S17

COUNTERMEASURE FOR

STEEP SLOPE FAILURE AND LAND SLIDE

"...Follow the Plan, Lower your Risk"

Simón Felipe Pacheco

STUDY ON
DISASTER PREVENTION BASIC PLAN
IN THE METROPOLITAN DISTRICT OF CARACAS

FINAL REPORT

SUPPORTING REPORT

S17

COUNTERMEASURE FORSTEEP SLOPE FAILURE AND LAND SLIDE

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CHAPTER 1. COUNTERMEASURE FOR STEEP SLOPE FAILURE AND LANDSLIDE

1. 1 Property to be Protected

Generally, investigation of slope disaster in Japan is conducted in accordance with the flow chart that is shown in Figure S17-1.1.1. The investigation of slope disaster is consisted of 2 sections that are “Wide Area Study” and “Individual Study (Minute Investigation)”. The study team conducted until “Hazard Evaluation” in the sediment study area.

The number of the interpreted instable steep slope and landslide is 230 and 8, respectively. Among the 230 steep slopes, there are 52 steep slopes above the road. Figure S17-1.1.2 shows the number by Municipality. Most of the steep slopes above house are located in Libertador and Sucre.

1. 2 Development of Sediment Risk Map

The risk map will be prepared based on the physical hazard in relation with the socio-economic information on the urban area. For the preparation of socio-economic data, the following damage survey and property survey were conducted.

Figure S17-1.2.1 shows the concept of how to decide the affected area (risk) by steep slope failure. The hazard area below the slope is within the two times of the vertical height of the slope whereas the hazard area above the slope is within the one (1) time of the vertical height of the slope. This concept is based on the Japanese ordinances on sediment disaster prevention.

Figure S17-1.2.2 shows the concept of how to decide the affected area (risk) by landslide. The newly affected area is up to the 50 % of the length of the risky slope.

Based on the above concept, the affected area was delineated for each potential steep slope failure and landslide. The hazard map for landslide and steep slope failure is shown in Figure S17-1.2.3 (1/4-4/4). The red area is affected area. The pink and the blue are the risky slope above house and road, respectively. The yellow is risky slope of landslide.

Most of the affected property belongs to the informal areas so called “barrio”. The number indicated in Table S17-1.2.1 is the number of “house”, that means the size of house has a large variation, especially in the formal areas.

The Risk map is shown in Fig S17-1.2.4. This is the map that is classified by the colors according to the density of houses in the hazardous area based on the hazard map.

1. 3 Steep Slope and Landslide Above House

1. 3. 1. Conceivable Measures

Table S17-1.3.1 shows the applicability of countermeasures for steep slope failure and landslide, etc. In the study area where the risky slopes exist, slope collapse is the most probable phenomena. According to this table, the applicable countermeasures for the slope collapse are earthwork, vegetation, water drainage for surface water, slope work, anchoring and wall and resisting structure. Among these, earth work and vegetation are not recommended because one of the features in the sediment study area is that most of the potential steep slope failure and landslide is occupied by houses. Those houses should become subject for relocation because of the slope protection works. Also it is necessary to conduct some slope protection works on the slope itself in order to protect the property below and above the slope. In this sense the conceivable measure is composed of the relocation of the houses occupying the slope and the slope protection works for the slope.

Here selecting of slope work, anchoring and wall and resisting structure as substantial protection works, a standard protection works are set as shown in Figure S17-1.3.1.

The above unit cost including labors, machine and engineering indirect cost is at present derived from some examples in other countries, whose price level is similar to Venezuela.

1. 3. 2. Cost and Property Value Comparison

In order to study the economic feasibility of the protection works and relocation, a typical steep slope above house is assumed as shown in Figure S17-1.3.2.

In the above case, the affected area below the slope is approximately 1,500 m^2. If one house in barrio is located per 100 m^2, the total property value is US$150,000(=15 houses * US$10,000 per house). This is much cheaper than the cost for the protection works.

The cost of the protection works would be higher as the slope area becomes large. Since there is an upper limit of the affected area, the economical efficiency for the slope protection works in informal area (barrio) can be regarded as quite low.

However, in formal area this kind protection works could be economically possible for extremely high intensity land use such as high rises complex. Table S17-1.3.2 is the list of selected risky slope above house. They are located in formal area and the property value to be affected is higher than the cost of necessary protection works. The property value for house in formal area was calculated to assume the value per square meter of the house 530,000 Bs. (1999) based on the flood damage survey result.

In principal, in formal area it is worth to study in detail the feasibility of slope protection works above house. It is recommended as shown in Figure S17-1.1.1, for each risky slope, detailed geotechnical investigation should be conducted by Venezuelan side in future.

1. 4 Steep Slope Above Road

For the risky slope above road, the protection works should be conducted because the economic and benefit (direct and indirectly) must be much higher than the construction cost. It is recommended as shown in Figure S17-2.1.1, for each risky slope, detailed geotechnical investigation should be conducted by Venezuelan side in future.

The total risky slope area above road is about 570,000 m^2. As shown in Figure S17-1.3.2, the construction cost for the typical slope protection work is set about US$200 per m^2. The total cost for the slopes of 570,000 m^2 is US$114,000,000. The most of the risk slopes are located above the Cota Mil, which is one of the trunk highways in Caracas. The protection works for these risky slope should taken into consideration.

Table S17-1.2.1 Affected Number of Houses by Steep Slope Failure and Landslide

	Number of houses located on the interpreted slope		Number of houses affected by the failure		Total	
	Formal Area	Informal Area	Formal Area	Informal Area	Formal Area	Informal Area
Steep Slope Failure	49	6,797	304	5,197	353	11,994
Landslide	2	383	16	139	46	522

