{m} \times \frac{37}{7} \Longrightarrow 710{,}479\text{m}$$

The average lengths per cabinet were estimated as below.

Estimation of overhead cable length per cabinet

$$\frac{\text{Total length of overhead cable of secondary network}}{\text{Total number of cabinet}}$$

$$\frac{3{,}600{,}000\ \text{m}}{4{,}628} \Longrightarrow 777.87\text{m / cabinet}$$

Estimation of under ground cable length per cabinet

$$\frac{\text{Total length of underground cable of secondary network} + \text{Total length of underground cable of primary network}}{\text{Total number of cabinet}}$$

$$\frac{3{,}746{,}939 + 710{,}479}{4{,}628} \Longrightarrow 963.14\text{m / cabinet}$$

Counting the numbers of ETB cabinets and calculation for each micro-zone have been done by using GIS and database system.

3) Estimation based on correlation between CAPITEL and electric network

Assumptions, for this estimation method are as follows:

1. Electric supply network in a micro-zone where no cabinet was shown in Figure23 is overhead cable network.
2. The length of ETB network is the same as the length of CAPITEL network in a micro-zone, and building density is higher than 1,000 nos/km^2. The length of CAPITEL is estimated by using correlation between CAPITEL and electric cable.

A correlation between the length of overhead cable of CAPITEL and the length of electric cable is derived based on the data of locality of ANTONIO NARINO, BARRIOS UNIDOS, LA CANDELARIA, MARTIRES, PUENTE ARANDA, RAFAEL URIBE and TUNJUELITO, where building density is 1,440 - 3,900 nos/km^2.

Such correlation is expressed as follow:

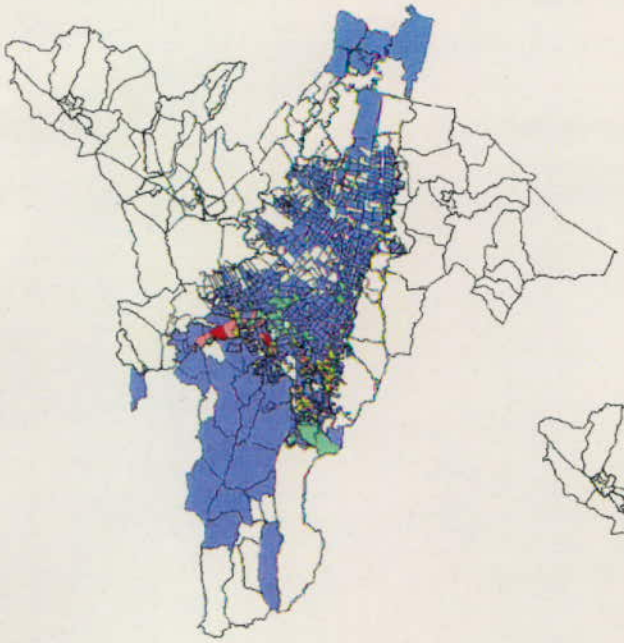
Length of CAPITEL (m) = 0.6719 × length of electric network (m) + 11754

The correlation coefficient is 0.89.

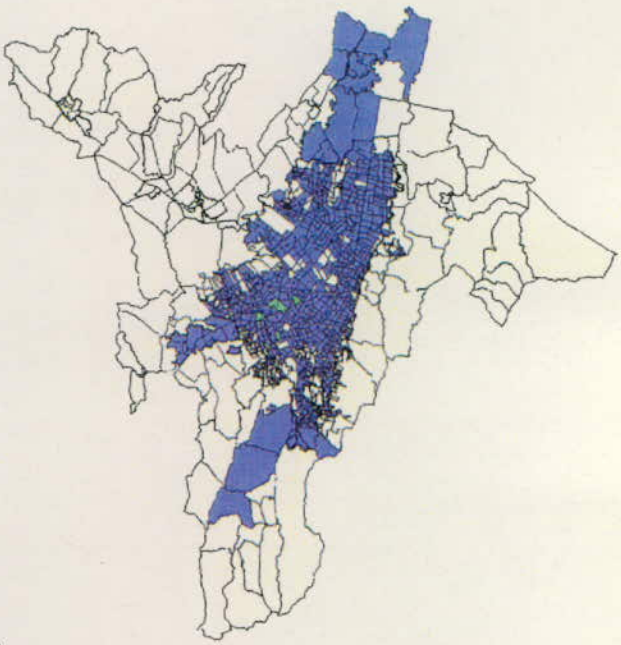
4) Estimation assuming the length of electric network as the length of ETB network

Assumptions for this estimation method are as follows

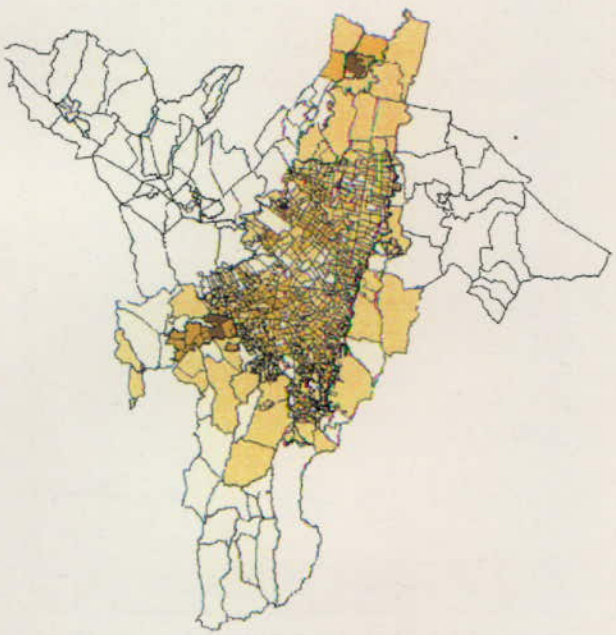
1. Telephone networking of a micro-zone where no cabinet is shown in Figure.23 is overhead cable.
2. The length of ETB network is the same as the length of electric network in micro-zone, and building density is lower than 1,000 nos/km^2.



La Cajita Fault Model



Guayuriba Fault Model



Present Condition



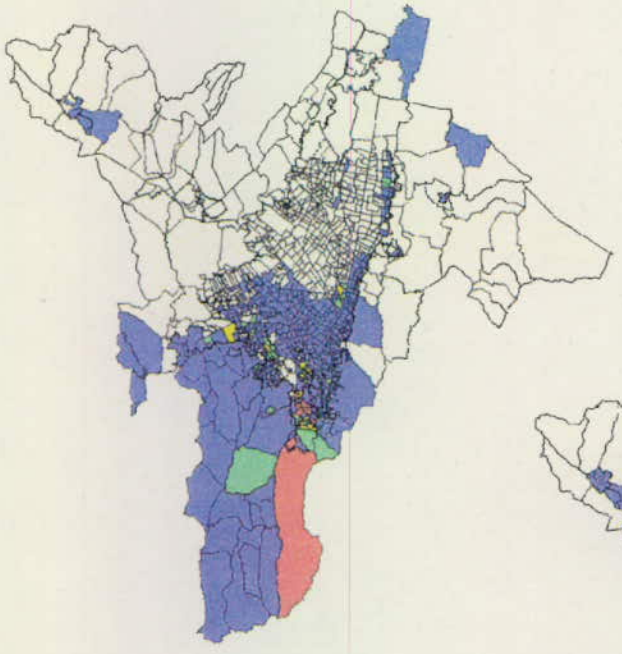


LEGEND

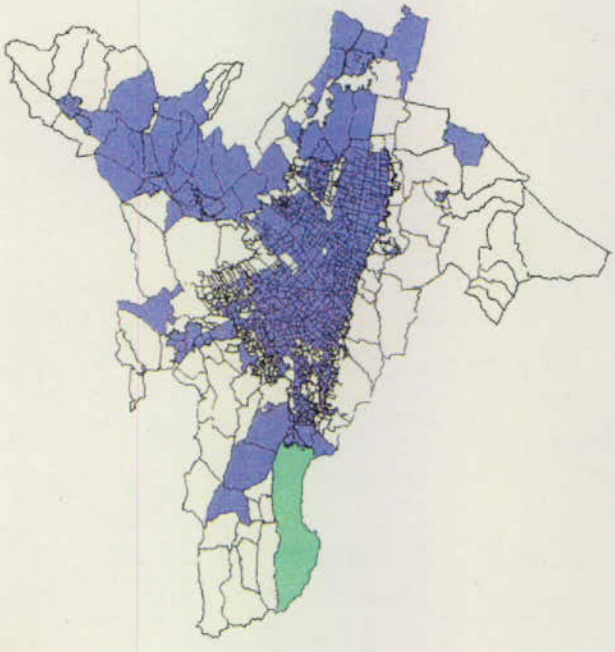
Number of Damaged Points
- 10 - 20
- 5 - 10
- 2 - 5
- 1 - 2
- 0 - 1
- No Data

Length of Gas Pipeline
- 0 - 1000
- 1000 - 15000
- 15000 - 25000
- 25000 - 56000
- 56000 - 85000
- No Data

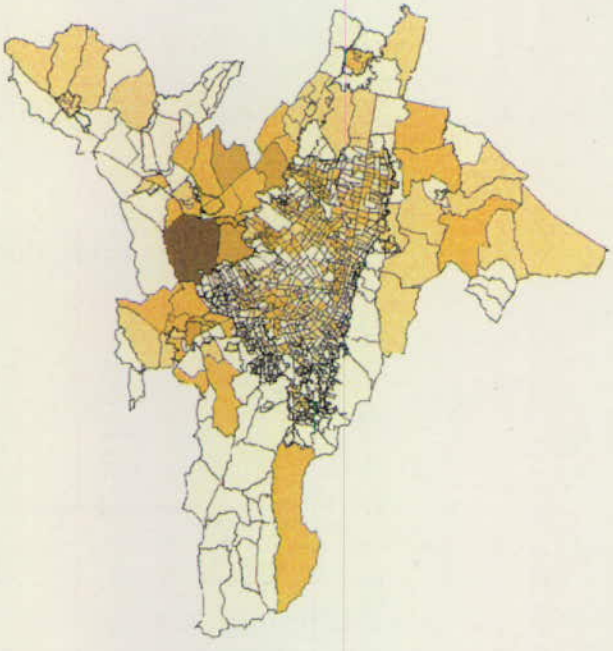
Appendix 4.2.7 | **Estimated Distribution of Gas Pipeline/Damage of Gas Pipeline**



La Cajita Fault Model



Guayuriba Fault Model



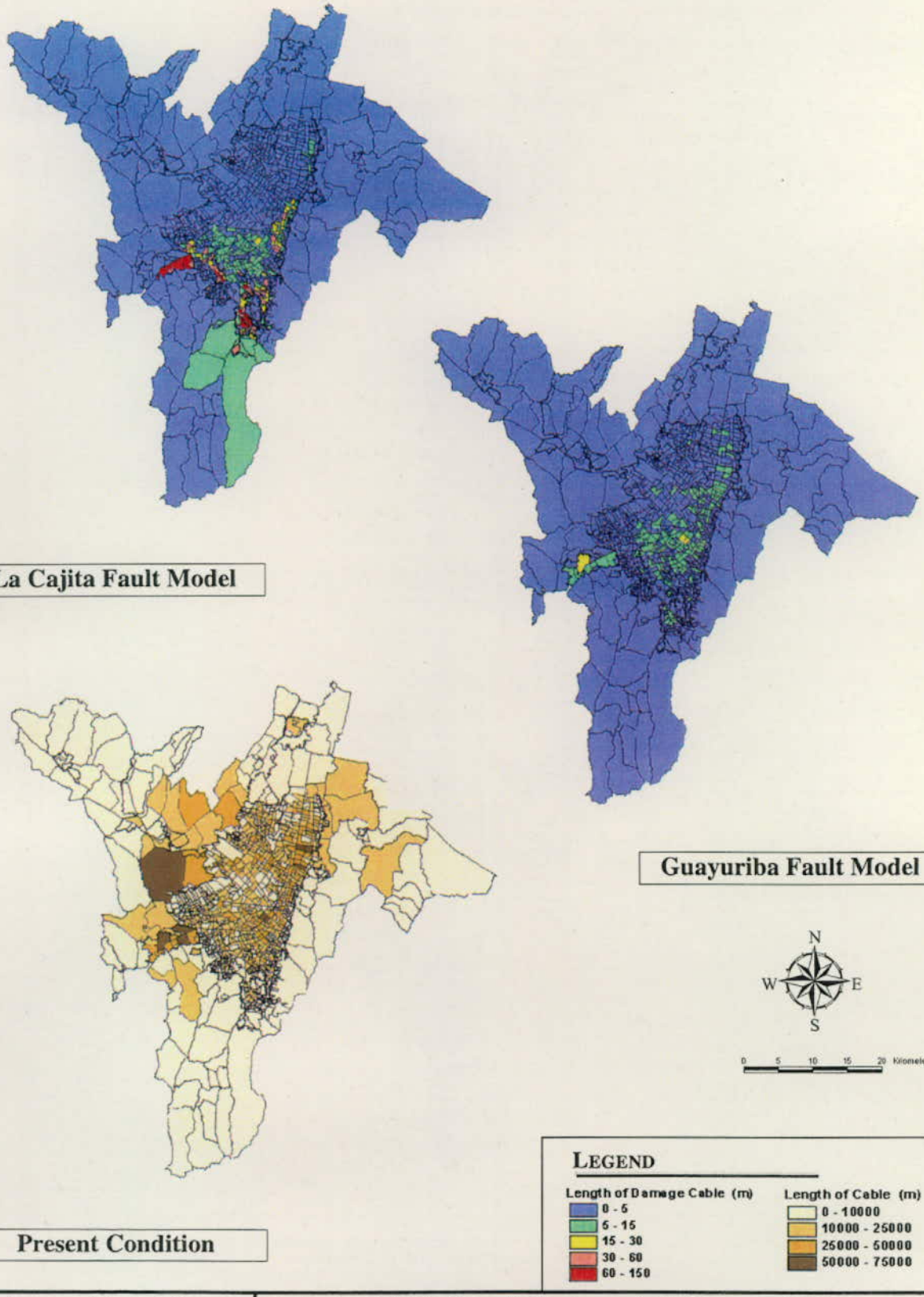
Present Condition



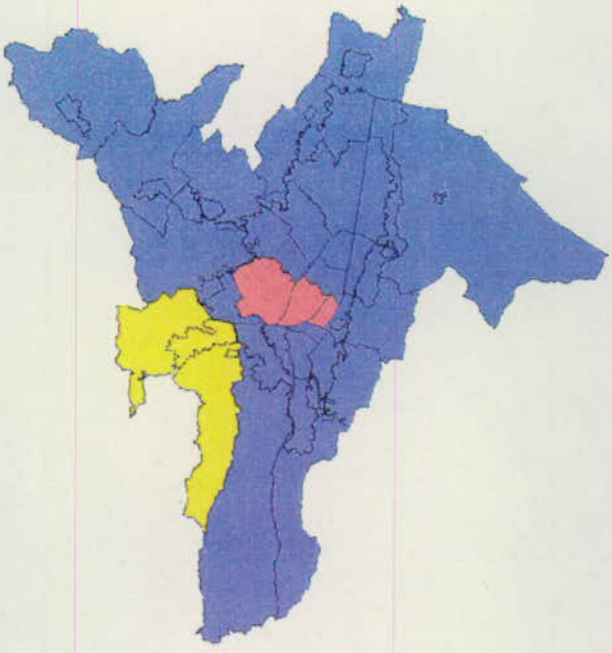
LEGEND

Length of Damaged Cable (m)	Total Length of Cable (m)
40 - 80	0 - 5000
20 - 40	5000 - 10000
10 - 20	10000 - 25000
0 - 10	25000 - 50000
No Data	50000 - 75000

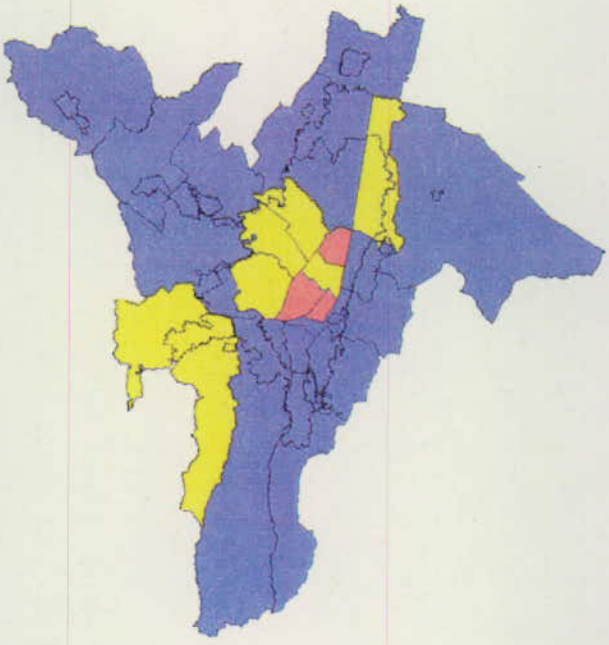
Appendix 4.2.8 | **Estimated Distribution of Electricity Cable/Damage of Electricity Cables**



Appendix 4.2.9 | **Estimated Distribution of Telephone Cable/Damage of Telephone Cable**