Table S17-1.3.1 Applicability of Countermeasures Against Slope Failures

CLASSIFICATION		TYPE OF WORK	CL	RF	RM	LS	DF	EB
1. **EARTHWORK**	Earthwork	Removal	○	○	○	○	○	×
		Rock Cutting	○	○	○	○	○	×
		Rock Pre-Splitting	○	○	○	△	○	×
		Soil Cutting	○	×	×	○	○	×
		Embankment	○	×	×	○	△	○
2. **VEGETATION**	Vegetation		○	△	×	○	○	○
		Hydroseeding	○	△	×	○	○	○
3. **WATER DRAINAGE**	Surface Drainage	Drain Ditch and Cascade	○	△	△	○	△	○
		Subsoil Drainage Hole	○	△	×	○	×	○
	Subsurface Drainage	Culverts	△	×	×	△	○	○
		Horizontal Drain Hole	○	×	○	○	△	○
		Drainage Well	×	×	×	○	×	×
		Drainage Tunnel	×	×	×	○	×	×
4. **SLOPE WORK**	Shotcrete Work	Shotcrete (mortar)	○	○	○	×	○	×
		Shotcrete (concrete)	○	○	○	×	○	×
	Crib Work	Cribwork (Precast)	△	△	×	△	×	○
	Pitching Work	Stone Pitching	○	○	△	×	×	○
5. **ANCHORING**	Anchoring	Soil Nail	○	△	×	△	△	○
		Rock Bolt	○	○	○	○	△	×
		Ground Anchor	○	○	○	○	△	×
6. **WALL AND RESISTING STRUCTURES**	Retaining Wall	Stone Pitching Wall	○	○	○	○	△	○
		Concrete Block Wall	○	○	○	○	△	○
		Retaining Wall(Supported Type)	○	○	○	△	△	○
		Crib Wall	○	○	○	○	△	○
		Gabion Wall	○	○	×	○	○	○
		Pile Wall	○	○	○	○	△	○
	Catch Work	Catch Fill	△	○	△	×	×	×
		Catch Gabion	△	○	△	×	○	×
		Catch Concrete Wall	△	○	△	×	△	×
7. **PILING WORK**	Piling Work	Steel Pipe Pile	△	×	×	○	×	×
		H Steel Pile	△	×	×	△	×	×
		Shaft Work for Resistance Slide	△	×	×	○	×	×
8. **PROTECTION WORK**	Protection Work	Rock Fall Catch Net	△	○	○	×	×	×
		Rock Fall Catch Fence	△	○	○	×	×	×
	Rock Shed	Rock Shed	△	○	○	×	○	×
		Debris Shed	△	△	△	×	○	×
	Sabo (Check) Dam	Slit Dam	×	×	×	△	○	×
		Check Dam (Sabo Dam)	×	×	×	○	○	×
9. **OTHERS**	Avoiding Problem Work	Diversion (Shifting)	△	△	○	○	○	△
		Route Relocation	△	△	○	○	○	△

○ : Applicable △ : Limited case × : Not applicable

CL : Collapse **RF** : Rock Fall **RM** : Rock Mass Failure **LS** : Land Slide **DF** : Debris Flow **EB** : Embankment Failure

Table S17-1.3.2 List of Risky Slope Above House to be Protected

Slope Code	Municipality	Area of Slope(m2)	Area of House on Slope(m2)	Number of House on Slope	Area of House on Affected Area(m2)	Number of House on Affected Area
40 091	Libertador	5,655	1235	1	12,404	5
40 148	Libertador	932	664	1	3,742	4
40 149	Libertador	563	773	2	2,016	5
40 161	Sucre	4,130	58	4	3,663	10
40 162	Sucre	2,953	107	4	6,052	6
40 225	Sucre	1,412	131	4	1,774	9
40 226	Sucre	1,361	507	3	3,457	7
40 228	Sucre	1,365	271	1	1,485	5
40 230	Sucre	2,123	18	2	4,129	10
40 232	Sucre	2,537	65	3	3,505	8
40 233	Sucre	1,890	391	1	10,616	7
40 272	Libertador	3,330	143	3	5,510	32
43 172	Sucre	868	79	2	886	11

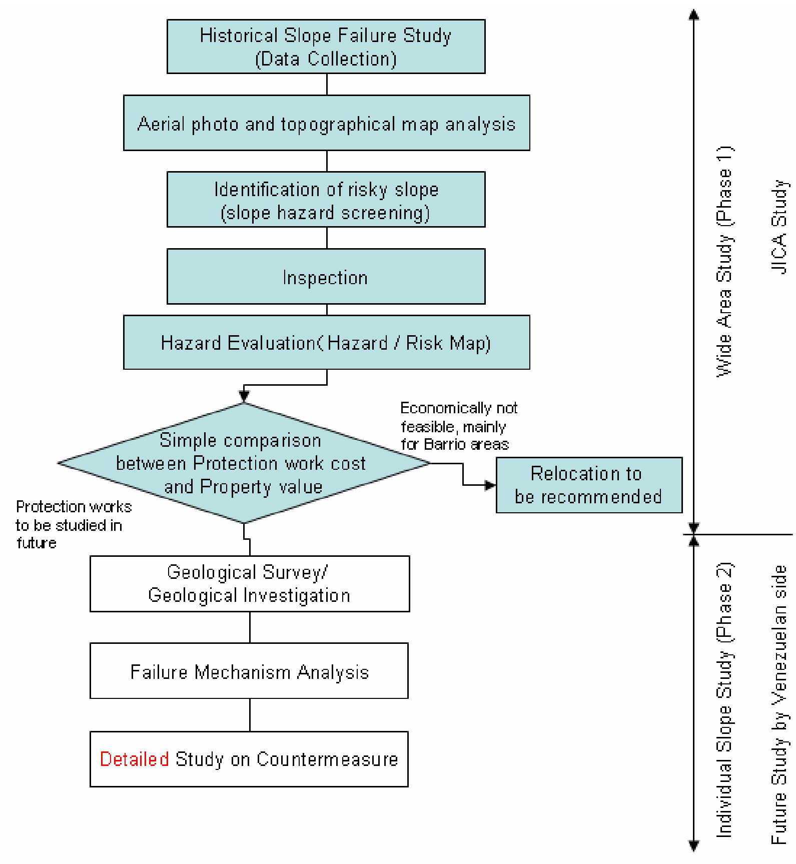


Figure S17-1.1.1 Work Flow Diagram for Study on Steep Slope Failure and Landslide

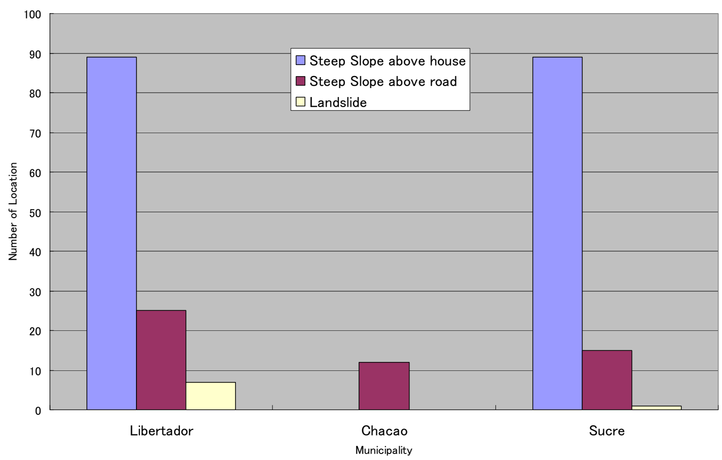


Figure S17-1.1.2 Number of Unstable Steep Slope and Landslide in the Sediment Study Area

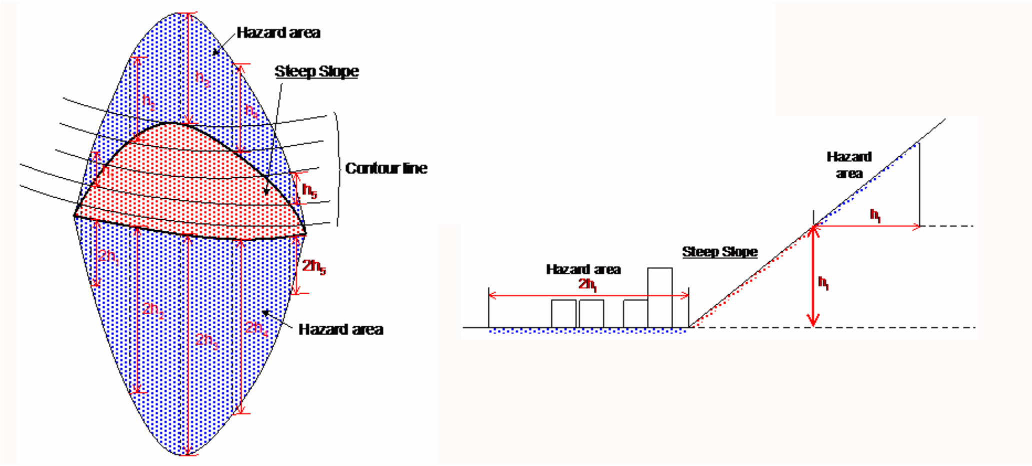


Figure S17-1.2.1　Concept of Affected Area (Risk) by Steep Slope Failure

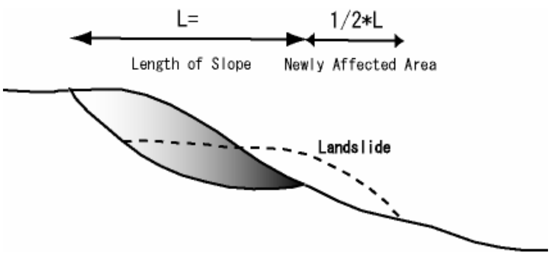


Figure S17-1.2.2　Concept of Affected Area (Risk) by Landslide

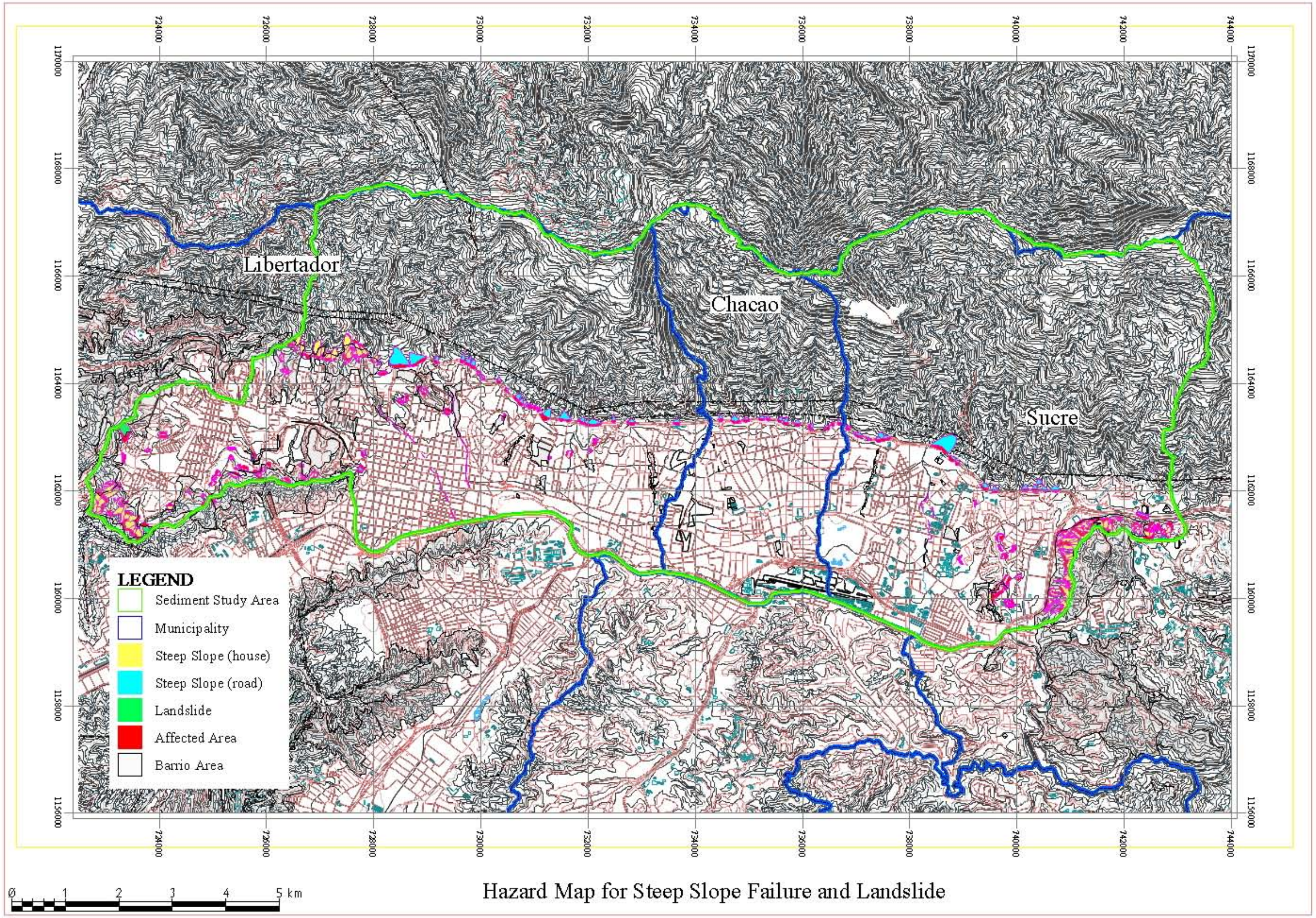


Figure S17-1.2.3(1/4) Hazard Map for Landslide and Steep Slope Failure (Whole Area)