La Cajita Fault Model



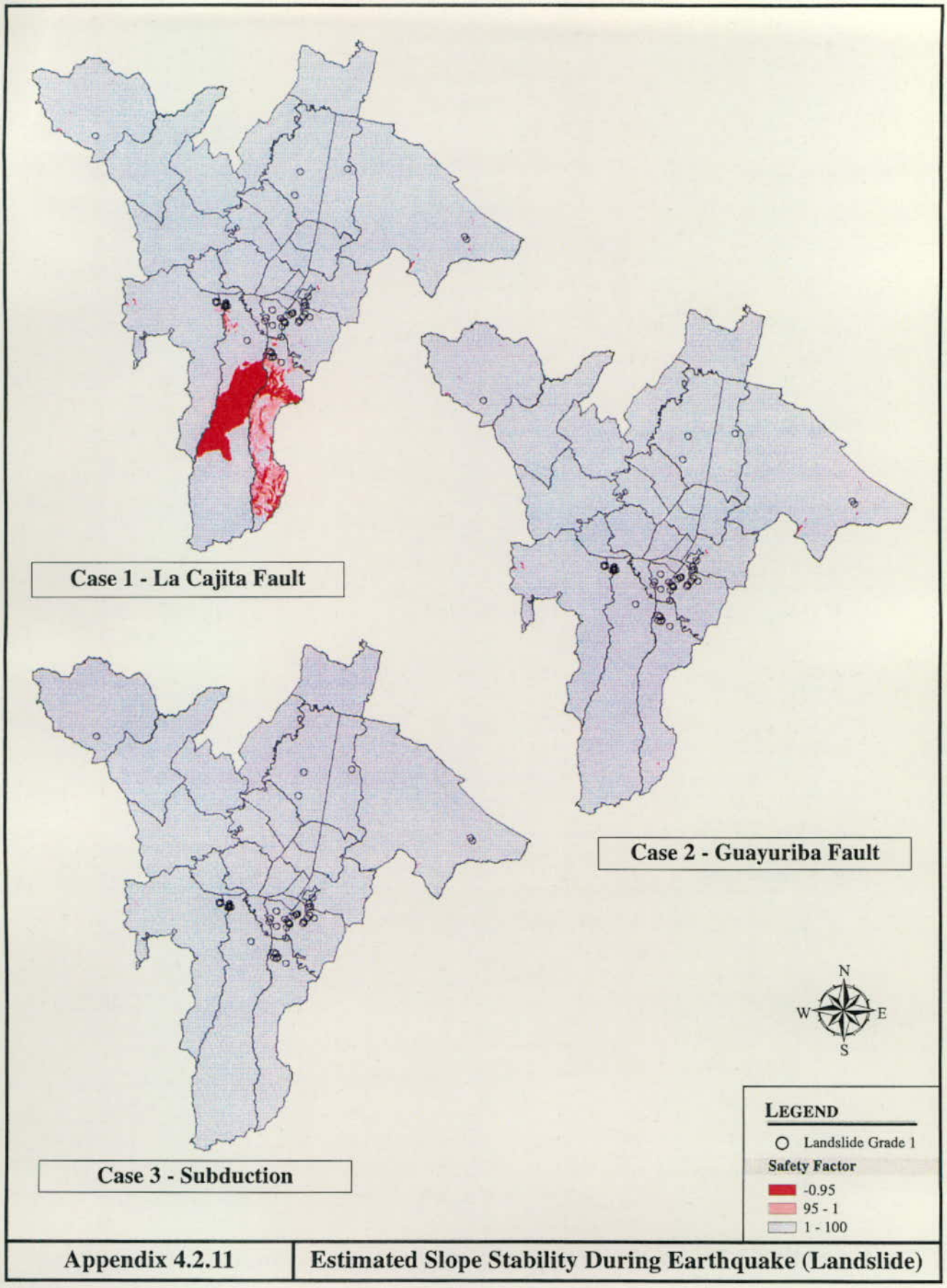
Guayuriba Fault Model

LEGEND

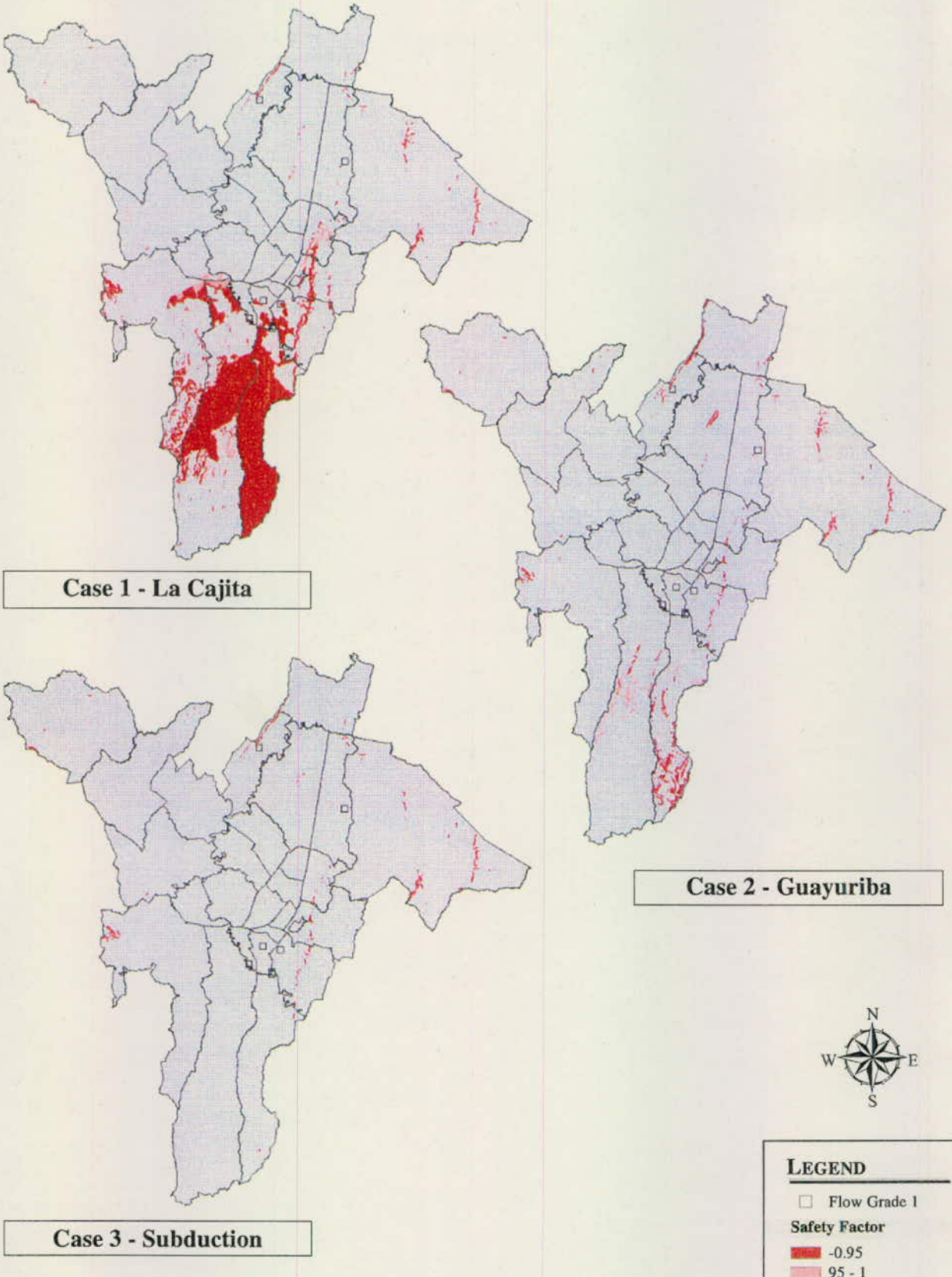
Seismic Risk

- High
- Medium
- Low

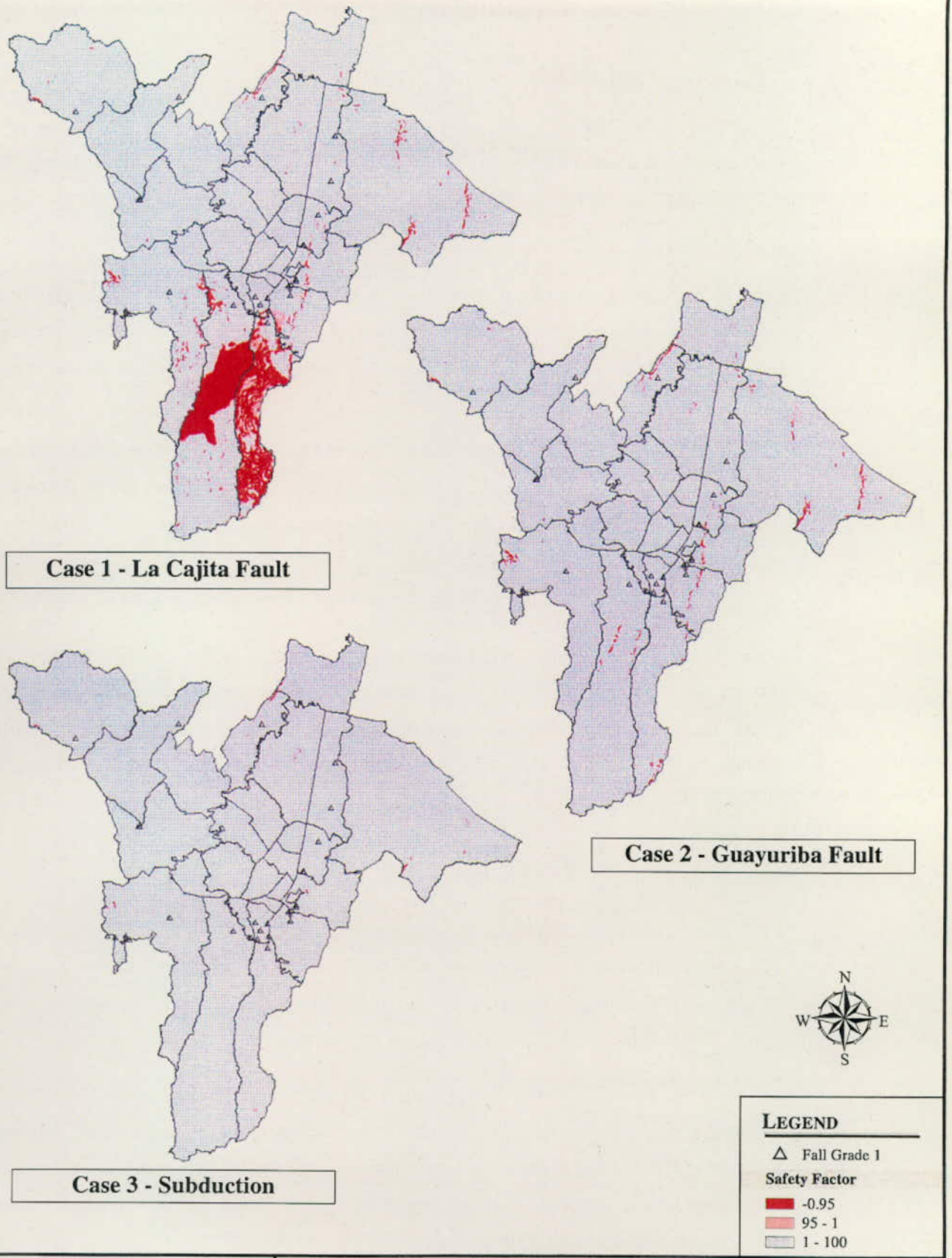
Appendix 4.2.10	Estimated Seismic Risk for Industrial Facilities



Appendix 4.2.11	Estimated Slope Stability During Earthquake (Landslide)



Appendix 4.2.12	Estimated Slope Stability During Earthquake (Flow)



Appendix 4.2.13	Estimated Slope Stability During Earthquake (Fall)

APPENDIX 4.2.14

1. CHAIN REACTIONS DURING DISASTER

Disaster in modern urban area is a complex, time evolving process. Damage in one part will spread and affect another part, if not handled properly. Following are examples of chain reactions during disaster that originate in physical damage of urban infrastructures.

Building damage

Damage to buildings would not only cause human casualties, but also disrupt adjoining electricity or telephone lines. Collapsed buildings would close narrow streets so that traffic or rescue work or would be obstructed. Those who lost their houses will need shelters and space.

Heavily damaged buildings would require demolition works. Dust pollution during demolition work by asbestos used in construction materials will cause health problems such as cancer in the long run. Besides, dump for massive garbage from demolished buildings would be a problem.

Damage in water service

Suspension of water service would directly affect human lives that need a few litters of water a day. Shortage of clean water or contamination of water by pipeline damage will cause health problem. Besides, it also affects fire fighting, and emergency medical operations. Breakage of water pipelines would cause water leaks and fill broken gas pipelines with mud and water, which would require cleanup of gas pipeline during recovery work.

Damage in gas service

Leakage of gas would cause fire or explosion, and may require evacuation of residents. Gas leak would obstruct rescue operation as well. Leakage of electricity can be a trigger of fire. Such a case can happen not only immediate period after earthquake, but also during recovery process of electricity and gas in damaged area.

Damage in electricity service

It would affect pumping of water, telephone line, among other lifeline services, that do not have power backup system. Lack of electricity also would affect medical operations, and absence of light would lessen security in the night. The suspension of traffic signal would cause confusion in traffic control.

Damage in telephone service

Disruption of telephone line will suspend communication. Even if telephone line were not damaged, traffic in telephone service would be saturated after earthquake due to the concentration of calling. Under such situation, communication would be only possible via radio or satellite.

Damage in road

Road would be closed by collapsed building or bridges. Cracks in the road or landslide would also affect the road condition. Further, abandoned or damaged vehicles would be obstacles. Such situation would hinder transport of emergency vehicles such as rescue, fire fighting, and emergency supply from outside. It would also enhance traffic jams, and affect traffic of roads that do not suffer damage.

Damage in landslide

It would block roads and damage nearby housings. It would also block river so that dammed water may cause flooding, in case of heavy rains. Landslides could occur long after major earthquake, especially associated with heavy rain, because strong shaking by an earthquake or its aftershocks could lessen the slope stability.

Damage in industrial facilities

The damaged industrial facilities would cause fire, leak, or even explosion. In the worst case, evacuation of residents would be necessary.

APPENDIX 4.2.15

1. LESSONS AND RECOMMENDATIONS IN DISASTER ATTENTIONS

Lessons from earthquakes in recent earthquake in Kobe and in Armenia are described according to the different stages in disaster attentions. Some recommendations are made.

1.1 Pre disaster stage

Risk perception of people in general against disaster

In western part of Japan, people in general had believed that earthquakes do not occur in the region, due to the less frequent activities in recent years compared to other regions. Kobe city did have seismic risk study, but expected magnitude for scenario earthquake was set at lower value.

The map of active fault in Japan that indicates existence of active fault near Kobe had been published, however, that map was little known to the public in general. Such low risk perception led to poor preparedness against earthquake disaster in that region.

The earthquake scenario should be made public in order to promote risk perception among public, and to make effective countermeasure plan.

Earthquake disaster in modern urban area

In Japan, the last experience of major earthquake disaster in urban area was Kanto earthquake in Tokyo in 1923. Throughout the period of rapid economic growth after Second World War, Japan has not suffered major earthquake disaster in modern urban area.

Earthquake disaster in a modern and major urban area would pose a complex situation. Its impact would not be limited in structural damage, but it would also affect social, economic aspects. The complete recovery and reconstruction would take at least several years after disaster.

1.2 Emergency stage

1.2.1 Direct attention

Administrative system in disaster management

In Japan, local government should handle disaster management in principle. The "national headquarter of disaster countermeasures" as defined by "basic law on disaster prevention" was established after four hours. However, "national headquarter of emergency countermeasures", that is not defined in the basic law, was then established

after three days. Its aim was to make more effective headquarter involving cabinet members. Rapid establishment of headquarter, with unified and substantial command is very important at the initial stage of disaster.

Assembly of emergency attention staffs

In Kobe city, 41 % of staffs came on the first day, and about 20% of stuffs came to office in Hyogo prefecture government after eight hours. Emergency power generator in City hall did exist, but it did not work because knowledgeable technical staff was absent.

Emergency attention staffs themselves could also be victims under major disaster, and in case staff with sufficient knowledge is lacking, emergency system does not work. For this reason, emergency staffs in some local government in Japan are given housing nearby the office, or 24 hours work shift system is held.

Initial damage information

The seismic intensity at Kobe had not been reported for the first thirty minutes due to the disruption of communication of network. This situation also contributed to the delayed emergency attention at emergency stage.

From this lesson, nation wide program of dense accelerograhs installation was executed in Japan, and satellite communication was put to use for accelerographs network.

Helicopters can be useful way to assess damage in wide area at emergency stage. In Los Angels, during Northridge earthquake in 1994, helicopter survey immediately after earthquake was very helpful. This was made possible because helicopter survey was routinely done by 24 hours shift for security reasons, important sites to be checked are listed in the survey manuals, and ground support was available.

Request for help

In Japan, official procedures of asking help from national government requires the request from damaged government. However, most severely damaged area cannot even ask help outside promptly. Legal framework that allows voluntarily help from outside without request in case of emergency would be necessary.