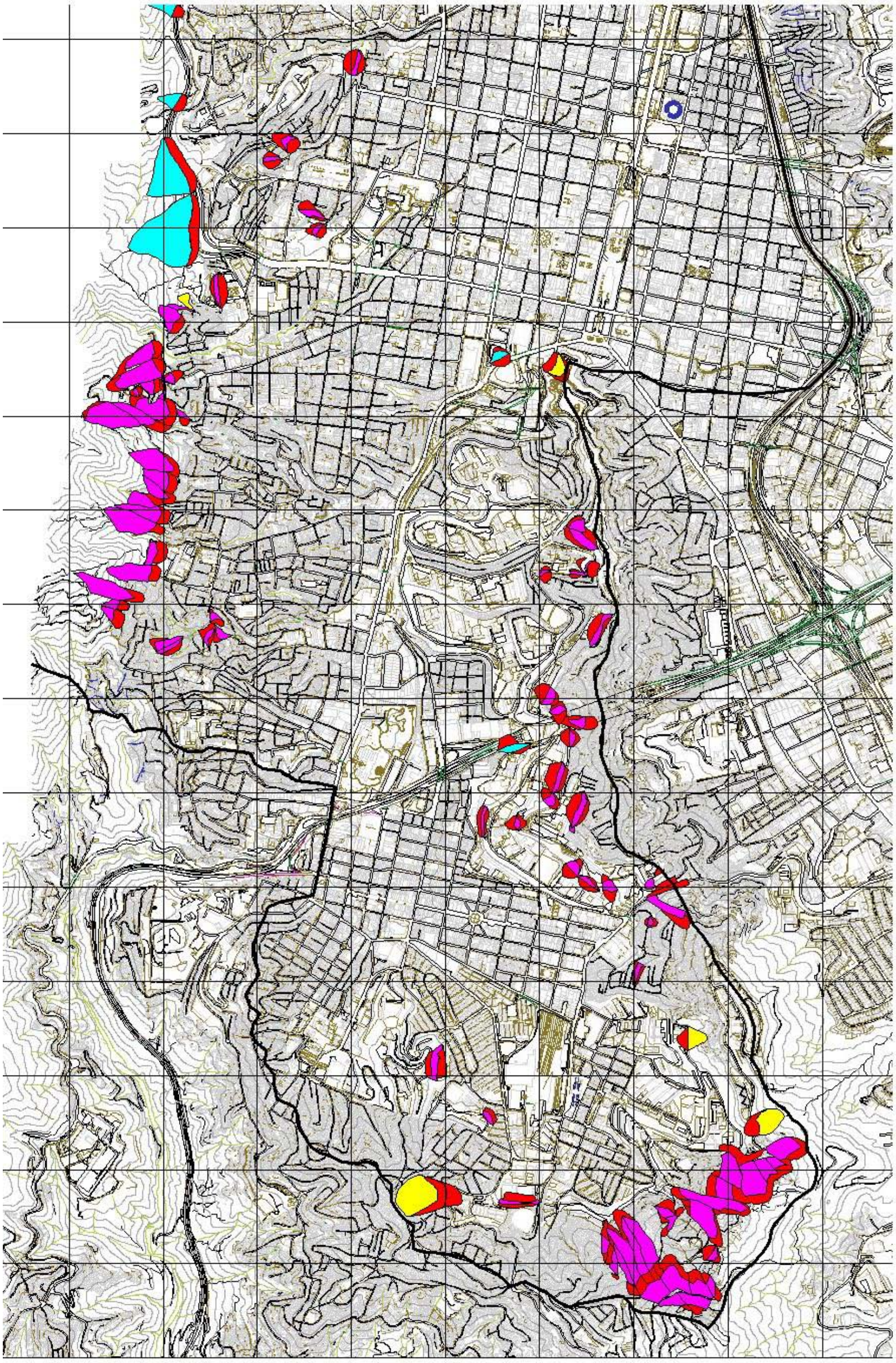


Figure S17-1.2.3(2/4)   Hazard Map for Landslide and Steep Slope Failure (Western Part)

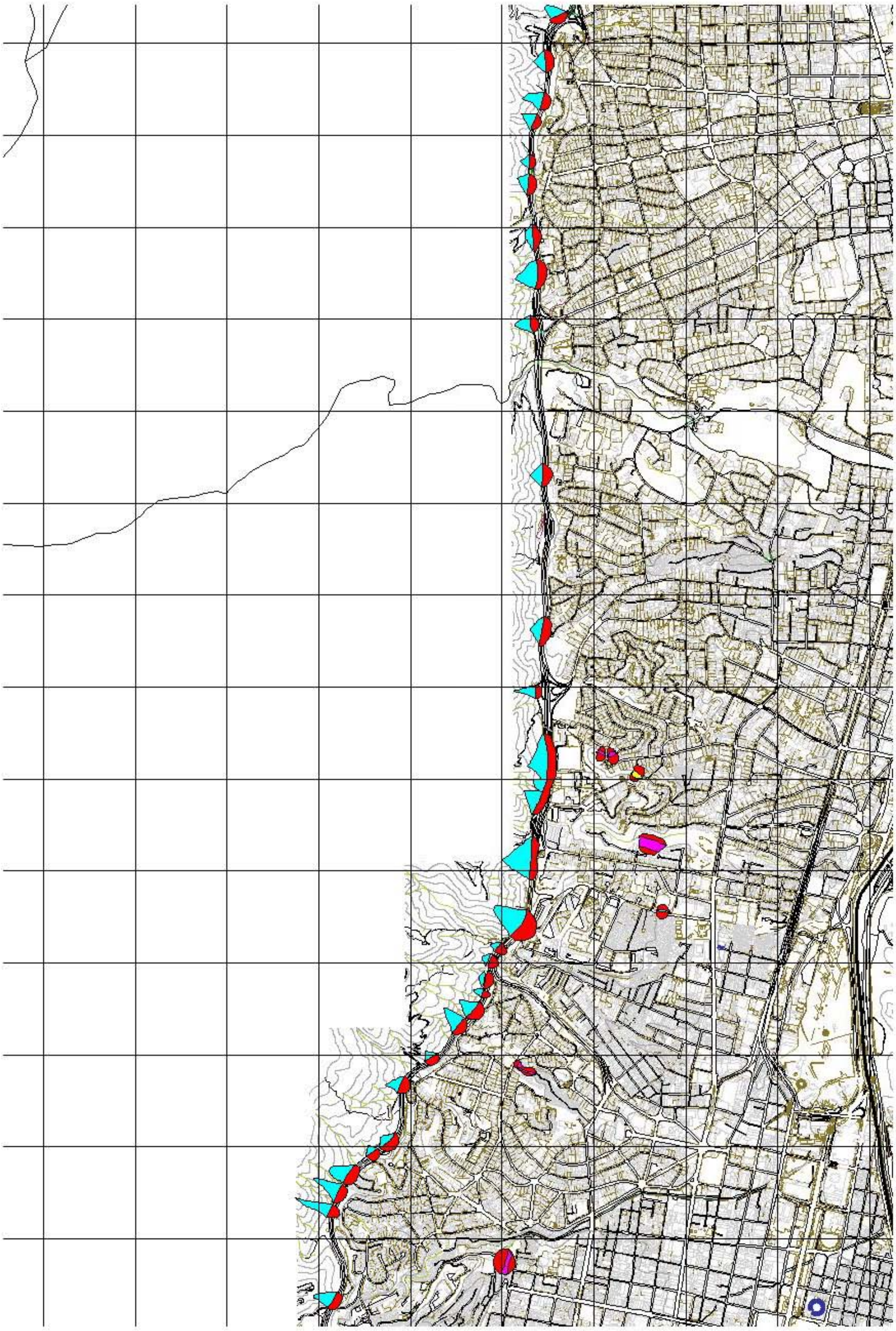


Figure S17-1.2.3(3/4) Hazard Map for Landslide and Steep Slope Failure (Central Part)

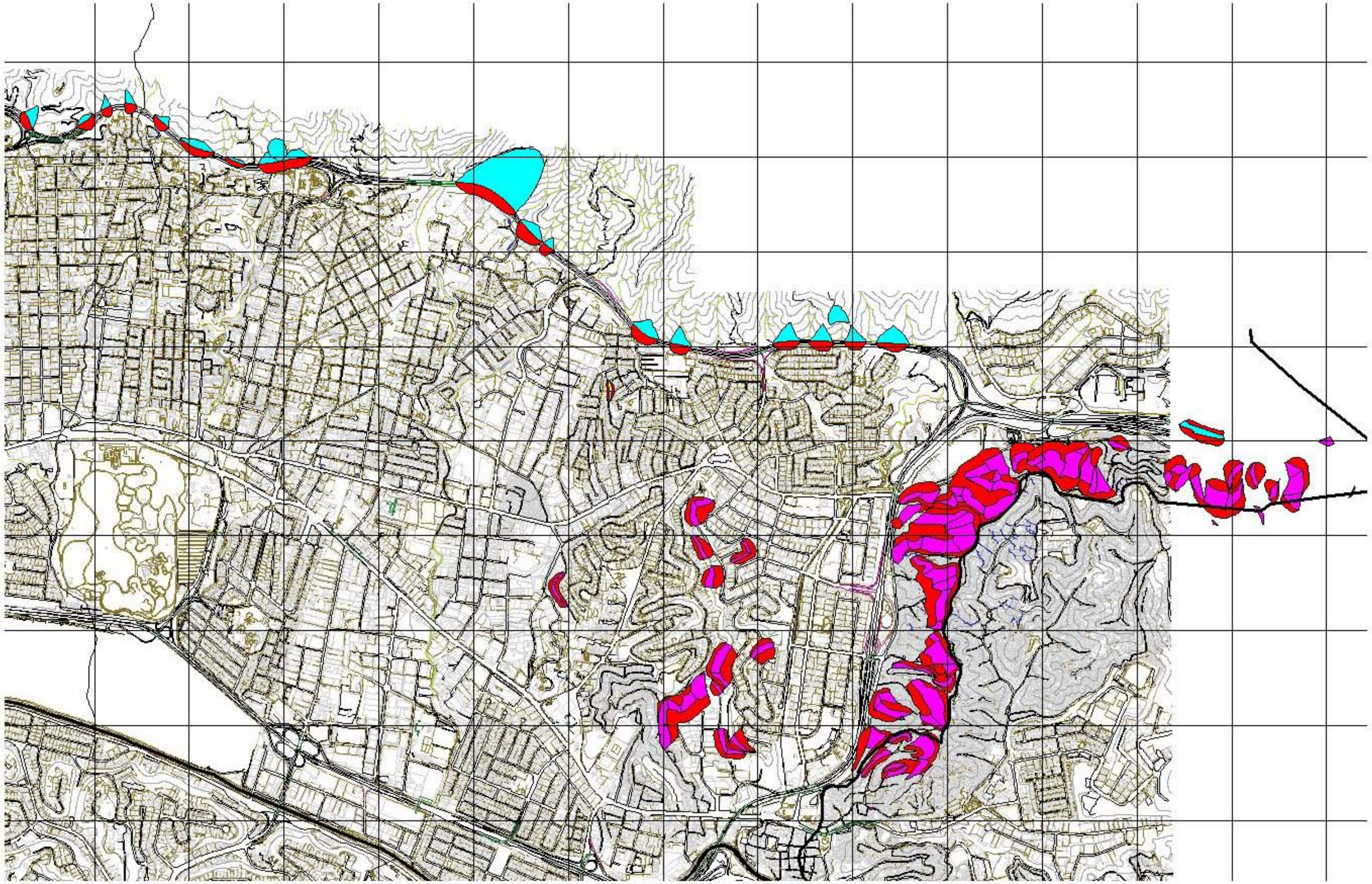


Figure S17-1.2.3(4/4)   Hazard Map for Landslide and Steep Slope Failure (Eastern Part)