Safety of public buildings

Many public buildings such as fire stations, police stations, hospitals, city hall severely damaged or collapsed during earthquake in Kobe. Even if the building survived, inside of office was in disorder due to the strong shaking, thus the public office had to be firstly cleaned up to start work.

The office that stores basic database of infrastructure also had been damaged, thus basic database had to be reconstructed from another office. Such situation inevitably hindered prompt and effective attention and repair works.

Survival of key public building during earthquake should be important for emergency attention, and they should be put priority in seismic reinforcement.

Priority of tasks

After emergency, request of attention for every aspect will rush to emergency attention office. Moreover, staff will be busy to respond the requests of mass media. The priority of tasks should be made, depending on the urgency and importance.

Search and rescue works

Number of damaged buildings and human casualty will be much more than those in normal situation. Official rescue teams, equipped to work for normal situation, cannot necessary attend all of the work under such situation, in a short time. In fact, the neighbors contributed many of rescue works during earthquake in Kobe, with limited rescue tools. Such rescue did work well in communities where neighbors know each other well. The experience in Kobe demonstrates that noise from demolition work, or from hovering helicopters obstructed search and rescue work, which needs tranquility to detect signals from buried victims under debris.

First 72 hours is the most critical period for rescue operation for saving lives, because the possibility of saving lives drastically diminishes after that period. Stock of rescue tools would be necessary in communities, so that residents can use it in case of emergency. Rescue operation often requires heavy machines, so that their rapid procurement would be necessary. Besides, coordination of rescue work would be necessary.

Emergency medical operation

The main difference in medical operation under emergency are simultaneous large number of patients, and many of which are rescued suffer so called crash syndrome. Not all of medical staffs are familiar with such situation. Thus training of medicals for triage, which puts the priority of attention of victims to save lives as many as possible, and treatment of crash syndrome would be necessary.

Major obstacle to emergency medical operation in Kobe was lack of water and electricity. Power generator, water, and medicines should be kept in important hospitals. Besides, communication among hospitals would also be important.

Avoiding secondary disaster

Aftershocks will follow after major earthquake. Secondary disasters as described below should be taken into consideration.

- Human casualty due to collapse of damaged building.
- Landslides triggered by aftershocks and rain.
- Floods by dam up of river due to landslides.

Quindio River was reported to be dammed up, and people living in shores were at risk on fifth day.

- Leaks of chemical materials from damaged industrial facilities, and fire.

There was a report of explosion by chemical products in Pereira on first day.

1.2.2 Urgent attention

Emergency stocks

Emergency supply of water and food was not available for the first three days after major earthquake, until organized aid started. The emergency stocks for that period should be reserved.

Traffic control

After major earthquake, road will be obstructed by collapsed building or bridges abandoned vehicles, landslides, cracks in the road. Moreover, lack of traffic light will lose control, and police who will be busy for attending security matters will not fully control the traffic under such situation.

The traffic under emergency should be controlled to the priority vehicles, such as rescue, firefighting, or ambulances. The priority route should be defined, and if main road is closed, detour route should be indicated.

Social stability

Rumor would be easily spread under emergency condition, when situation is confusing, and people are very nervous and anxious about any information. In Japan, a mere precaution notice to aftershock was misunderstood as prediction of next major earthquake, and caused panic.

In Armenia, looting started in the second day in downtown. Bands of vandals arrived from outside in the second day. Many firemen left Armenia on sixth day, because looting and vandalism against their equipments was immense.

1.2.3 Emergent attention

Safety inspection of buildings

Safety inspection on damaged building should be performed, with the help of engineers. Since there would be so many buildings to be inspected after major earthquake, volunteers of engineers or students would be necessary.

The items and methodology of evaluation, and training of inspector should be prepared beforehand. The responsibility of evaluation and the way to use the result should be clarified. The safety evaluation may be expressed as "safe", "limited entry", or "dangerous". Buildings that are evaluated as "limited entry" would require detailed inspection later on.

Sanitary problems

Number of dead will also be much more than that in usual time. Sanitary care will be a problem to avoid epidemic diseases, when clean water is lacking. Human waste disposal shall be a big problem, in case sewage or water system is not functioning. Portable or temporary toilet would be necessary.

In Armenia, garbage collection had been suspended in the first week, and appearing of rats is reported in the second week. The spreading of lime over the debris started in second week. Fumigation also began in temporal shelters, and sanitary authority executed massive vaccination to prevent epidemic.

Fiber used in tiles of asbestos cements caused health problems during demolition works in Armenia. Same problem is also reported in Kobe, when demolishing damaged old buildings containing asbestos, which would cause cancer in the long run. In demolition works, effect of dust or asbestos on health of workers and residents should be taken care of.

1.3 Response stage

1.3.1 Recovery attention

Shelters

In Kobe, relocation of victims was done separately, and mutual help system among existing community had been lost. This caused isolation, and caused serious social problems later on. In case habitants are relocated to shelters, integration or function of mutual help within community should be kept.

Mental and psychological treatment

Those who have survived the disaster would have mental or psychological problems with experience of losing families or friends. Also, rescue workers who worked under severe condition also needed such care.

Such situation would emerge after immediate danger diminishes, but lasts for a long period if not treated properly. Psychological cares for survivors should be taken care of.

Public assistance information system

Various type of information will be required in the response phase. These can be provided not only by mass media, but also by community based paper media, or by Internet. The media should be carefully selected in order to facilitate to transmit information listed below.

- Name of dead or missing persons,
- Status of damage
- Reception of damage report and registration of victims
- List of shelters and provided services
- Available assistance and its application method
- Recovery status and plans for public facilities and lifeline services
- Aftershock information

Organizing volunteers

Many volunteers would join aid activities in damaged area, but they would cause confusion if not properly organized.

To work with the volunteers efficiently, they should be registered with the information of area of activity, and properly allocated among damaged area.

1.3.2 Social mitigation attention

Reconstruction planning

To establish a master plan of reconstruction, detailed study of damage should be done. In Japan, new constructions in damaged area can be restricted by law, while establishment of reconstruction master plan is underway. Some local governments have reconstruction plan prior to the major earthquake, based on the results of damage estimation study. This is because after experiencing the disaster, it would be difficult to concentrate to draw a master plan, and detailed damage estimation enables quantitative evaluation.

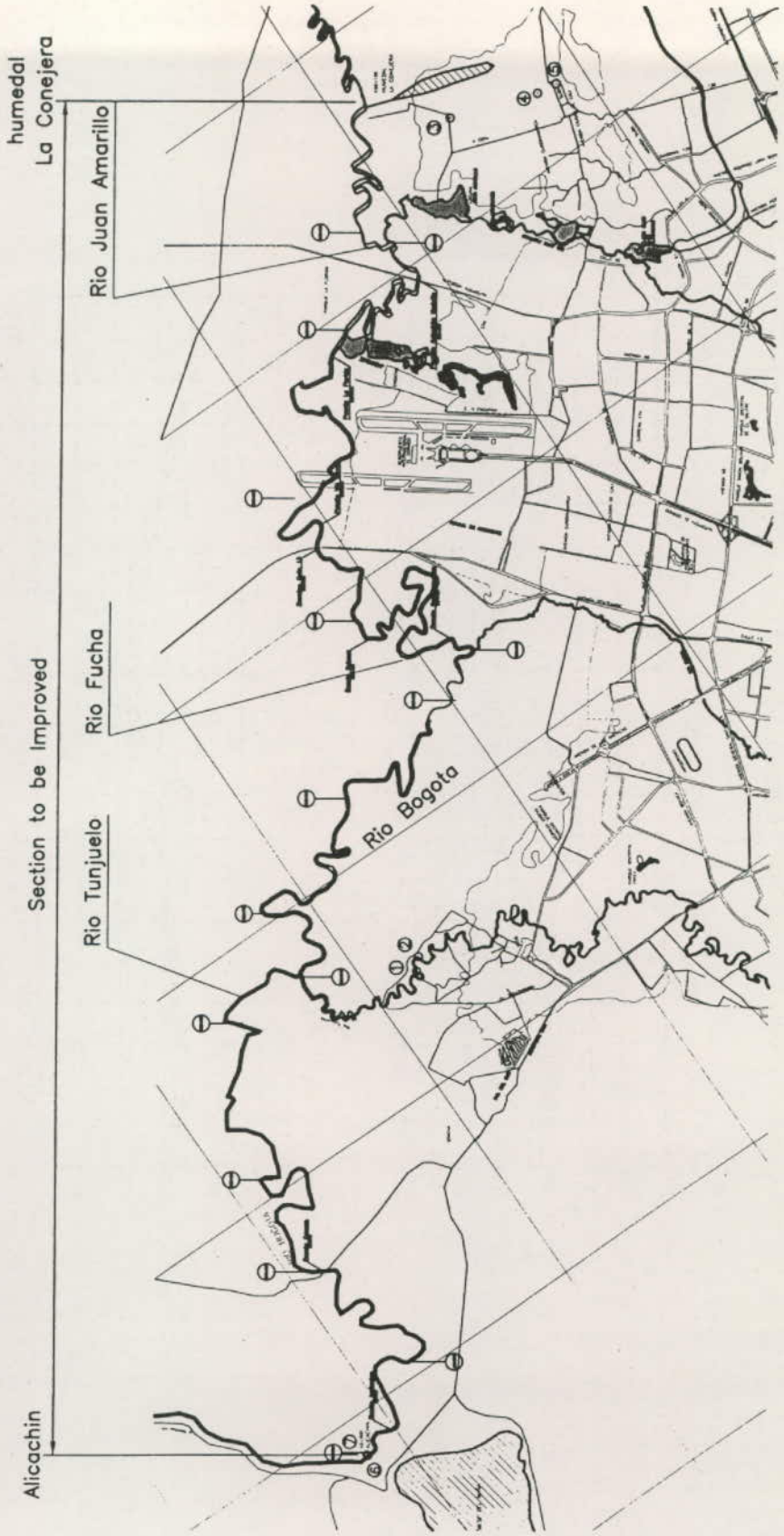
Attention to victims

Victims would need various assistances from different sectors in government, such as exemption or reduction of tax or medical fees, application of financial support or relocation of housing, etc. In order to provide such services in simplified process, victims should be registered in database, and history of assistance received should be recorded.

Improvement of disaster preparedness

Detailed study on damage and its recovery process should be made to record the status and learn lessons by engineering communities, research institutes, and administration. The recovery should not only aim to recover but also improve the preparedness for next possible disaster. Improvement of seismic code, regulations, guidelines, and laws shall be made with the result of detailed study.

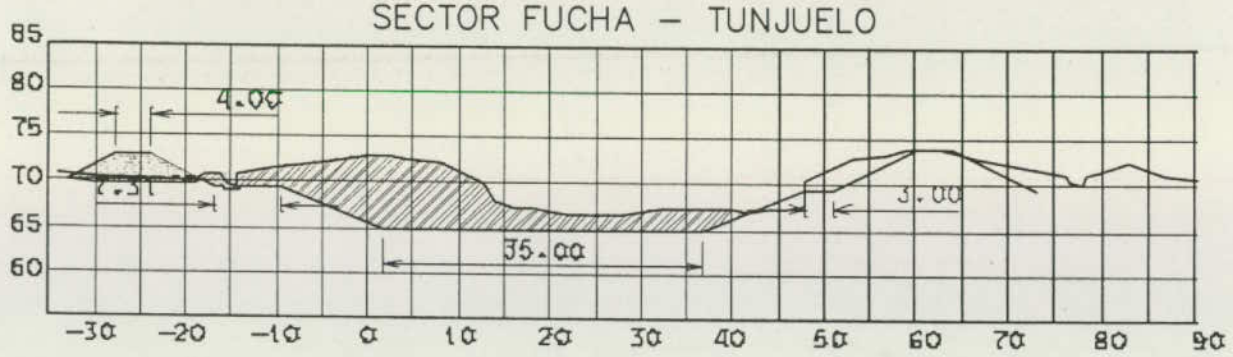
Appendix for Chapter 5



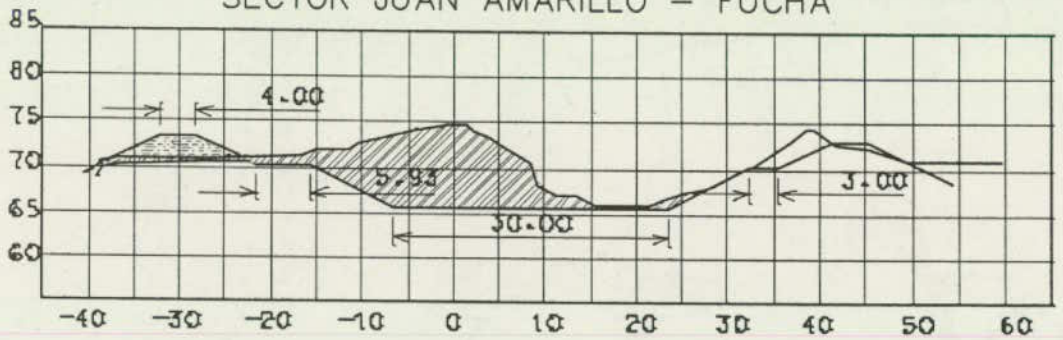
Appendix 5.2.1	Section to be Improved (Rio Bogota)