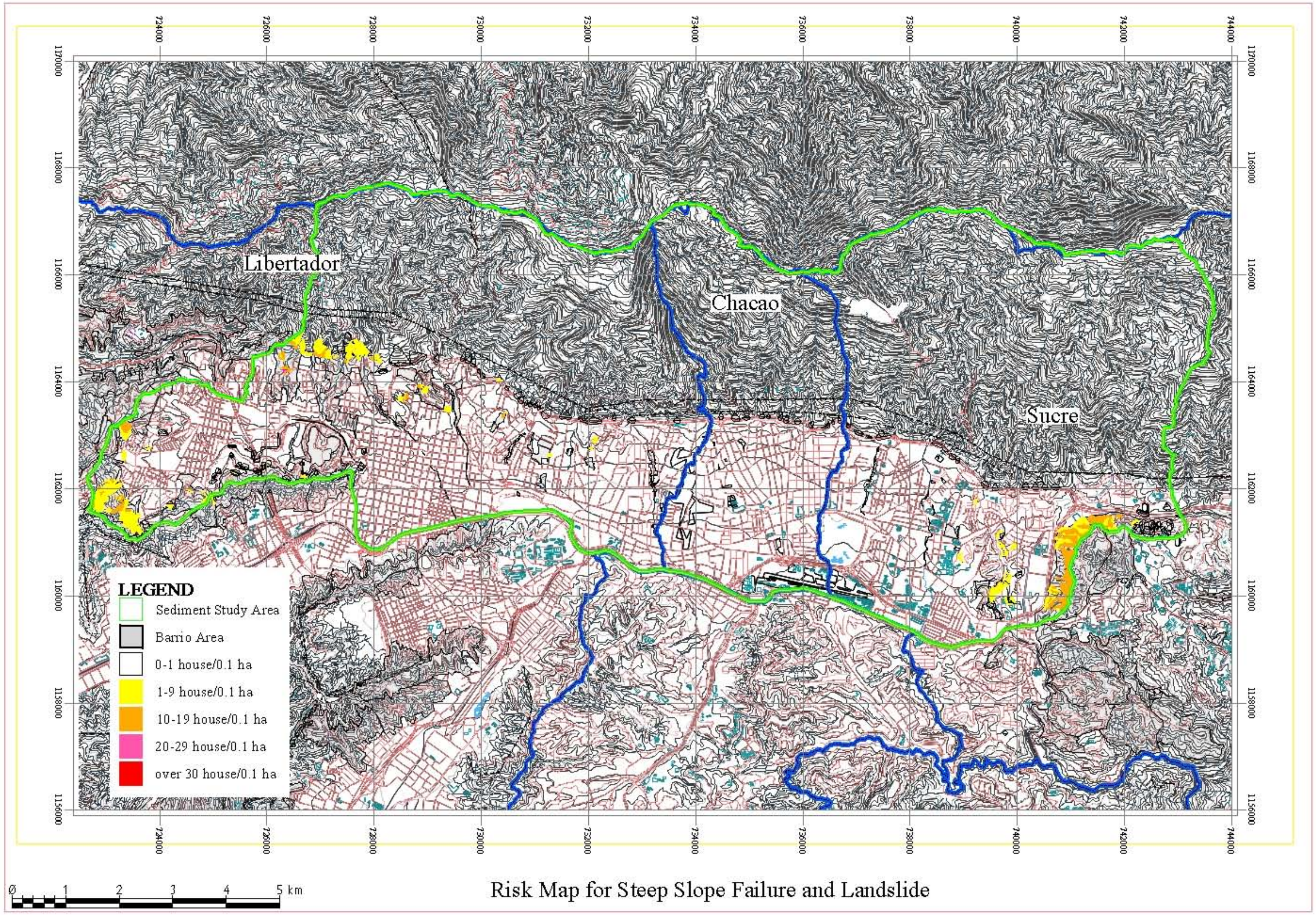


Figure S17-1.2.4 Risk Map for Landslide and Steep Slope Failure (Whole Area)

Figure S17-1.3.1 Standard Protection Works for Cost Estimation

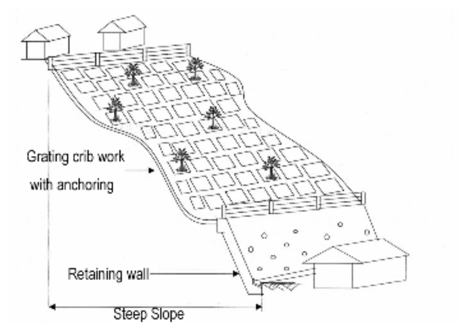
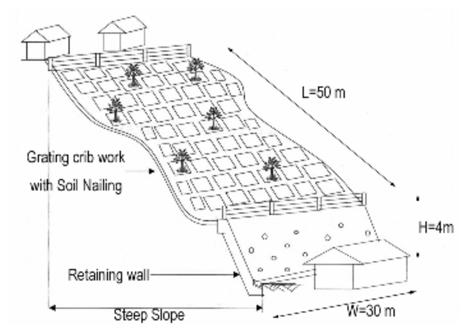
Schematic Image of Protection Works	Outline of Works	Unit Cost
	Relocation of Houses on Steep Slope	US$10,000 per house
	Grating crib work	US$80 per m^2
	Soil-nailing (1 piece per 2 m^2)	US$200 per 1 piece
	Retaining wall	US$80 per m^3

Figure S17-1.3.2 Cost Estimation for Typical Protection Works

Schematic Image of Protection Works	Outline of Works	Cost
	Relocation of Houses on Steep Slope= 15 houses * US$10,000 per house	US$150,000
	Grating crib work = 50m*30m* US$80	US$120,000
	Soil-nailing (1 piece per 2 m^2)= 50m*30m*0.5 piece* US$200	US$150,000
	Retaining wall= 4m*30m*1m* US$80	US$9,600
	TOTAL	US$429,600

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EARLY WARNING AND EVACUATION

"We are Caracas united, by the prevention of disasters"

Yoshitaka Yamazaki

STUDY ON
DISASTER PREVENTION BASIC PLAN
IN THE METROPOLITAN DISTRICT OF CARACAS

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EARLY WARNING AND EVACUATION

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S-18 EARLY WARNING AND EVACUATION

CHAPTER 1. GENERAL

1. 1 Background of Study on Early Warning and Evacuation

The study on sediment disaster prevention was conducted as shown in the work flow diagram (Figure S18-1.1.1). The subjective sediment disasters in the Study are debris flow disaster and landslide / steep slope failure disaster in the sediment study area. For these disasters, the hazard and risk were studied and identified based on the study on topography, geology, hydrology and meteorology.

The debris flow hazard is caused directly by the sediment runoff associated with heavy rainfall in the Avila Mountain. The sediment from the Avila goes down the alluvial fans of the Caracas Valley, resulting into physical and social damage to people and property in Caracas. The extent and seriousness of the debris flow hazard were identified and shown in the hazard maps.

The hazard by landslide and steep slope failure was also identified as hazard map including the affected area by each risky slope.