Cross Section of Rio Bogota Proposed by EAAB

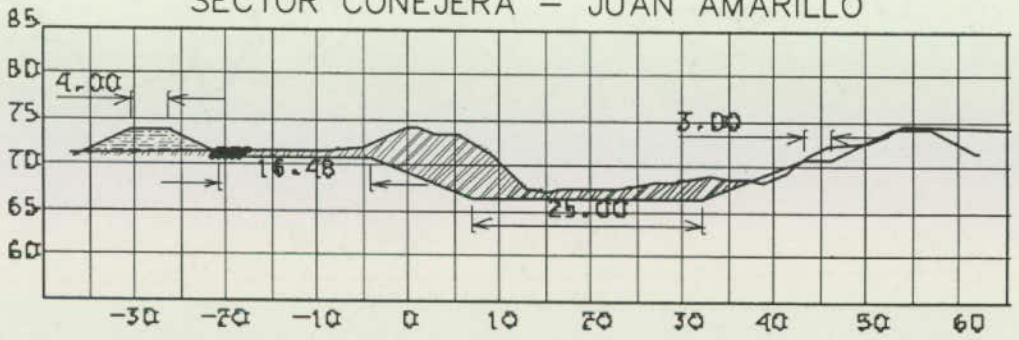
SECTOR FUCHA – TUNJUELO



SECTOR JUAN AMARILLO – FUCHA

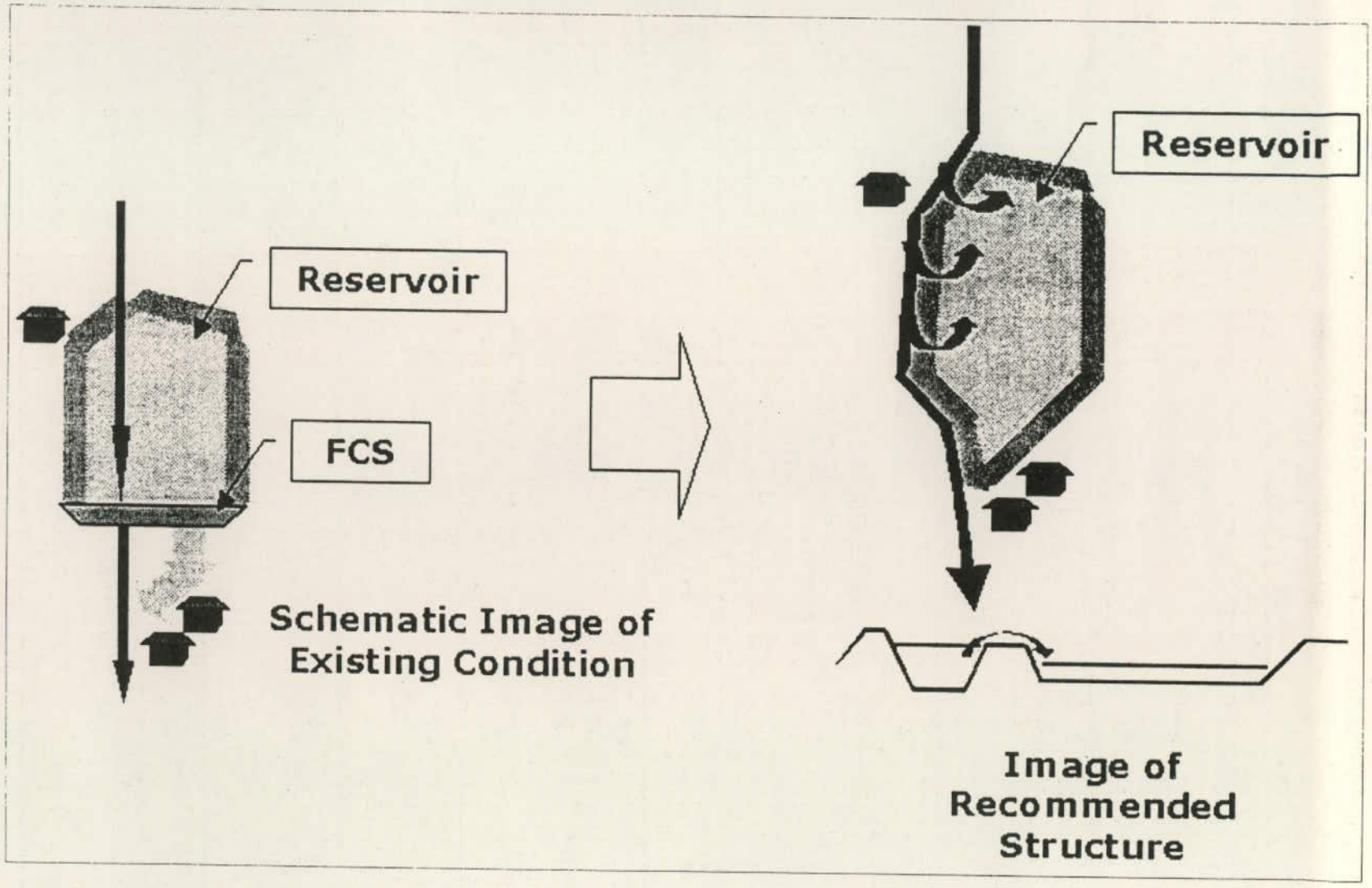


SECTOR CONEJERA – JUAN AMARILLO



Appendix 5.2.3

Improvement of Flood Control Structure



Appendix 5.2.4 Integrated Risk Point for each UPZ

Localidad	UPZ No.	UPZ Name	Type No	Type	Ha	Population	Earthquake	Landslide	Flood	Chemical
1. Usaquén	1	Paseo de los Libertadores	4	Development	659.72	35,185	5	4	5	5
	9	Verbenal	1	Residential of incomplete urbanization	344.94	51,148	3	4	5	4
	10	La Uribe	8	Endowment Predominant	338.44	8,461	3	4	5	4
	11	San Cristobal Norte	1	Residential of incomplete urbanization	272.31	79,697	4	4	5	4
	12	Toberin	6	Commercial	291.27	45,130	4	5	5	2
	13	Los Cedros	3	Qualified residential	644.99	103,128	4	4	5	4
	14	Usaquen	5	With Urban Centrality	440.71	30,275	4	4	5	4
	15	Country Club	8	Endowment Predominant	285.03	20,562	4	5	5	4
	16	Santa Barbara	5	With Urban Centrality	456.89	45,438	4	5	5	4
2. Chapinero	88	El Refugio	3	Qualified residential	297.59	31,681	4	3	5	4
	89	San Isidro - Patios	1	Residential of incomplete urbanization	113.02	8,311	4	4	5	5
	90	Pardo Rubio	2	Consolidated Residential	240.45	29,496	4	3	5	4
	97	Chico Lago	6	Commercial	422.39	34,184	4	5	5	4
	99	Chapinero	6	Commercial	161.26	21,677	4	4	5	4
3. Santa Fe	91	Sagrado Corazon	6	Commercial	126.66	4,595	4	4	5	4
	92	La Macarena	2	Consolidated Residential	55.84	14,479	3	4	5	5
	93	Las Nieves	6	Commercial	172.41	13,783	4	4	5	3
	95	Las Cruces	1	Residential of incomplete urbanization	98.48	24,628	2	5	5	4
	96	Lourdes	1	Residential of incomplete urbanization	231.63	59,166	3	4	5	5
4. San Cristobal	32	San Blas	1	Residential of incomplete urbanization	352.19	95,685	3	4	5	5
	33	Sosiego	2	Consolidated Residential	235.49	41,021	1	4	5	4
	34	20 de Julio	1	Residential of incomplete urbanization	266.55	115,188	3	4	5	5
	50	La Gloria	1	Residential of incomplete urbanization	385.88	113,591	1	4	5	5
	51	Los Libertadores	1	Residential of incomplete urbanization	389.08	77,388	2	3	4	5
5. Usme	52	La Flora	1	Residential of incomplete urbanization	206.88	16,523	2	4	5	5
	56	Danubio	1	Residential of incomplete urbanization	268.11	23,095	1	3	5	5
	57	Gran Yomasa	1	Residential of incomplete urbanization	530.24	118,444	2	3	4	4
	58	Comuneros	1	Residential of incomplete urbanization	483.22	65,869	2	3	3	5
	59	Alfonso Lopez	1	Residential of incomplete urbanization	233.54	19,955	2	4	5	5
	60	Parque Entrenubes	8	Endowment Predominant	535.13	727	3	4	5	5
	61	Ciudad Usme	4	Development	992.37	3,639	4	4	5	5
6. Tunjuelito	42	Venecia	2	Consolidated Residential	642.89	130,731	2	5	4	4
	62	Tunjuelito	1	Residential of incomplete urbanization	385.16	59,922	2	4	3	3
7. Bosa	49	Apogeo	1	Residential of incomplete urbanization	496.6	34,116	3	5	5	4
	84	Bosa Occidental	1	Residential of incomplete urbanization	717.45	166,262	2	5	2	4
	85	Bosa Central	4	Development	402.24	144,621	2	5	3	4
	86	El Porvenir	4	Development	564.86	32,507	3	5	2	5
	87	Tintal Sur	2	Consolidated Residential	210.43	2,753	4	5	2	5
8. Kennedy	44	Americas	5	With Urban Centrality	381	80,079	3	5	5	3
	45	Carvajal	2	Consolidated Residential	435.62	137,700	3	5	5	3
	46	Castilla	2	Consolidated Residential	500.22	103,163	3	5	4	4
	47	Kennedy Central	2	Consolidated Residential	337.17	151,441	3	5	5	4
	48	Timiza	2	Consolidated Residential	431.38	1,501,610	2	5	4	4
	78	Tintal Norte	4	Development	345.16	76,587	5	5	3	4
	79	Calandaima	4	Development	318.63	21,709	3	5	4	4
	80	Corabastos	1	Residential of incomplete urbanization	187.51	21,502	2	5	3	4
	81	Gran Britalia	1	Residential of incomplete urbanization	179.41	63,454	2	5	4	4
	82	Patio Bonito	1	Residential of incomplete urbanization	314.21	102,709	2	5	3	4
	83	Las Margaritas	8	Endowment Predominant	148.52	349	4	5	4	5
	113	Bavaria	7	Industrial Predominant	277.72	17,755	3	5	5	3
9. Fontibon	75	Fontibon	6	Commercial	496.45	138,722	4	5	3	4
	76	Fontibon San Pablo	7	Industrial Predominant	359.97	26,838	4	5	2	4
	77	Zona Franca	7	Industrial Predominant	490.22	22,632	5	5	2	4
	110	Ciudad Salitre Occidental	3	Qualified residential	224.04	21,773	4	5	5	4
	112	Granjas de Techo	7	Industrial Predominant	479.57	13,279	3	5	3	3
	114	Modelia	3	Qualified residential	255.9	37,092	3	5	5	3
	115	Capellania	7	Industrial Predominant	276.75	16,724	4	5	4	3
	117	Aeropuerto El Dorado	8	Endowment Predominant	742.98	9,857	5	5	2	3
10. Engativa	26	Las Ferias	5	With Urban Centrality	474.06	127,252	3	5	5	4
	29	El Minuto de Dios	2	Consolidated Residential	367.91	127,506	3	5	3	4
	30	Boyaca Real	2	Consolidated Residential	452.25	146,066	4	5	5	4
	31	Santa Cecilia	2	Consolidated Residential	308.28	77,537	4	5	5	3
	72	Bolivia	2	Consolidated Residential	449.34	93,949	3	5	2	5
	73	Garces Navas	2	Consolidated Residential	557.43	114,979	3	5	2	4
	74	Engativa	1	Residential of incomplete urbanization	588.2	56,373	3	5	2	4
	105	Jardin Botanico	8	Endowment Predominant	161.7	872	4	5	5	4
	116	Alamos	7	Industrial Predominant	197.13	6,227	4	5	4	3
11. Suba	2	La Academia	4	Development	610.07	94	5	5	3	5
	3	Guaymaral	4	Development	1135.7		5	4	3	4
	17	San Jose de Bavaria	3	Qualified residential	439.68	41,581	4	4	5	4
	18	Britalia	2	Consolidated Residential	328.41	40,886	3	4	5	4
	19	El Prado	2	Consolidated Residential	428.95	72,549	3	5	5	4
	20	La Alhambra	3	Qualified residential	284.28	37,693	4	5	4	4
	23	Casa Blanca Suba	4	Development	419.92	30,159	2	4	5	4
	24	Niza	3	Qualified residential	764.86	72,667	4	4	4	4
	25	La Floresta	3	Qualified residential	389.94	28,504	4	4	4	4
	27	Suba	1	Residential of incomplete urbanization	645.78	75,333	3	4	4	4
	28	El Rincón	1	Residential of incomplete urbanization	720.33	211,681	3	4	3	4
	71	Tibabuyes	1	Residential of incomplete urbanization	745.78	95,108	3	5	1	5

Localidad	UPZ No.	UPZ Name	Type No	Type	Ha	Population	Earthquake	Landslide	Flood	Chemical
12. Barrios Unidos	21	Los Andes	3	Qualified residential	275.01	35,409	4	5	5	4
	22	Doce de Octubre	2	Consolidated Residential	335.28	71,530	4	5	5	4
	98	Los Alcazares	2	Consolidated Residential	414.27	64,087	4	5	5	4
	103	Parque El Salitre	8	Endowment Predominant	164.96	2,109	5	5	5	5
13. Teusaquillo	100	Galerias	2	Consolidated Residential	237.92	33,685	4	5	5	3
	101	Teusaquillo	2	Consolidated Residential	237.54	29,162	4	5	5	4
	104	Parque Simon Bolivar - Can	8	Endowment Predominant	396.96	2,840	4	5	5	4
	106	La Esmeralda	3	Qualified residential	192.88	35,856	4	5	5	4
	107	Quinta Paredes	3	Qualified residential	175.25	24,316	4	5	5	1
	109	Ciudad Salitre Oriental	3	Qualified residential	180.48	233	4	5	5	4
14. Martires	37	Santa Isabel	2	Consolidated Residential	200.8	44,229	4	5	5	4
	102	La Sabana	6	Commercial	453.78	51,308	4	5	5	3
15. Antonio Nariño	35	Ciudad Jardin	2	Consolidated Residential	134.17	29,121	3	5	5	4
	38	Restrepo	5	With Urban Centrality	359.42	69,618	4	5	5	4
16. Puente Aranda	40	Ciudad Montes	2	Consolidated Residential	443.41	107,144	3	5	5	4
	41	Muzu	2	Consolidated Residential	249.42	73,270	4	5	5	4
	43	San Rafael	2	Consolidated Residential	327.45	91,990	3	5	5	4
	108	Zona Industrial	7	Industrial Predominant	344.82	5,585	4	5	5	1
	111	Puente Aranda	7	Industrial Predominant	359.39	11,845	4	5	5	1
17. La Candelaria	94	La Candelaria	8	Endowment Predominant	183.89	25,865	3	2	5	4
18. Rafael Uribe	36	San Jose	2	Consolidated Residential	208.35	53,543	3	4	5	4
	39	Quiroga	2	Consolidated Residential	381.78	117,589	3	5	5	4
	53	Marco Fidel Suarez	1	Residential of incomplete urbanization	179.24	77,335	3	4	5	4
	54	Marruecos	1	Residential of incomplete urbanization	358.6	70,650	2	3	4	4
	55	Diana Turbay	1	Residential of incomplete urbanization	182.12	70,228	1	4	4	4
19. Ciudad Bolivar	63	El Mochuelo	4	Development	321.14	884	3	4	4	5
	64	Monte Blanco	8	Endowment Predominant	790.49	6	4	4	3	5
	65	Arborizadora	2	Consolidated Residential	326.97	58,991	1	4	4	4
	66	San Francisco	1	Residential of incomplete urbanization	182.34	86,054	2	4	3	4
	67	Lucero	1	Residential of incomplete urbanization	581.61	228,212	3	4	3	4
	68	El Tesoro	1	Residential of incomplete urbanization	223.1	54,503	3	4	4	5
	69	Ismael Perdomo	1	Residential of incomplete urbanization	554.89	90,084	2	1	5	4
	70	Jerusalem	1	Residential of incomplete urbanization	350.08	64,994	3	4	5	5
La Carela							4	5	2	5
Chia							3	5	3	4
Cota							3	5	5	4
Funza							4	5	5	4
Facatativa							3	5	2	4
Madrid							4	5	5	4
Mosquera							4	5	4	4
Soacha							3	5	4	5

Appendix 5.3.1 Emergency Response Plan

1) Road and Bridge

There is no emergency response plan of roads and bridges for seismic disaster.

2) Water Supply Company

(1) General

EAAB is the only one company that has a contingency plan. The companies in eight municipalities do not have such plans. The contingency plan for the water supply/sewage system in each city municipality was not prepared by each public company. However, the above-mentioned EAAB contingency plan includes some part of the municipal area. Public company should prepare an individual contingency plan for the facilities. The followings are organization aspect, staff, information collection and distribution, emergency response measures, etc. of the present contingency plan by EAAB.

(2) Organization aspect

The Contingency Plan is related to the actions to be taken by EAAB in order to prevent and cope with emergencies that might be present on the main distribution network of potable water in Bogotá City, which consists of pipes with diameters between 16" and 78".

The Plan comprises a Strategic and Administrative Plan, an Operative Plan and Action Plan, a supplementary database, a chronological chart and an implementation budget.

According to the results of the vulnerability study on the main network, there have been established three emergency levels, which will have management strategies within the Contingency Plan and are described in the Operative Plan.

The three emergency levels are classified depending on the affected area, number of damages, control capacity, damages to the community, environmental deterioration and the requirement of external support. The classification is shown in Table 1.

Table 1 Classification of Emergency levels by EAAB

Level 1 Corresponds to emergencies that might appear due normal operation.	Level 2 Corresponds to emergencies that might appear as a consequence of a low intensity earthquake or simultaneous failures on the network	Level 3 Corresponds to the presence of medium to high intensity earthquake.
AFFECTED AREA: Certain . Area under rationing conditions in a period of time less than 72 hours. NUMBER OF DAMAGES: Damages controllable by EAAB CONTROL: EAAB Brigade PERSONAL INJURIES: None DAMAGES TO THE COMMUNITY: Not implied ENVIRONMENTAL DETERIORATION: Not implied EXTERNAL SUPPORT: Not required	AFFECTED AREA: Considerable. Under lingering rationing conditions, more than 72 hours. NUMBER OF DAMAGES: Simultaneous damages controllable by EAAB, with the contractors' support CONTROL: EAAB Brigade, Emergency Local Committee PERSONAL INJURIES: Lesser DAMAGES TO THE COMMUNITY: Infers on its daily activities EXTERNAL SUPPORT: Local Emergency Committee	AFFECTED AREA: Considerable without service rendering NUMBER OF DAMAGES: Simultaneous damages non-controllable by EAAB CONTROL: EAAB Brigade, Emergency Local Committee PERSONAL INJURIES: Severe injuries even death DAMAGES TO THE COMMUNITY: Severe, lack of service, alteration in local activities. EXTERNAL SUPPORT: National Emergency Committee, International help.

Source: Contingency Plan by EAAB, 2000.

In order to implement the contingency plan, first EAAB has established a permanent committee, which is in charge of evaluating and setting what are stipulated in the Plan, as well as to analyse different "levels of emergency" classified in this Plan.

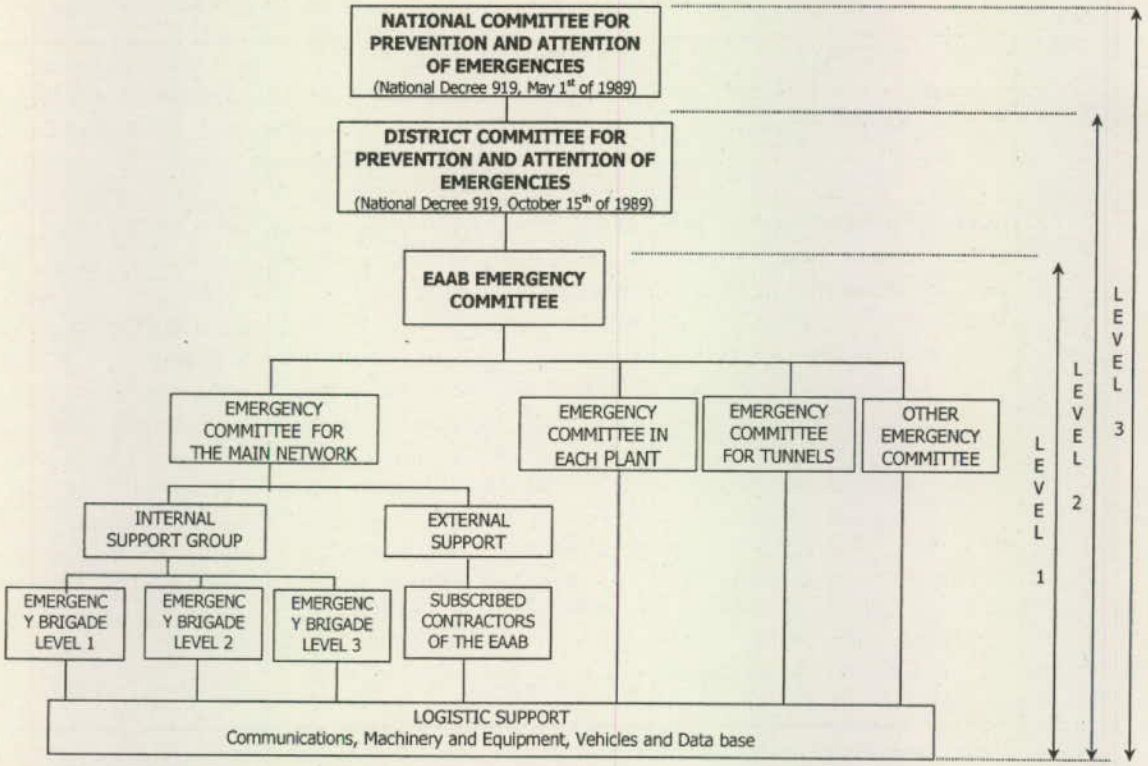
This committee will also lead the action of the contingency plan with the defined strategies for each level.