The counter measures to mitigate and reduce the hazard / risk by the sediment disasters have a wide variety of types. The general sediment disaster prevention program is shown in Figure S18-1.1.2, which was derived from a Japanese text book edited by Mr. Yasuo Nakano, the former JICA Advisory Committee Chairman for this study. As shown in this figure, there are quite a few items for sediment disaster prevention. Mainly these items can be categorized into structure measures and non-structure measures conventionally.

In principal, the sediment disaster prevention should be executed in comprehensive manner. Also in Caracas, the importance of establishment of proper early warning and evacuation system for sediment disaster is indisputable as well as the importance structure measures such as Sabo dam. The establishment of early warning and evacuation could be effective to save people life whereas not effective to reduce substantial damage on property. It is certain that structure measure such as sediment control structure is only measure to protect property from sediment hazard.

1. 2 Meteorological Significance in Caracas

Early warning and evacuation are a kind of preparedness to be realized by co-working of government and community for the anticipated sediment disaster. This preparedness can be said a fighting with leading time. The leading time varies according to meteorological condition as well as topography of the area (Figure S18-1.2.1).

Caracas is located in sub-tropical low pressure region. As it is written in the Supporting Report S13, there are five (5) meteorological factors which cause heavy rainfall in and around the Caracas Valley. Basically these factors are associated with small spatial scale and short time scale phenomena. Among these factors, the cold front in the Caribbean Sea has so long time scale and large spatial scale that the cumulative rainfall by the meteorological factor can be anticipated, however, threshold rainfall such as short duration rainfall is sometimes caused by local meteorological factors. The weather tendency is difficult to be anticipated. In terms of the precise weather forecast, it can be said that Caracas is comparatively difficult area.

Moreover, the Avila mountain is contiguous to the urban area in the Caracas Valley, so the leading time which means the time from a threshold event such as rainfall to a disaster is very short.

As described in the above, Caracas is comparatively difficult area with respect to the effective implementation of early warning and evacuation from the technical viewpoint. However, it is believed that the significance of the institutional arrangement as a preparedness for early warning and evacuation is indisputable. The study team believes that it is important to start from minimum institutional arrangement as well as necessary hydrological analysis to establish a proper early warning and evacuation system in the future as proposed in this report in order to save peoples life in Caracas.

1. 3 Components of Study on Early Warning and Evacuation

The early warning and evacuation system itself has a wide range of variety as shown in Figure S18-1.1.2. In this study, the following study components were selected,

Institutional Arrangement

The study on institutional arrangement covers from the national government to municipalities, which are the member of C/P of this study. The study includes the proposal on hydrological measurement system.

Critical Rainfall

The study on critical (threshold) rainfall was done considering the situation of Vargas and Maracay (Limon River).

Community Activity

The study on community was done to select two (2) communities as a part of social survey in the JICA study (Supporting Report S24).

1. 4 Definition

In Venezuela, meteorological warning has been used as national, global and regional warning. At present, the web page of MARN issues a daily meteorological bulletin, forecast, which sometimes contains warning (“alerta” in Spanish) for significant weather conditions. Indeed this warning is applied for region such as the entire of Caracas and Central Coast in Vargas.

In this report, when a word ”warning” is used, it means local warning which should cover only the Caracas valley or more detailed area such as a western part of the Avila.

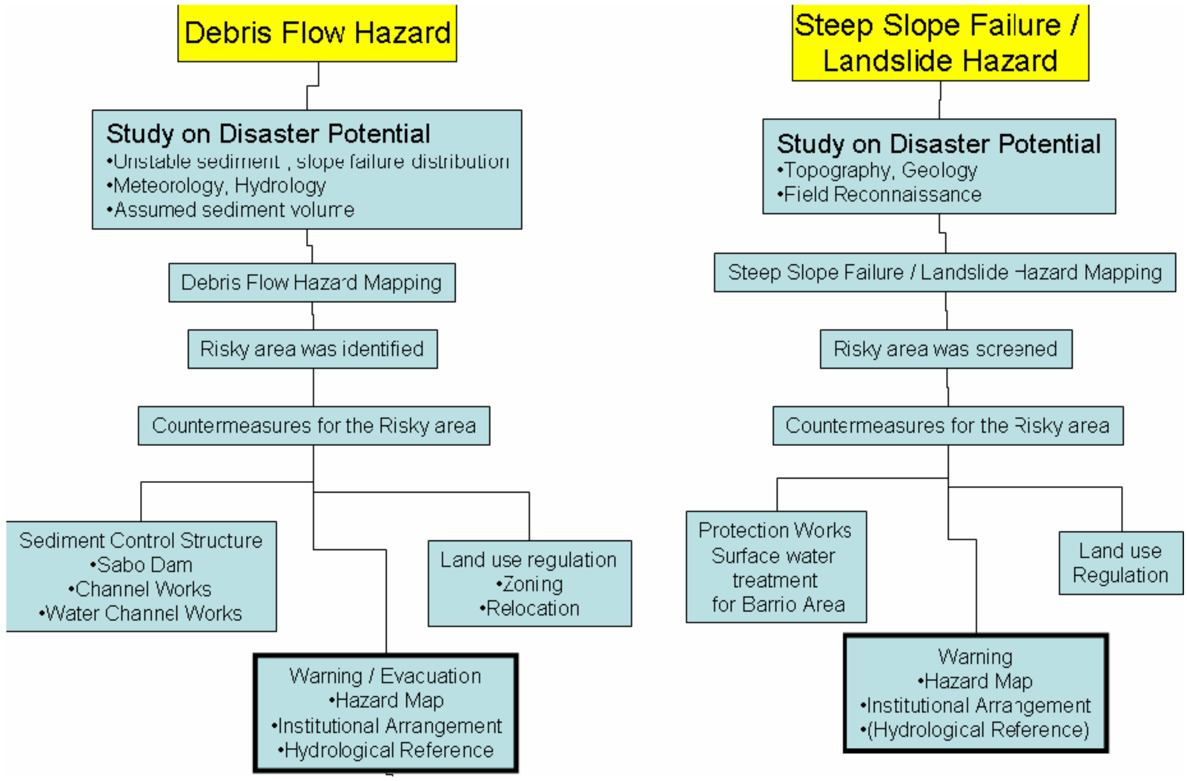

Figure S18-1.1.1 Early Warning and Evacuation as a Component in Sediment Disaster Prevention