The Committee is formed by the representatives of some of EAAB directions and of the operation and maintenance group according to what is shown in the organizational chart below.

In order to define the follow-up actions in the event of a contingency, the emergency committee counts on the support of different groups, which are divided into Internal and External support groups.

The internal support group is in charge of setting up the procedures established as “responses” from EAAB, counting on the committee’s own logistics and the different brigades.

The External support group is in charge of coordinating the different needs to local or national external institutions. Figure 1 shows the administrative and organizational chart to manage an emergency situation.



Source: Contingency Plan by EAAB in 2000

Figure 1 Administrative and Organizational Chart to Manage Emergency

(3) Staff

In order to cope with emergencies related to network problems, at the present time there are three divisions located in three different strategic points of the city which are north, centre and south, where the information of daily damages in each area is obtained and integrated. Each zone has emergency brigades to attend the emergencies immediately. Additionally there exists the support of the Division of Civil work of EAAB.

There are not specific information about the number of technicians, engineers and/or workers available for reparation in each zone.

(4) Information collection and distribution

The division in charge to coordinate the operations in an emergency case will be the Operation and Maintenance division. With the collected information of damages the division must support the actions logistically, coordinate the works to be done, update the information of field works and integrate newly received information.

In respect to own communication medias in case of emergencies and for the normal function, EAAB has a radio system called Trunking that has a coverage in Bogotá City, as well as cellular phones for each one of the directives of the company.

Additionally there are radio telephones with own frequencies, telephones and beeper; the brigade of the Central of Operations has six radio telephones distributed in the coordinators in each floor to communicate with in any emergency. For Chingaza Dam system, there is a radio system in VHF that can be connected to the Trunking system.

(5) Repair goods

The tables 2, and 3 show the current equipment available from EAAB for each service area to utilize for emergencies. Information is not only on water supply system equipment but also on waste water system equipment.

Table 2 Distribution of equipment in the service areas in the capital district (Water Supply Network - Maintenance Management)

Equipments	Zones		
	North	Centre	South
	Quantity	Quantity	Quantity
Digger type Jonh Deere	0	1	0
Tipcarts	2	2	2
Compressor	1	1	1
Disk lawn mower	1	1	1
Illumination Tower	1	1	2
Soldering Equipment	0	0	1
Electric Power Plant 2KVA (220V)	1	1	1
Vibro - Compactor	0	0	1
Plumbing Trucks	4	3	4
Light Truck type F-350	2	3	4
Unit of Power	0	0	0
Mixer of 11/2 Bto.	0	0	0
Backhoe	1	0	1
Compactor of Impact	1	0	0
Total No.	14	13	18

Source: Contingency Plan by EAAB, 2000

Table 3 Distribution of equipment in the service areas in the capital district (Waste Water Network - Maintenance Management)

No.	Type of Equipment	Symbol	Total Existing Equipments	North Area	Centre Area	South Area
1	Suction-Pressure truck (VACTOR)	L	15	4	4	7
2	Pressure	EP	2	0	0	2
3	Rod	EV	9	2	3	4
4	Capstan	EC	12	4	3	5
5	Backhoe s/caterpillar	RE	5	1	2	2
6	Backhoe s/tire	RE	1	0	1	0
7	Digger s/Tire	RC	2	1	0	1
8	Loaders	F	5	2	1	2
9	Mini loaders	MC	5	2	2	1
10	Backhoe s/caterpillar, s/tire	F	5	1	2	2
11	Bulldozer	T	3	1	0	2
12	Trailer	R	5	2	1	2
13	Crane	E	1	0	1	0
14	Compressor	K	3	1	1	1
15	Pumping Engine 6"	BD	7	2	2	3
16	Pumping Engine 8"	BD	4	1	1	2
17	Pumping Engine 10"	BD	4	1	1	2
18	Sound	RS	7	2	2	3
19	Power unit	UP	4	1	1	2
20	Simple Tipcart	Q	7	3	1	3
21	D/simple cabin Tipcart	Q	8	2	3	3
22	D/cabin reconstruction Tipcart	Q	14	4	4	6
23	Tipcart with more capacity	Q	3	1	1	1
24	Level Machine	MN	1	0	1	0
Total No.			**132**	**38**	**38**	**56**

Source: Contingency Plan by EAAB, 2000

(6) Inspection

The plan does not specify the presence of inspectors to check the damages occurred in the network. However, the plan says that any person related with EAAB who identifies a rupture or damage in the network or any dangerous situation, has the obligation to report it to his immediate superior or directly to the Maintenance Division by radio or by telephone.

(7) Emergency Repair

Once an emergency is happened, the emergency committee will analyze the place or places where the emergency is located and the number and localization of valves to be closed in order to reduce leakages. Then the committee will send a group formed by the brigades (upon on each zone), to confirm the report of damages and to close the required valves. The brigade coordinator should inform to the emergency committee coordinator the intensity of the damage by radio.

After analyzing the kind of emergency and if it is classified as Level 1 or Level 2, the committee must determine if the company has enough capacity for coping with it or if it is necessary to contact some supporters like contractors.

If the emergency is classified as Level 3, the committee must contact the general manager that must inform and ask for support to the District Committee for Prevention and Attention of Emergencies, to the Local Committees or if necessary, to the National Committee for Prevention and Attention of disasters.

On the other hand, the emergency committee must analyze the emergency and establish which portion EAAB brigades repair and which other by contractors. Once the situation is understood, the committee must inform to the citizens about the damages, especially, the information related to reparation time. Following recommendations are given:

- Installation of pressure reduction equipment where necessary in order to reduce pressure towards supply stop area
- Preparation and maintenance of equipment and material for emergency use is recommended.

(8) Organization for disaster prevention

The criteria of personnel deployment are necessary to prepare and to inform it to the concerned people.

The methods where and how to go to the gathering place in an emergency are necessary to be known by the personnel to be deployed.

The roles of emergency action organization are recommended to be clear.

The manuals for actions of public relation are necessary to be prepared for such cases as in an usual operation, just in and after a disaster by earthquake and at supply stop.

3) Gas Natural Company

(1) General

The Contingency Plan is prepared by the Gas Natural gas company based on the vulnerability study on the main distribution network of gas pipes in Bogotá City which consists of steel pipes with diameters between 4" and 14".

The plan includes objectives, target emergency incident, categorization of emergency level, judgment of categorization, notification way, staff, information collection and distribution, emergency response measures, etc.

(2) Present emergency response plan

A. Objectives, target emergency incident and strategy

The plan is prepared in order to prevent and cope with emergencies that might be present on the main distribution network. The Objectives, target emergency incident and strategy of the plan is shown in Table 4.

Table 4 Objectives, Target, and Strategy of Contingency Plan by Gas Natural Company

Objectives	Target emergency incident	Strategy
a. Safeguard people and goods. b. Environmental preservation. c. Service maintenance and security pressures in the networks. d. Target for the public image.	a. Large amount of gas leakage into the atmosphere. b. Presence of gas in confined spaces. c. Gas leakage migrating toward confined spaces. d. Fire. e. Explosion. f. Over pressure g. Lack of Supply.	a. Emergency actions: a centralized manner from the Coordination of Emergency Attention Center (C.C.A.E). b. Handling of a gas leak: immediate isolation, securing zone/path of distribution net or affected facility. c. Potential risk of the leak: avoid total decompression of facility or of the involved net path. d. Attention priority: leak inside a house and in the high pressure net. e. Presence of huge event: handle along with the Emergency Local Committees, also if necessary, collaboration from other companies. f. Preventive action: carrying out the preventive/corrective maintenance along with the patrolling/operative continuous control of all Natural Gas Company facilities.

Source: Natural Gas Company, 2001

B. Categorization of emergency level

According to the results of the vulnerability study on the main network, the company has established three emergency levels, which will have management strategies within the Contingency Plan. The three emergency levels are classified such as very serious emergency, serious emergency and damage, depending on the affected area, number of damages, control capacity, damages to people, environmental deterioration and the requirement of external support. The categorization levels of emergencies are shown in Table 5.

Table 5 Categorization Level of Emergencies

Level 1. Very Serious Emergency	
Very Serious Emergency in Distribution and Transportation	Serious Accident
	a) If the accident affects people (death or serious injuries) or the facilities of Natural Gas Company or others with serious material damages.
	b) Accident situation that reaches a public repercussion in a way seriously altering the image of Natural Gas Company, even if the effect of the accident on people or properties is just slight or none at all.
	c) Seismic, avalanche and landslide events.
	Serious Supply Problem
	a) If the accident affects the supply due to a defect or pressure excesses.
	b) If the accident affects the supply of a hospital, industry, customer, potential consumption of more than 4 million m^3 per year.
	c) Accident situation that affects the supply and reaches a public repercussion in a way seriously altering the image of Natural Gas Company, it does not affect the number of customers.
Very Serious Emergency in Reception	a) Failure in the reception of natural gas, which comes from the transporters.
Level 2. Serious Emergency	
Serious Emergency in Distribution	Minor Accident
	a) If the accident affects people (minor injuries) or properties of others with some slight damage.
	b) Great intensity leaks, without causing personal or material damages, without provoking a potential risk situation, and not reaching serious public repercussion.
	c) If a great amount of complaints are recorded due to an elevated level of gas odor in a reduced area.
	d) Situations that openly compromise the Company without any serious consequences to people and goods.
	Slight Supply Problem
	a) If the accident affects the supply due to a defect or pressure excesses; however, if the situation reaches a public repercussion considered as serious, then the incident could go up to the next level even if the number of customers does not reach the stipulated one.
Level 3. Damage	
Damage	a) Leak situation in which no one is injured and no public alert is given.
	b) If the accident affects the supply due to defect or pressure excesses .

Source: Contingency Plan by Natural Gas Company, 2001.

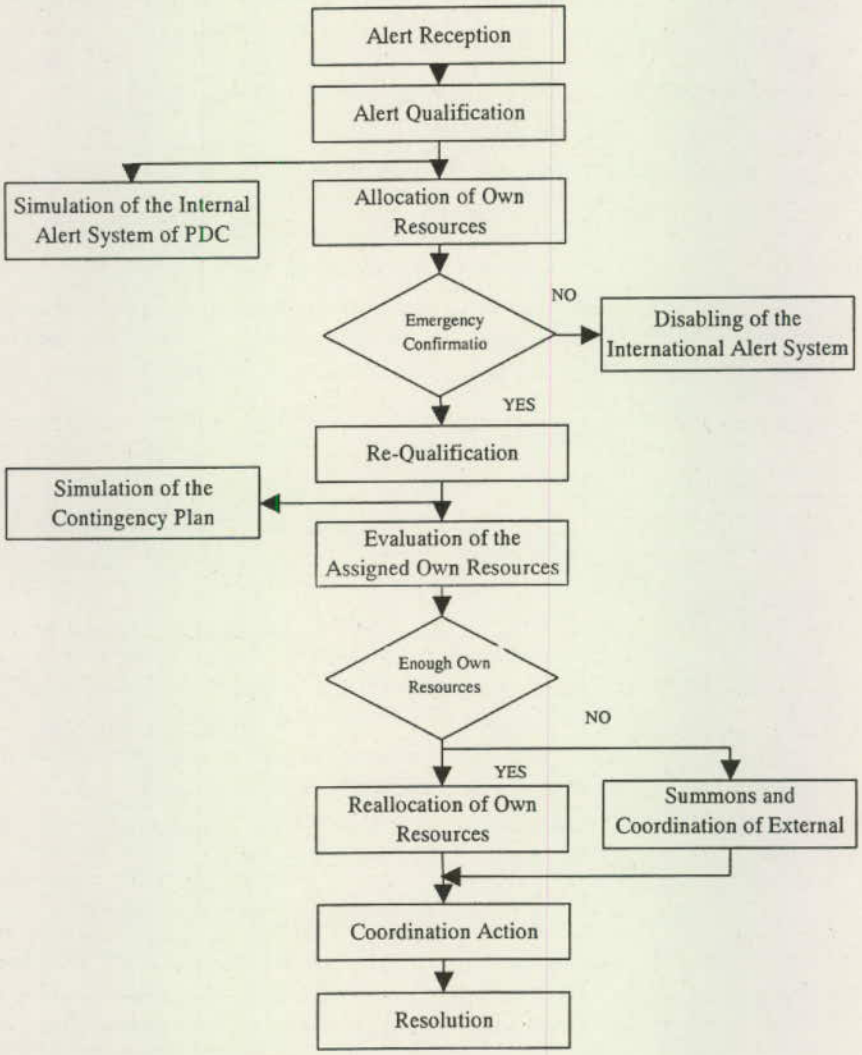
C. Emergency response chart

Emergency Attention Center (C.C.A.E in Spanish) is established first and emergency actions will be coordinated in a centralized manner from the Center.

If a huge incident is happened and exceeding the response capacity of Gas Natural, then it will be coordinated to be handled along with the Emergency Local Committees.

Also, if necessary, collaboration from the related companies that are storing, transporting and/or distributing hydrocarbon (or derived substances), will be required

Figure 2 is the flow chart showing the emergency response.



Source: Contingency Plan GAS NATURAL Company

Figure 2 Emergency response chart

D. Staff

There are two different kind of division systems for Bogotá City: The commercial one, which divides the city in three different sectors, and the technical one (to attend emergencies) which takes the city as a whole.

The attention of emergencies in Bogotá City is performed in two steps: The first one is carried out by gas Natural Company directly, that consists of reduction or elimination of the problem (make the area safe), and the second step that consists of reparation or re-construction of the damaged portion.

This second stage is performed by contractor companies under the contract of Gas Natural (private companies). For the attention of emergencies outside Bogotá, both steps are carried out by contractors. However there in not information available about staff in the two stage idea. Gas Natural says they can fix ten damages per day from the interview.

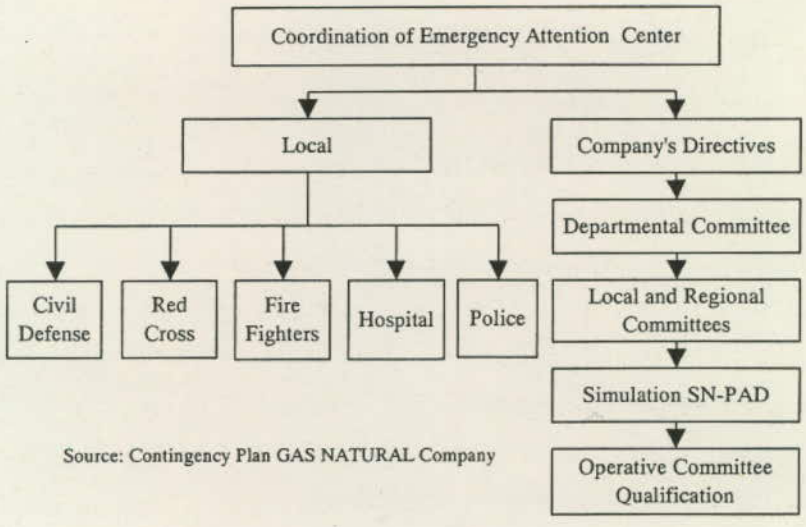
E. Information collection and distribution

In order to receive information of problems or emergencies in the Gas Natural network, the company has two different systems: the one is through the dispatch centre where some valves at the main network is monitored in real time by the measurement of gas volume, temperature, pressure, smell and calorific value.

The other information system is through the Urgency Center where phone calls from the users are received in aspects related to distribution and gas usage. All phone calls are introduced to a computer system to follow the progress of the emergency, and to categorize the level of problem. Leakage and gas smelling reports have priority over lack of gas.

In respect to communication medias, they use normal cellular phones (Bell South system) in an emergency case and there is a special transmission/radio at the main building in order to make contact with the fire department or the DPAE through a special frequency.

Figure 3 shows the flow how the notification is transmitted



Source: Contingency Plan GAS NATURAL Company

Figure 3 Flow of Notification Transmission

F. Emergency response measures

Repair Resources

For the emergency attention, Gas Natural, counts on the following resources:

- A Coordination of Emergency Attention Center (C.C.A.E.), which works 24 hours, everyday, year round. It's the place where the alerts are received, resources are assigned, actions are coordinated and also the communication with the public emergency institutions.
- Personnel to coordinate other companies or the public authorities with a telemetric measure of the operation parameters in order to attend the gas distribution problem
- Intervention equipment skilled for the immediate attention of emergencies. located on field in a strategic way in order to reach the place of an emergency in a shortest time possible.
- An announcement system to convoke the personnel, from the contract companies and from the public emergency institutions.
- Prevention and Attention of Disasters National System (SN-PAD in Spanish) through activating the notification chain, which proposes to involve the operator with the local emergency committees. The simulation of the Emergency Plan foresees the activation of the emergency structure of the company and SN-PAD at a local and regional level.
- Own communication system, between the intervention and maintenance teams with C.C.A.E.
- Own maintenance equipment and that from contract companies, with the necessary training in order to carry out every type of reparations in the utilization of facilities, auxiliary facilities as well as in the distribution network of high and mid pressure.

G. Inspection measures

No information available

H. Emergency measures

For immediate measures, the followings are taken:

- To assign resources for the solution, such as moving equipment and contracting the proper company, according to the emergency categorization.
- To take the first action for the resolution at the emergency field based on the coordination under C.C.A.E. and on the collected all the possible information in order to evaluate the magnitude of the emergency.
- To verify if the sources mobilized initially for the resolution are proper or not, by examining of the results of the first action.
- To coordinate all the actions to be taken in order to solve the emergency from the field and from C.C.A.E.

- To establish the initial communication with the authorities presented at the emergency field.
- To request the police intervention for the jurisdiction and/or the fire department to help solving the emergency and to assign medical assistance for the company's personnel or others affected by the accident.
- To keep informed the company's hierarchy of the emergency situation.
- In case of leakage, fire or gas explosion and if it is necessary to evacuate housings, public/private buildings, then the displacement and lodging orders will be given to the people affected by the emergency.
- To give alerts to the public authorities in case of serious or very serious emergencies that had been transmitted to the public mass media.
- To coordinate the authorities concerned and communication.

4) Disaster Prevention and Emergency Response Plan of Electrical Supply System

(1) Emergency Response Plan of EMGESA

A. Present disaster preparedness and emergency response plan

a) General

EMGESA has contingency plans, but only in the buildings and due to emergencies such as fire, floods or small earthquakes. These plans only consider aspects related with the evacuation of the personnel and their safety, but not plans related with the continuity of the electrical generation or how to prepare the potential damages.

b) Staff

The personnel in each generation plant is only the minimum necessary to administrate and make the normal maintenance procedures. The normal maintenance involves the mechanical and electrical matters, together with the checking of pipes.

c) Information Collection and Distribution

There is main control center where all the generation plants are monitored. Additionally, within each plant there is control center that monitors in real time variables such as pressure in the pipes and amount of energy generated, and is able to control the valves. Information about communication systems is not available.

d) Emergency response measures

Repair goods

If some serious problem occurs in a plant, like the damage of a turbine, the plants do not have the capability for repairing it in original state. It always needs to hire a special firm to perform this

kind of maintenance work, and sometimes the damaged elements should be transported to other city in order to be repaired.

A deep preventive maintenance is performed every year in each plant.

Emergency power generation

There is not a specific plan for the redundancy of the electric generation system. But usually all the plants owned by EMGESA are not operated at the same time.

The system of generation plants that uses water of Rio Bogotá is divided into two chains of generation called the old chain and the new one. Latter chain which is connected with Guavio plant is usually operated.

But the old chain is started when more power generation is required, even though its efficiency is very low compared to the new generation chain.

Recovery measures

There are not plans or rehabilitation measures. Furthermore, there are not plans for mutual help with other companies like CODENSA or EEB in emergency cases.

(2) Disaster Prevention and Emergency Response Plan of EEB

A. Present disaster preparedness and emergency response plan

a) General

The company has Environmental Management Plans for the transmission lines of 230 kV that conform to the Central and South corridors. The system is called Bogotá.

Within such studies, a contingency plan for each case was studied, but these plans are only available at the dependences of the company. The available information of these plans was limited.

b) Staff

EEB does not perform reparations directly, so the company does not have equipment or machinery. The preventive and corrective maintenance, and the emergency response are carried out by a contract with special companies.

These contractors are supervised directly by EEB and must fulfill the requisites given in the contract, the inspection manual and the company statute

c) Information Collection and Distribution

The company has the regional control center, which controls and supervise the assets owned by the company. The company supervises the infrastructure of transmission through the regional

control center that functions 24 hours per day all the year. When an event or emergency in the system occurs, the engineer in charge performs the procedures and warns the maintenance coordinators.

d) Emergency response measures

Repair goods

There is not information available in respect to repair goods. As mentioned before, EEB does not perform any kind of reparation works directly. This kind of work is all done by contractors.

Inspection and emergency repair

There is a little information as follows:

- The reparation of a tower could take 30 days, while repairing a broken wire takes 12 hours.
- The company participates actively in the Committee for Electrical System Security, which is integrated for all the Energy companies in Cundinamarca and Meta.

(3) Disaster Prevention and Emergency Response Plan of CODENSA

A. Present disaster preparedness and emergency response plan

a) General

CODENSA has prepared the contingency plan which is related to the actions taken by CODENSA in order to prevent and respond to emergencies that might be present on the main distribution network of electricity in Bogotá City and the whole country as well.

b) Summary of contingency plan

A summary of the objective, scope of the actions that the personnel might perform and the covered events by the contingency plan are shown in Table 6. The covered disasters are mainly seven (7) disasters such as fire, seismic movement, collapsed structure, explosion and etc., and several scope of personnel intervention is mentioned.

Table 6 Summary of Contingency Plan by CODENSA

Objective	Covered Disasters	Scope of Personnel Intervention
a. To have a coordinated group of human resources, physical, technicians, administrative and financial resources to assist quickly and efficiently events that threaten the stability and permanency of the company, the community or the environment	a. Fire in administrative areas and offices b. Fire in substations c. Seismic Movements d. People trapped in collapsed structures e. Attack with explosive f. Bomb threat g. Holdup, kidnapping or forced taking	a. To act according to the procedures settled down in the Plan b. To use the protection and control means for emergencies, available in the headquarters. c. All intervention in the event of emergency should have support on external rescue squads. d. Never act if your life or personal integrity is put in danger. e. The actions that occupants of the headquarters would perform, will be at the level of first answer and control of incipient events. f. All event whose magnitude overcomes the present personnel's capacities in the headquarters, or the capacity of the control equipment available for emergencies, should be commended to external rescue squads.

Source: CODENSA, 2001.

c) Organization

The organizational structure for emergencies is shown in Figure 4 and the sequence of internal response in emergency case is shown in Figure 5.

General coordinator of emergencies manage and control of emergency situation through 10 head quarters.

The brigade personnel collects information and give it through emergency coordinator to general coordinator for analysis and decision.

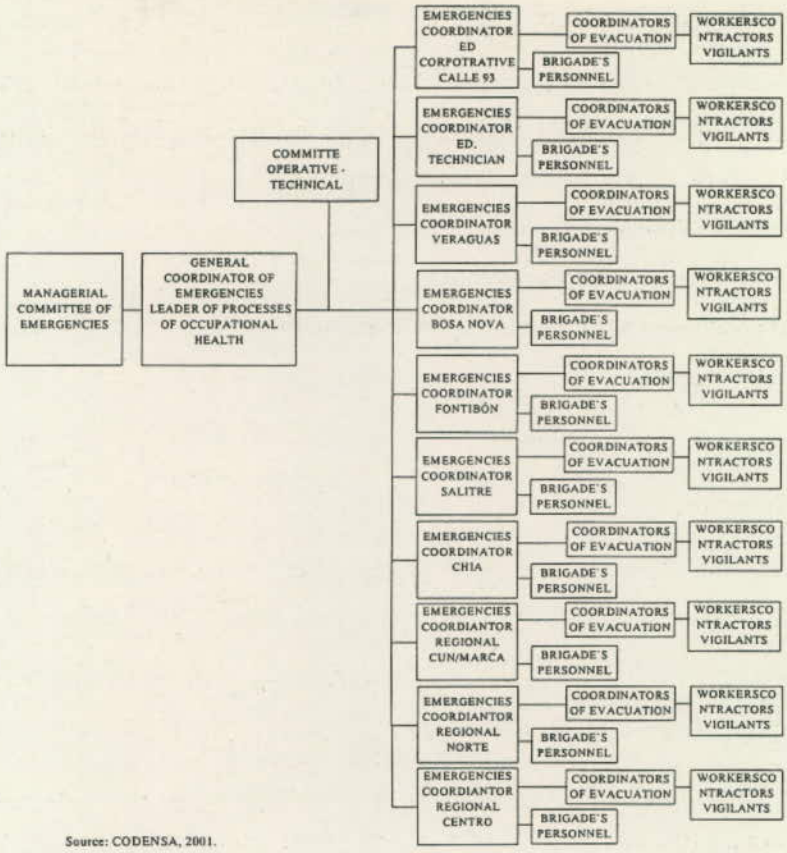


Figure 4 Organizational Structure for Emergencies

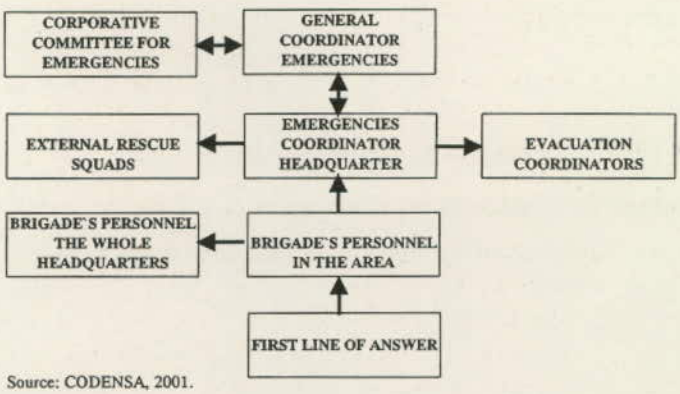


Figure 5 Sequence of Internal Response in Emergency

d) Staff, information collection and distribution

Even though the Study Team has not received much information about CODENSA , it is known that the maintenance, control and reparations are performed by personnel of the company, but as in a similar case of EAAB, because the size of the network, CODENSA hires external contractors to carry out some work.

e) Emergency response measures

The contingency plan has executed the vulnerability analysis of the headquarters, and is performing the organizational structure, brigades, training and simulation. Besides, the plan is advancing in the following implementation plans.

- Specific Procedures;
- Inventories of external resources;
- Improvement of protection level in substations, and
- External performance plans.

5) Telecommunication System

(1) General

There are six institutions, ETB, CAPITEL, EPM. Bogotá, TEELECOM, COMCEL, BELLSOUTH with regard to telephone communication system in Bogotá metropolitan area.

ETB have 37 local control centers and 4,500 cabinets in Bogotá City. While CAPITEL have 10 local control centers and 98 radio bases.

There is no information available for the disaster preparedness plan and emergency response plan of telephone communication system except a little information.

Only a little information is from ETB. ETB are performing vulnerability study to 37 local control center buildings and the Study of 15 buildings is already finished as of May 2001. Reinforcement of 8 buildings are under reinforcement and will be completed in 2001.

(2) Emergency Response Plan

A. General

As above mentioned, there is no information available for present disaster preparedness and emergency response plan, only requisite recommendation is made for preparation of those plans.

Appendix 5.3.2 Matrix for Organization

Table 1 Organizations and Responsibilities in Emergency Responses (Bogota D.C.)

	Transportation	Communication	Public works and Engineering	Fire-fighting	Information and Planning	Mass care	Resources Support	Health and Medical Services	Urban Search and Rescue	Hazardous Materials	Food	Energy
Mayor	S	S	S	S	S	S	S	S	S	S	S	S
Government Secretary						S					S	
DAPD			S		S		S					
Health Secretary						S		**P**	S	S		
Treasury Secretary							S					
DAMA			S		S					S		
DPAE-FOPAE	S	S	S	S	**P**	S	**P**	S	S	S	S	S
Firemen Official Body				**P**					**P**	**P**		
Civil Defense	S			S		S		S	S	S	S	
Red Cross						S		S	S	S	S	
Metropolitan Police	S	S		S	S			S	S	S	S	
Military Unit	S	S	S	S		S		S	S			
District Administrative of Social Welfare						**P**	S				**P**	
Transit Police	S	S		S	S				S			
EAAB ESP			S	S	S	S						
IDU	S		P									
EEB CODENSA			S			S						**P**
ETB TELECOM		**P**										
Department of Community Action		S			S	S		S	S		S	
Local Mayors	S	S	S	S	S	S	S	S	S	S	S	S
Secretary of Traffic and Transport	**P**											
Concejo Colombino de Segridad (CCS)										S		
Metro Vivienda			S						S			
TRANSMILENIO	S											
Natural Gas E.S.P										S		

Note: Primary Agency: Responsible for coordination of the emergency support function

Support Agency: Responsible for supporting the primary agency

Source: JICA Study Team, Bogota City Government

Table 2 Preparedness and Responsible Agencies for Disaster Prevention (Bogota D.C.)

	Government Buildings	Transportation facilities	Hospital buildings	Medical Arrangement	Hazard Materials	Communication System	Public Education	Lifeline facilities	Prepare for Emergency Res.	Parks	Landslide	Flood Control Facilities	House Buildings
Mayor	S	S	S	S	S	S	S	S	S	S	S	S	S
Government Secretary	S	S			S	S	S	S	P				
DAPD	S	S	S			S	S	P	S	S	S	S	S
Health Secretary	S		P	P	S	S	S		S				
Treasury Secretary	S	S	S										
DAMA					P				S				
DPAE-FOPAE	S	S	S	S	S	P	S	S	S	S	P	S	S
Firemen Official Body					S	S	S		S				
Civil Defense						S	S		S				
Red Cross			S	S		S	S		S				
Metropolitan Police					S	S							
Military Unit					S								
District Administrative of Social Welfare							S						
Transit Police						S			S				
EAAB ESP								S	S			P	
IDU	P	P	S					S	S				
EEB CODENSA								S	S				
ETB TELECOM						S		S	S				
Department of Community Action													
ECOPETROL					S			S					
Secretary of Education							P						
Metro Vivienda													P
Local Mayors	S	S	S	S	S	S	S	S	S	S	S	S	S
District Institute of Recreation and Sports									S	P			

Note: Primary Agency Responsible for coordination of the emergency support function

Support Agency Responsible for supporting the primary agency

Source: JICA Study Team, Bogota City Government

Table 3 Organizations and Responsibilities in Emergency Responses in Cundinamarca

	Transportation	Communication	Public works and Engineering	Firefighting	Information and Planning	Mass Care	Resources Support	Health and Medical	Search and Rescue	Hazardous Materials	Food	Energy
Governor	S	S	S	S	S	S	S	S	S	S	S	S
General Secretaey	S	S	S	S	S	S	S	S	S	S	S	S
Military Brigade	S	S	S		S	S	S	S	S		S	
National Police	S	S	S		S		S	S	S		S	
Firemen Office		S		**P**	S	S	S		S	**P**		
Secretary of Health	S	S		S	S		S	**P**	S	S		
CAR			S	S	S	S				S		
Civil Defense	S	S		S	S	S	S	S	**P**	S	S	
Red Cross	S	S		S	S	S	S	S	S	S	S	
Secretary of Planning			S		S		S					
Government Secretary OPAD	P	P	S	S	P	S	**P**	S	S	S	**P**	S
Secretary of Agriculture and Rural Development			S		S		S				S	
Secretary of Treasury			S		S		S					
Secretary of Public Works			**P**		**S**	S	S					**P**
Secretary of Environment				S	S					S		
Secretary of Social Development					S	**P**	S					
Traffic and Transportation Administration Department	S				S					S		
Human Talent Administrative Department					S							
Eight Municipalities	S	S	S	S	S	S	S	S	S	S	S	S
Empresa Energ					S							S
Empresa Electrica CODENSA		S			S							S
Sec. Prensa		S										
TELECOM		S										
Communidad	S	S	S	S	S	S	S	S	S	S	S	S
Concejo Colombiano de Segridad (CCS)										S		

Note: Primary Agency: Responsible for coordination of emergency support function

Support Agency: Responsible for supporting the primary agency

Source: JICA Study Team, Cundinamarca Government

Table 4 Preparedness and Responsible Agencies for Disaster Prevention inCundinamarca

	Government Buildings	Transportation facilities	Hospital buildings	Medical Arrangement	Hazard Materials	Communication System	Public Education	Lifeline facilities	Prepare for Emergency Res.	Parks	Landslide	Flood Control Facilities	House Buildings
Governor	S	**S**	S	S	S	S	S	S	S	S	S	S	S
General Secretary		**P**											
Military Brigade						S	S		S				
National Police						S	S		S				
Firemen official Body					**P**	S	S		S				
Secretary of Health			**P**	**P**		S	S		S				
CAR					S		S						
Civil defense						S	S		S				
Red Cross						S	S		S				
Secretary of Planning	S		S				S	S	S		S	S	
Government Secretary OPAD	**P**	S	**P**	S	S	**P**	S	S	**P**	S	S	S	S
Secretary of Agriculture and Rural development									S			S	
Secretary of Treasury	S	S	S			S	S	S					
Secretary of Public Works	S		S			S		S	S		**P**	S	S
Secretary of Environment					S		S		S				
Secretary of Education							**P**						
Secretary of Social Development							S		S				
Institute of Vivienda									S				S
Traffic and Transportation administration		S							S				
CUNDEPORTE										S			
Eight Municipalities	S	S	S	S	S	S	S	S	S	**P**	P	P	P

Note: Primary Agency: Responsible for coordination of the emergency support function

Support Agency: Responsible for supporting the primary agency

Source: JICA Study Team, Cundinamarca Government

Table 5 Organizations and Responsibilities in Emergency Responses (National)

	Transportation	Communication	Public works and Engineering	Fire-fighting	Information and Planning	Mass care	Resources Support	Health and Medical Services	Urban Search and Rescue	Hazardous Materials	Food	Energy
President office	S	S	S	S	S	S	S	S	S	S	S	S
Ministry of Interior				S	S		S					
Ministry of Finance and Public Credit							S					
Ministry of National Defense		S										
Ministry of Health		S			S	S		P	S	S	S	
Ministry of Communication		P			S							
Ministry of Transportation	P								S	S		
Ministry of Environment			S	S						S		
National Department of Planning					S		S					
Colombian Civil Defense	S			S		S		S	P	S	S	
Colombian Red Cross		S		S		S		S	S	S	S	
Colombian Chamber of Construction			S									
Colombian Society of Construction Engineer			S									
DGPAD	S	S	P	S	P	S	P	S	S	P	S	S
National Institute of Roads (INVIAS)	S		S									
Military Forces (FF,MM)	S	S	S	S		S		S	S			
Colombian Telecommunication's Enterprise (TEELECOM)		S										
Ministry of Education					S	S						
National Institute of Familiar Comfort(ICBF)						P		S			P	
National System of Fire Fighters		s		P					S	S		
Ministry of Agriculture,						S					S	
Ministry of Energy			S							S		P
Ministry of Development			S							S		S
Consejo Colombiano de Seguridad (CCS))										S		

Note: Primary Agency: Responsible for coordination of the emergency support function

Support Agency: Responsible for supporting the primary agency

Source: JICA Study Team, DGPAD

Table 6 Preparedness and Responsible Agencies for Disaster Prevention (National Level)

	Government Buildings	Transportation Facilities	Hospital Building	Medical Arrangement	Hazard Materials	Communication System	Public Education	Lifeline Facilities	Prepare for Emergency Res.	Investigation
President Office	S	S	S	S	S	S	S	S	S	
Ministry of Interior	S					S			S	
Ministry of Finance and Public credit	S		S						S	
Ministry of National Defense	S					S			S	
Ministry of Health	S		P	P		S	S		S	
Ministry of Communication	S					P	S	S	S	
Ministry of Transportation	S	P				S		S	S	
Ministry of Environment	S					S	S		S	S
National Department of Planning	S	S	S			S		S	s	S
Colombian Civil Defense						S	S		P	
Colombian Red Cross Society			s	S		S	S		S	
Colombian Chamber of Construction	S									
Society of Construction Engineer	S							S		
DGPAD	P	S	S	S	S	S	S	S	S	P
National Police									S	
National Institute of Roads(INVIAS)						S		S	S	
Military Force (FF.MM)						S			S	
Colombian Telecommunication's Enterprise (TELECOM)						S		S		
Ministry of Education	S						P			S
National Institute of Familiar Comfort (ICBF)	S								S	
National System of Fire Fighters						S			S	
Ministry of Agriculture	S									
Ministry of Energy	S							S	S	S
Ministry of Development	S							P	S	S
National University										S

Note: Primary Agency: Responsible for coordination of the emergency support function

Support Agency: Responsible for supporting the primary agency

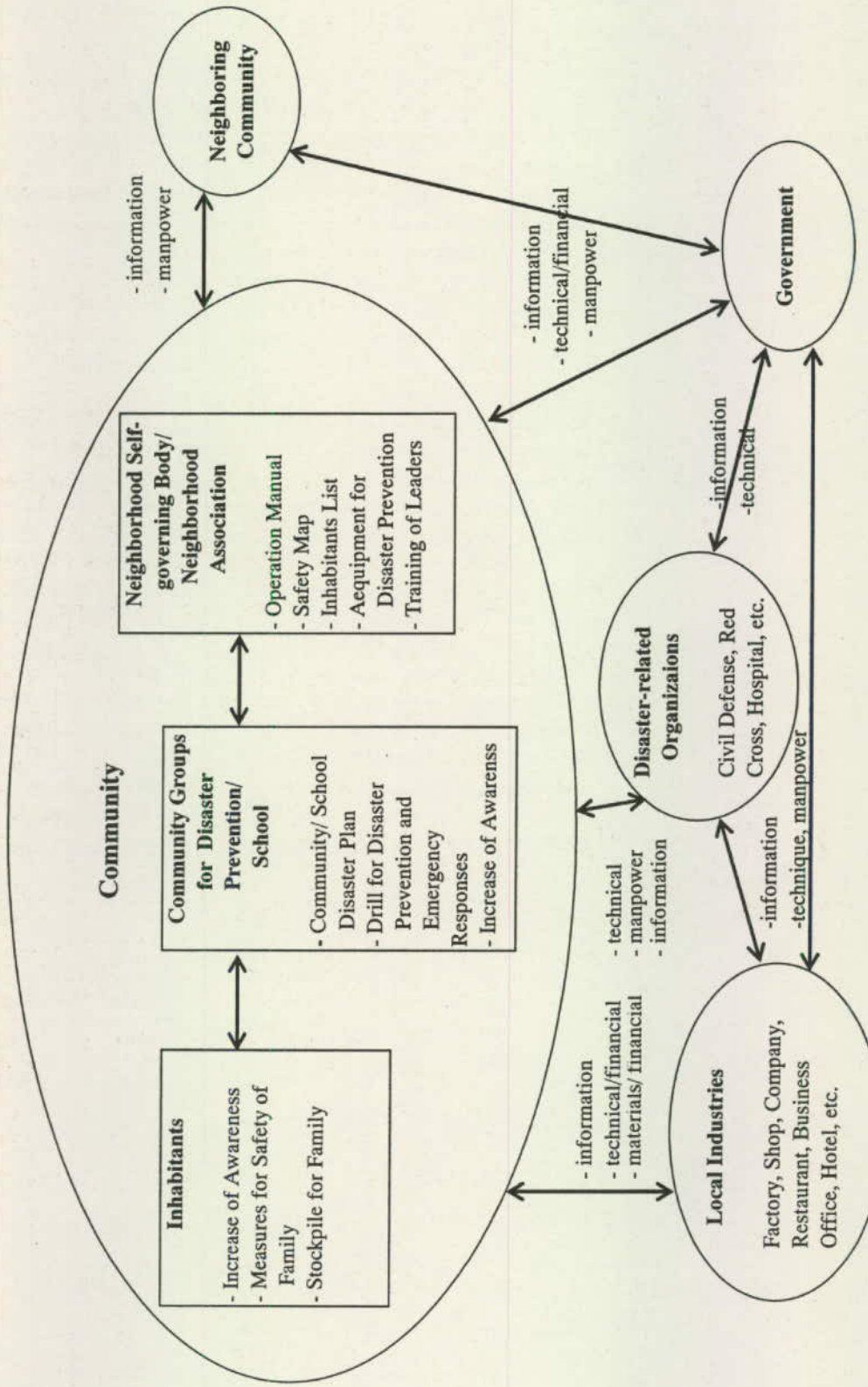
Source: JICA Study Team, DGPAD

Appendix 5.5.1 Summary of Laws and Regulations for Rehabilitation

Laws and regulations	Descriptions
Decree 1355, 1970 National Police Code	The mayors of a municipality can order a demolition if a construction is about to be collapsed and if public safety is in risk, or in order to stop a fire or to stop any other public calamity.
Decree 1547, 1984	The National Calamity Fund must be used to maintain the environmental sanitation during the reconstruction and rehabilitation phases.
Decree 919, 1989	On the other hand, the mayors in the disaster area have the power to command the demolition of any construction that represents a risk for security or health of the inhabitants. The National Office for Attention of Disasters would recruit studies to evaluate areas where no settlements or buildings can be constructed because of environmental danger or risk reasons. Section IV, it describes the administrative procedures for land or properties acquisition and/or expropriation, when public benefit or social reasons exist. The Committee in charge of the reestablishment of minimum conditions for environmental sanitation is the National Operative Committee for the Attention of Disasters. The National Fund of Vicinal Roads will provide the funds to plans of actions for the attention of disasters, without co-financing requirements.
Law 388, 1997	According to criteria of public utility, land or properties can be expropriated. In order to perform this process, national and territorial entities, as well as industrial and commercial companies of the state of the national, prefecture and municipal orders, have the faculty to develop it. The expropriation must be done to fulfill the objectives and land uses established on the POT, and the procedure for it is the one foreseen in law 9th of 1989. In respect to expropriation by administrative way, it can be done if the correspondent administrative authority considers the presence of emergency conditions; the institution must pay an indemnity, which is equal to the commercial valuation of the property. Even though the land usage or distribution is not related directly to disasters or rehabilitation projects, the land distribution done in the POTs might represent a guideline for the reconstruction of a city.

Source: Summarized by JICA Study Team

Appendix 5.6.1 Ideal Relationship among the Concerned Parties for Disaster Management



Appendix 5.8.1 Project List

1. Implementation Plan - Strengthen Important Buildings (Bogota)

Program		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
1.1	Strengthen Emergency Commanding Centers	1.1.A. Seismic diagnosis study of the Ministry of Interior	Ministry of Interior	8	
		Reinforcement of the Ministry of Interior	Ministry of Interior	386	
		1.1B. Seismic diagnosis study of the OPAD	Cundinamarca Government	1	
		1.1.C. Reinforcement of the OPAD	Cundinamarca Government	60	
		1.1.D. Seismic diagnosis study of Cundinamarca Prefecture	Cundinamarca Government	91	
		1.1.E. Reinforcement of Cundinamarca Prefecture	Cundinamarca Government	4,582	
		1.1.F. Seismic diagnosis study of the 19 Locality Offices	Each locality Bogotaá	89	
		1.1.G. Reinforcement of the 19 Locality Offices	Each locality Bogotaá	4,459	
		1.1.H. Seismic diagnosis study of the 8 Municipalities	Each municipality of Cundinamarca	42	
		1.1.I. Reinforcement of the 8 Municipalities	Each municipality of Cundinamarca	2,129	
1.2	Strengthen Operation Buildings	1.2.A. Seismic diagnosis study of the Police Headquarter La Estanzuela	Police	2	
		1.2.B. Reinforcement of the Police Headquarter La Estanzuela	Police	86	
		1.2.C. Seismic diagnosis study of the Civil Defense Headquarter	Civil Defense	24	
		1.2.D. Reinforcement of the Civil Defense Headquarter	Civil Defense	1,176	
		1.2.E. Seismic diagnosis study of the Red Cross Headquarter	Red Cross	76	
		1.2.F. Reinforcement of the Red Cross Headquarter	Red Cross	3,816	
		1.2.G. Seismic diagnosis study of the Central Command of Army	Ministry of Defense	194	
		1.2.H. Reinforcement of the Central Command of Army	Ministry of Defense	9,723	
1.3	Strengthen Important Hospitals	1.3.A. Seismic diagnosis study of the 38 Hospitals and Clinics in III Level Category 1.3.B. Service	Each Hospital	1,201	
		1.3.B. Reinforcement of the 38 Hospitals and Clinics in III Level Category 1.3.B. Service	Each Hospital	60,062	
1.4	Strengthen Rescue Operation Buildings	1.3.A. Seismic diagnosis study of the 13 Fire Fighting Stations	Fire fight Bogotaá City	30	
		1.3.B. Reinforcement of the 13 Fire Fighting Stations	Fire fight Bogotaá City	1,483	
		1.3.C. Seismic diagnosis study of the 27 Police Stations	Police	301	
		1.3.D. Reinforcement of the 27 Police Stations	Police	15,070	
		1.3.E. Seismic diagnosis study of the 14 Civil Defense Branches	Civil Defense	28	
		1.3.F. Reinforcement of the 14 Civil Defense Branches	Civil Defense	1,412	
		1.3.G. Seismic diagnosis study of the 124 Army Buildings	Ministry of Defense	648	
		1.3.H. Reinforcement of the 124 Army Buildings	Ministry of Defense	32,385	
1.5	Strengthen Hospitals	1.5.A. Seismic diagnosis study of the 15 Hospitals and Clinics	Each Hospital	139	
		1.5.B. Reinforcement of the 15 Hospitals and Clinics	Each Hospital	6,936	
1.6	Strengthen Regional Evacuation Buildings	1.6.A. Seismic diagnosis study of the Regional Evacuation Places	Bogotaá City	214	
		1.6.B. Reinforcement of the Regional Evacuation Places	Bogotaá City	10,683	
1.7	Strengthen Other Potential Evacuation Sites	1.7.A. Seismic diagnosis study of the 84 Kindergarten Buildings	Bogotaá City	68	
		1.7.B. Reinforcement of the 84 Kindergarten Buildings	Bogotá City	3,406	
1.8	Strengthen Other Important Government Buildings	1.8.A. Seismic diagnosis study of the 28 Ministries Buildings	Each Ministry	659	
		1.8.B. Reinforcement of the 28 Ministries Buildings	Each Ministry	32,936	
1.9	Strengthen Transportation	1.9.A. Seismic diagnosis study of the Airport	Airport Authorities	361	
		1.9.A. Reinforcement of study of the Airport	Airport Authorities	18,052	
		1.9.B. Seismic diagnosis study of the Bus Terminal of Bogotá	Secretary of Transport	90	
		1.9.C. Reinforcement of the Bus Terminal of Bogotá	Secretary of Transport	4,520	
1.10	Strengthen Goods Storage Site	1.10.A. Seismic diagnosis study of Corferias - Exhibition Center	Bogotá City	108	
		1.10.B. Reinforcement of Corferias - Exhibition Center	Bogotá City	5,393	
1.11	Strengthen Food Storage Site	1.11.A. Seismic diagnosis study of Corabastos	Bogotá City	201	
		1.11.B. Reinforcement of Corabastos	Bogotá City	10,097	

1. Implementation Plan - Strengthen Important Buildings (Cundinamarca)

Program		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short (2002, 2003, 2004) / Medium (2005, 2006, 2007) / Long (2008, 2009, 2010)
1.12	Strengthen Emergency Commanding Centers in Cundinamarca	1.12.A. Seismic diagnosis study of the Local Major Offices	Cundinamarca Government	93	
		1.12.B. Reinforcement of the Local Major Offices	Cundinamarca Government	1,868	
1.13	Strengthen Organizations for Rescue Operation in Cundinamarca	1.13.A. Seismic diagnosis study of the Fire Fighting Stations	Fire fight	7	
		1.13.B. Reinforcement of the Fire Fighting Stations	Fire fight	348	
		1.13.C. Seismic diagnosis study of the Police Stations	Police	18	
		1.13.D. Reinforcement of the Police Stations	Police	925	
		1.13.E. Seismic diagnosis study of the Civil Defense	Civil Defense	2	
		1.13.F. Reinforcement of the Civil Defense	Civil Defense	83	
		1.13.G. Seismic diagnosis study of the Red Cross	Red Cross	4	
		1.13.H. Reinforcement of the Red Cross	Red Cross	212	
		1.13.I. Seismic diagnosis study of the Army	Ministry of Defense	1	
		1.13.J. Reinforcement of the Army	Ministry of Defense	50	
1.14	Strengthen Important Hospitals in Cundinamarca	1.14.A. Seismic diagnosis study of the Hospitals and Clinics	Each Hospital in Cundinamarca	28	
		1.14.B. Reinforcement of Hospitals and Clinics	Each Hospital in Cundinamarca	1,403	
1.15	Strengthen Hospitals in Cundinamarca	1.15.A. Seismic diagnosis study of the Health Consulting Centers	Each Health Consulting Center in Cundinamarca	120	
		1.15.B. Reinforcement of Health Consulting Centers	Each Health Consulting Center in Cundinamarca	5,976	
1.16	Strengthen Regional Evacuation Sites in Cundinamarca	1.16.A. Seismic diagnosis study of the Regional Evacuation Places	Cundinamarca Government	38	
		1.16.B. Reinforcement of Regional Evacuation Places	Cundinamarca Government	1,896	
1.17	Strengthen Other Potential Evacuation Sites in Cundinamarca	1.17.A. Seismic diagnosis study of Schools & Kindergartens	Cundinamarca Government	454	
		1.17.B. Reinforcement of Schools & Kindergartens	Cundinamarca Government	22,687	

2. Implementation Plan - Infrastructure - Bridges Program

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule (Short / Medium / Long) 2002 2003 2004 2005 2006 2007 2008 2009 2010
2.1	Seismic diagnosis study and reinforcement of vehicular bridges along emergency road network and high liquefaction potential area	2.1.A. Seismic diagnosis study of vehicular bridges (25 bridges)	IUD	2,000	
		2.1.B. Reinforcement of the above bridges (29 bridges)	IUD	29,000	
2.2	Seismic diagnosis and reinforcement of vehicular bridges in emergency road network and out of liquefaction area	2.2.A. Seismic diagnostic study of bridges (69 bridges)	IUD	5,500	
		2.2.B. Reinforcement of the above structures (88 bridges)	IUD	88,000	
2.3	Seismic diagnosis and reinforcement of vehicular bridges in other road network and high liquefaction potential area	2.3.A. Seismic diagnostic study of bridges (11 bridges)	IUD	900	
		2.3.B. Reinforcement of the above structures (13 bridges)	IUD	13,000	
2.4	Seismic diagnosis and reinforcement of vehicular bridges in other road network than above	2.4.A. Seismic diagnostic study of bridges (48 bridges)	IDU	3,800	
		2.4.B. Reinforcement of the above structures (48 bridges)	IDU	48,000	
2.5	Seismic diagnosis and reinforcement of pedestrian bridges in emergency road network	2.5.A. Seismic diagnostic study of bridges (30 bridges)	IDU	600	
		2.5.B. Reinforcement of the above structures (110 bridges)	IDU	55,000	
2.6	Seismic diagnosis and reinforcement of pedestrian bridges in high liquefaction potential area	2.6.A. Seismic diagnostic study of bridges (3 bridges)	IDU	50	
		2.6.B. Reinforcement of the above structures (3 bridges)	IDU	1,800	
2.7	Seismic diagnosis and reinforcement of pedestrian bridges in other area	2.7.A. Seismic diagnostic study of bridges (33 bridges)	IDU	200	
		2.7.B. Reinforcement of the above structures (33 bridges)	IDU	16,500	
2.8	Seismic diagnosis study and reinforcement of vehicular bridges in Cundinamarca	2.8.A. Seismic diagnosis of vehicular bridges (17 bridges)	INVIAS	500	
		2.8.B. Reinforcement of the above bridges (17 bridges)	INVIAS	27,200	
2.9	Seismic diagnosis and reinforcement of pedestrian bridges in Cundinamarca	2.9.A. Seismic diagnostic study of pedestrian bridges (19 bridges)	INVIAS	100	
		2.9.B. Reinforcement of the above structure (19 bridges)	INVIAS	10,000	

3-1. Implementation Plan - Life Line Program - Water Supply System

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule Short / Medium / Long 2002 2003 2004 2005 2006 2007 2008 2009 2010
3-1.1	Reinforcement of Distribution tanks and Pump stations	3-1.1.A. Seismic diagnosis study of equipment, structure and foundation (10 stations)	EAAB	600	
		3-1.1.B. Reinforcement of the above structures:	EAAB	6,000	
3-1.2	Reinforcement of Transportation and distribution system	3-1.2.A. Seismic diagnosis study of pipeline and the attached structure	EAAB	400	
		3-1.2.B. Reinforcement of the above	EAAB	4,000	
		3-1.2.C. Replacement of CIP with sleeve joint of RC, of PVC and of Asbestos Cement with high seismic pipe and joint	EAAB	200,000	
		3-1.2.D. Emergency shutdown valve or new valve installation for minimizing area for water supply	EAAB	20,000	
3-1.3	Reinforcement of Purification plant, Distribution plant	3-1.3.A. Seismic diagnosis study of equipment, structure and foundation	EAAB	740	
		3-1.3.B. Reinforcement of the above as listed below;		7,400	
		3-1.3.C. Mechanical, electrical and instrumentation equipment. Inspection and Reinforcement of redundancy of cables, electric generator, pump facility, chemical agent storage tank, chlorination equipment	EAAB	2,000	
3-1.4	Reinforcement of Supply Facilities	3-1.4.A. Inspection and Reinforcement of branches for high seismic resistance installed where large deformation of ground is foreseen	EAAB	4,000	
3-1.5	Reinforcement of Other Plant, pipeline and facilities	3-1.5.A. Seismic diagnosis study of plant, pipeline, equipment, structure and foundation	EAAB	2,000	
		3-1.5.B. Replacement of pipeline, by-pass pipe, block system of distribution network, connection with other watershed or other responses, etc	EAAB	200,000	
3-1.6	Provision of Emergency Water Tanks	3-1.6 A. Provision of Emergency Water Tanks in Bogota	EAAB	69,455	
		3-1.6 B. Provision of Emergency Water Tanks in Bogota	EAAB	10,305	

3-2. Implementation Plan - Life Lines Programs - Gas Supply Systems

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
3-2.1	Reinforcement of City Gate Receiving Station	3-2.1.A. Seismic diagnostic study of vessel, spherical gas holders, support structures, foundation	Gas Natural Company	50	
		3-2.1.B. Reinforcement of the above structure, equipment and foundation	Gas Natural Company	200	
		3-2.1.C. Seismic diagnostic study of administrative (control) building	Gas Natural Company	20	
		3-2.1.D. Reinforcement of the above structure	Gas Natural Company	60	
3-2.2	Reinforcement of Valve station (Carvajal) located in high liquefaction potential area	3-2.2.A. Seismic diagnostic study of vessel, spherical gas holders, support structures, foundation	Gas Natural Company	100	
		3-2.2.B. Reinforcement of the above structure, equipment and foundation	Gas Natural Company	400	
3-2.3	Reinforcement of Trunk and distribution pipeline installed in high liquefaction potential area	3-2.3.A. Seismic diagnosis study of pipeline	Gas Natural Company	200	
		3-2.3.B. Reinforcement or replacement of the above structure	Gas Natural Company	1,000	
3-2.4	Installation of other station, and trunk and distribution pipeline	3-2.4.A. Seismic diagnosis study	Gas Natural Company	400	
		3-2.4.B. Introduction of block system	Gas Natural Company	2,000	
		3-2.4.C. Installation of emergency shutdown valve	Gas Natural Company	2,000	

3-3. Implementation Plan - Life Lines Programs - Electrical Supply Systems - CODENSA

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
3-3.1	Seismic diagnosis and reinforcement of 13 substations in high potential liquefaction area	3-3.1.A. Seismic diagnostic study of structure and foundation (13 stations)	CODENSA	260	
		3-3.1.B. Reinforcement of the above structure, foundation (13 stations)	CODENSA	2,600	
3-3.2	Reinforcement of other stations and administrative building	3-3.2.A. Seismic diagnosis and reinforcement of structure and foundation	CODENSA	400	
3-3.3	Seismic diagnosis and reinforcement of Power plant	3-3.3.A. Seismic diagnostic study of administrative building, structure and foundation, dam structures (9 structures)	EMGESA	3,000	
		3-3.3.B. Reinforcement of the above structures (9 structures)	EMGESA	10,000	
3-3.4	Seismic diagnosis and reinforcement of other facility	3-3.4.A. Seismic diagnostic study of administrative building, structure and foundation (9 structures)	EMGESA	500	
		3-3.4.B. Reinforcement of the above structure (9 structures)	EMGESA	5,000	

3-4. Implementation Plan Life Line Programs Telecommunication Facilities

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short 2002 2003 2004	Medium 2005 2006 2007	Long 2008 2009 2010
3-4.1	Seismic diagnosis and reinforcement of 9 local control stations in high liquefaction potential area	3-4.1.A. Seismic diagnosis study of local control station (9 administrative buildings)	ETB	360			
		3-4.1.B. Reinforcement of the above stations (9 buildings)	ETB	3,600			
3-4.2	Seismic diagnostics and reinforcement for other local control station		ETB	3,000			
3-4.3	Seismic diagnosis and reinforcement of Mobile stations in high liquefaction potential area	3-4.3.A. Seismic diagnostic study of administrative building, structure and foundation in Kennedy.	CAPITEL	60			
		3-4.3.B. Reinforcement of the above building and structure and foundation	CAPITEL	600			
3-4.4	Seismic diagnosis and reinforcement of other mobile stations and facilities		CAPITEL	2,000			

4. IMPLEMENTATION PLAN - URBAN DEVELOPMENT

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short 2002 2003 2004	Medium 2005 2006 2007	Long 2008 2009 2010
4.1	Redevelopment of Priority Area	4.1.A. Community Level Road Development	IDU	25,976			
		4.2 Regional Park Development Project	Bogotá City	61,937			
4.2	Road Development Programme	4.2.A. Road Expansion Project for the Building Dense Area	IDU	109,862			
4.3	Open Space Development Programme	4.3.A. Regional Park Construction Project	Bogotá City	27,378			
4.4	Educational / Enlightenment Programme	4.4.A. Disaster Prevention Pamphlets Creation and Distribution Project	Bogotá City	-			
		4.4.B. Disaster Prevention Drill Execution Project	Bogotá City	-			
		4.4.C. Community Safety Map Creation Project	Bogotá City	-			

5. Implementation Plan - Earthquake Engineering Programs

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
5.1	Geophysical study of subsurface structure	5.1.A. Microtremor array measurement for subsurface velocity structure estimation.	DPAE	-	
		5.1.B. Microtremor array measurement for site effect study in municipalities in Cundinamarca.	DPAE	-	
		5.1.C. Seismic reflection study for subsurface velocity structure estimation	DPAE	-	
		5.1.D. Seismic refraction study for subsurface velocity structure estimation	DPAE	-	
		5.1.E. Down hole measurement at accelerograph site for site response evaluation	DPAE	-	
5.2	Geothecnical study for site response and liquefaction evaluation	5.2.A. Liquefaction evaluation in Bogotá and Cundinamarca	DPAE/ INGEOMINAS	-	
		5.2.B. Geothecnical study in municipalities in Cundinamarca for site response evaluation	DPAE/ INGEOMINAS	-	
		5.2.C. Database construction of geothecnical information	DPAE/ INGEOMINAS	-	

6. Implementation Plan Earthquake Engineering Programs

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
6.1	Landslides protection works	6.1.A. La Carbonera	DPAE	4,990	
		6.1.B. Montebello	DPAE	7,671	
		6.1.C. El Espino	DPAE	214	
		6.1.D. Jerusalen	DPAE	469	
		6.1.E. El Paraiso	DPAE	690	

7. Implementation Plan Flooding Programs

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
Structural Measures				251,790	
7.1	Río Bogotá	7.1.A. Relocation of Bogotá City Side bank	EAAB	171,675	
		7.1.B. Heightening of dikes in both sides	EAAB/ Cundinamarca		
7.2	Río Tunjuelo (Bogota)	7.2.A. Improvement of Flood Control Structure	EAAB	57,225	
7.3	Rio Botello (Facatativa)	7.3.A. River improvement	Cundinamarca	22,890	
7.4	Rio Soacha (Soacha)	7.4.A. River improvement	Cundinamarca		
7.5	Qda. Toma (La Carela)	7.5.A. River improvement	Cundinamarca		
Non-Structural Measures					
7.6	Warning System	Flood Forcasting and Warning System	Bogota/ Cundinamarca	20	
7.7	Preparation of Flood Risk Map	Hydrological Study	Bogota/ Cundinamarca	962	

8. Implementation Plan Industrial Facilities

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
8.1	Handling of hazardous materials	8.1.B. Establishment of inspection system for hazardous materials	DAMA/ CAR	-	

9. Implementation Plan - Health Programs in Disaster Prevention (Part 1)

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule (Short / Medium / Long; 2002 2003 2004 2005 2006 2007 2008 2009 2010)
9.1	Strengthen of the Organizational Capacities for Health Disaster Preparedness	9.1.A. Strengthening *'Area de Emergencies y Desastres (AED)'* in *Secretaria de Salud*, Bogotá.	Bogotá	220	
		9.1.B. A similar unit like 'AED' in the government of Cundinamarca to improve emergency response capacities	Cundinamarca	330	
9.2	Improvement the Emergency Health Information/Communication System	9.2.A. Improving radio communication system to synchronize CRUC with CRU	Bogotá/ Cundinamarca	80	
		9.2.B. Expansion of radio communication system to all private hospitals and private health-related entities	Bogotá	30	
9.3	Action Plan to Improve the Hospital Capacities for Disaster Emergency Services	9.3.A. Strengthening function of Level III Hospitals E.S.E. to be equipped with Haemodialysis Units, Burn Unit for severely injured victims	Bogotá	2,500	
		9.3.B. Enlarging emergency services at Level III Hospitals by extending spaces and increasing staff for the Emergency Unit	Bogotá	1,000	
		9.3.C. Equipping Level III Hospitals with portable medical equipment to enlarge the inpatient receiving capacity in the event of a disaster	Bogotá	200	
		9.3.D. Implementing seismic reinforcement work of building structures and functions at Level III Hospitals E.S.E. in Bogota	Bogotá	8,000	
		9.3.E. Implementing seismic reinforcement work of facilities at Level II Hospitals E.S.E. in Bogota	Bogotá	10,000	
		9.3.F. Enlarging capacities of water reservoir, fuel tank, and medical gases at Level III Hospitals to sustain themselves for 3 days in the event of a disaster	Bogotá/ Cundinamarca	300	
		9.3.G. Reserving open spaces next to Level III Hospitals for setting up temporary inpatient camps to receive overflowing number of injured persons	Bogotá/ Cundinamarca	-	
9.4	Action Plan to Increase the Capacities to Stock Emergency Supplies and Equipment	9.4.A. Increasing stock of drugs and medical supplies at Central Store to supply to pre hospital care and Level I and II hospitals for 3 days activities	Bogotá/ Cundinamarca	810	
		9.4.B. Increasing stock of blood for transfusion at Central Store to supply to Level II and III hospitals for 2 days activities	Bogotá/ Cundinamarca	100	
		9.4.C. Increasing stock of disinfectants and instrument for environmental health activities at affected area and camps: Cresol, soaps, etc.	Bogotá/ Cundinamarca	100	
		9.4.D. Increasing stock of general equipment for setting up and operating Medical Aid Stations	Bogotá/ Cundinamarca	7,300	
		9.4.E. Increasing stocks of drugs and medical supplies at Level III Hospitals to sustain themselves for 3 days without supplementing in the event of a disaster	Bogotá/ Cundinamarca	230	
		9.4.F. Creating an Information System of inventory of stocked medical supplies, drugs and equipment in the Central Store, public hospitals and the Red Cross: This will be designed as a part of general inventory system	Bogotá/ Cundinamarca	30	
9.5	Action Plan to Increase Health Education and Training for Disasters	9.5.A. Compiling manuals and textbooks on disaster health activities and first aid for education and training of health personnel and community people	Bogotá/ Cundinamarca	420	
		9.5.B. Improvement of health personnel capacity by increasing frequency of education and training activities to professional personnel once a year to four times	Bogotá/ Cundinamarca	450	
		9.5.C. Improvement of health personnel capacity by increasing frequency of education and training activities to Community Health Volunteers	Bogotá/ Cundinamarca	756	
		9.5.D. Prevailing first aid techniques and disaster preparedness to community people by increasing frequency of seminars	Bogotá/ Cundinamarca	360	
		9.5.E. Implementing triage and disaster medicine training to medical doctors at El Rosario University	Bogotá/ Cundinamarca	20	
9.6	Action Plan to Strengthen the Preparedness Activities for Environmental Health, Disease Prevention and Mental Care System	9.6.A. Strengthening the 'Environmental health and Disease prevention system to prepare for a massive disaster' from central to 'localized/municipal' levels organization, manuals, training and simulations	Bogotá/ Cundinamarca	100	
		9.6.B. Creating a 'Post-disaster Mental Care System' at Bogota D.C. level organizing mobile mental care teams by contract, fixed clinics at Level III hospitals, and training	Bogotá/ Cundinamarca	100	

10. Implementation Programs Education Plan

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
10.1	Staff in charge of Disasters	10.1.A. Teachers Training. Existing Programme provided by DPAE can be evaluated and followed up.	DPAE	-	
		10.1.B. Government Staff Training Program for Disaster Management in the Country. Selective staff will be trained.	DPAE	-	
10.2	School Education	10.2.A. School Curriculum and Extracurricular Activities. Model schools will be assigned. Annual teaching guide will be prepared, teaching aids/side readers will be utilized and extracurricular activities will be implemented.	Secretary of Education	-	
		10.2.B. School Disaster Management Plan. Model schools will be selected for preparation plan.	Secretary of Education	-	
		10.2.C. Courses for Disaster Management in Universities. Model universities will be selected for experimental courses.	Secretary of Education	-	
10.3	Social Education	10.3.A. Formulation of community Level Education Programme: The Program will be applied to model communities.	Secretary of Education	-	
		10.3.B. Formation of Self-reliant Groups of Disaster Prevention	Secretary of Education	-	
		10.3.C. Formulation of Community Disaster Plan: Model communities and existing community groups will be selected considering the socio - economic characteristics and disaster history.	Secretary of Education	-	

11. Implementation Plan Information System Program

Programme		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
11.1	Establishment of Disaster Management Information System		Bogota City	9,620	

12. Implementation Plan Monitoring Programs

Program		Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule: Short / Medium / Long (2002 2003 2004 2005 2006 2007 2008 2009 2010)
12.1	Monitoring Program	12.1.A. Establishment of Monitoring System at El Espino	DPAE	52	
		12.1.B. Implementation of Monitoring at El Espino	DPAE	10	
		12.1.C. Establishment of Monitoring System at San Luis	DPAE	25	
		12.1.D. Implementation of Monitoring at San Luis	DPAE	10	
		12.1.E. Improvement of Monitoring System at Carbonera	DPAE	50	
		12.1.F. Implementation of Monitoring at Carbonera	DPAE	10	
12.2	Seismic instrumentation and monitoring	12.2.A. Installation of accelerographs in municipalities in Cundinamarca	DPAE	-	
		12.2.B. Telemetry data communication system of accelerographs in municipalities in Cundinamarca	DPAE	-	
		12.2.C. Data collection and analysis of accelerogram in municipalities in Cundinamarca	DPAE	-	
		12.2.D. Database construction of recorded accelerogram	DPAE	-	