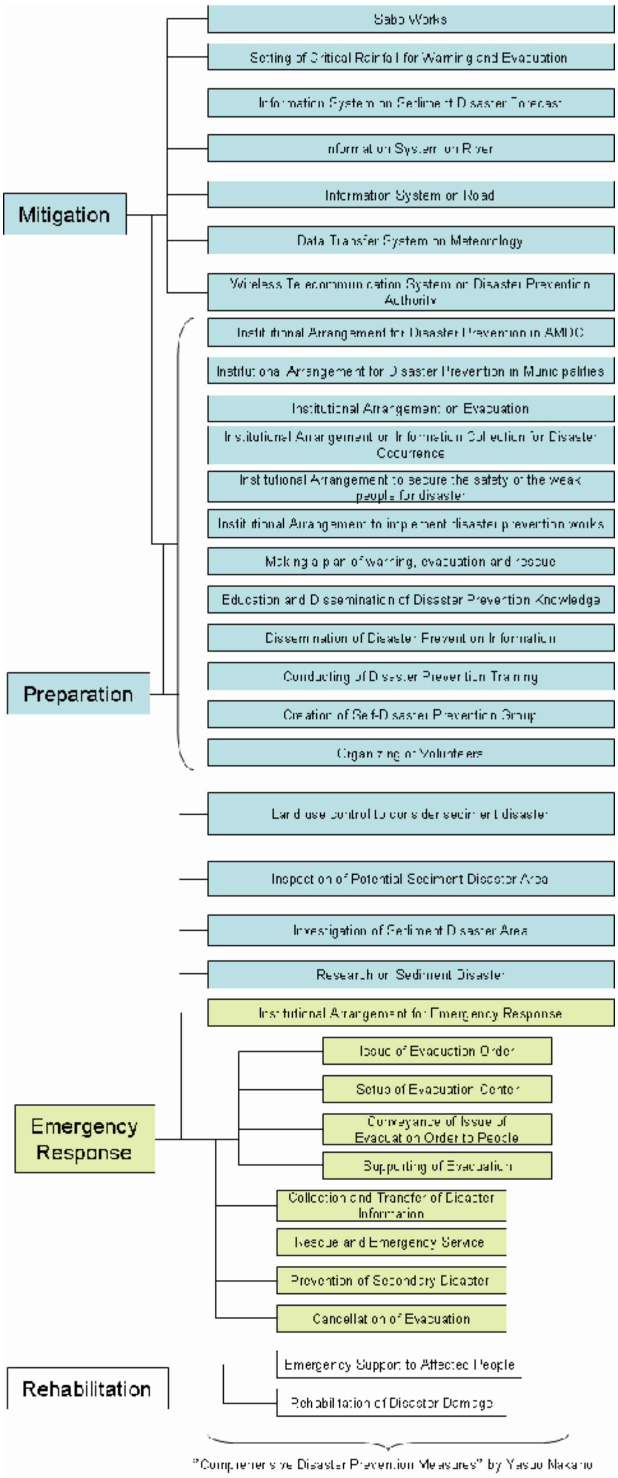

Figure S18-1.1.2 General Sediment Disaster Prevention Program

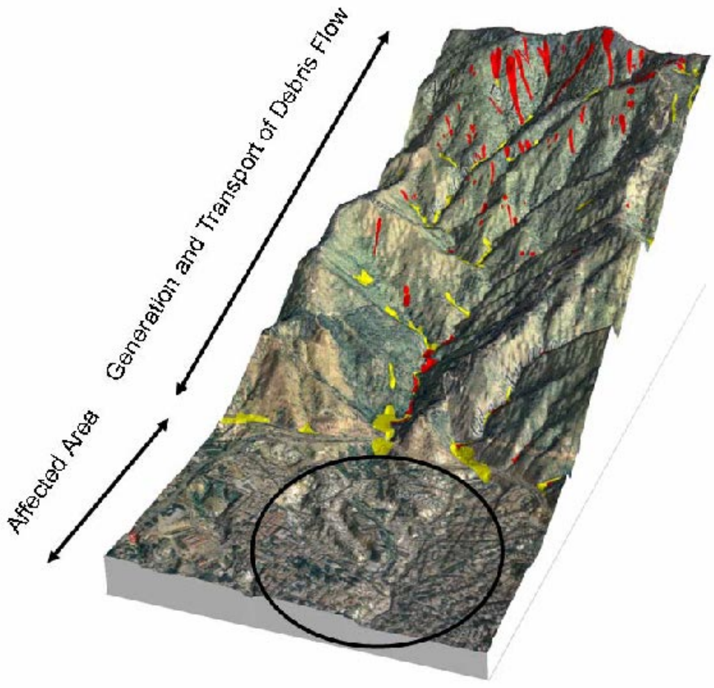

Figure S18-1.2.1 Closeness Between Debris Flow Occurrence Area and Affected Area (Cotiza Stream)

CHAPTER 2. INSTITUTIONAL ARRANGEMENT

2. 1 Methodology

For the study on institutional arrangement to respond to debris flow disaster, the Study Team proposed the discussion with related institutions as shown in the process of Figure S18-2.1.1.

In the beginning of the study, the study team evaluated the present condition regarding early warning and evacuation in Caracas to collect information and conduct hearing from the related organization such as MARN, ADMC, Municipalities. Especially the on-going project called Venehmet of MARN was confirmed by collecting of the latest information from officials of MARN.

Next, based on the above evaluation and the collected information, the study team prepared a draft early warning and evacuation plan as a draft agreement document, which covered the institutional framework from the central government to community. This draft agreement was distributed in Spanish language to MARN, ADMC, UCV and three (3) municipalities in order to ask their comments to the study team.

Using the draft agreement, the periodical meetings such as C/P meeting in Bandela and El Cafetal were held to discuss the early warning system.

After collecting significant comments from the related organizations, the revised agreement was prepared as the proposal of this study. The proposal was rearranged as individual projects as shown in section 2.5.

2. 2 Present Condition

2. 2. 1. Activity of MARN

Ministry of Environment and Natural Resources (MARN) is a primary organization to monitor meteorology and hydrological information in the national level. One of the responsibilities of MARN is to monitor and analyze the condition of meteorology and hydrology in and around Venezuela and to inform the credible information to the people in Venezuela.

Indeed the Web page of MARN has some pages on meteorology and hydrology of Venezuela to show the daily weather conditions, satellite image such as GOES satellite and regional weather warning (alerta in Spanish). The same kind of Web page is maintained by FAV as the mission to support their own operation.

In this sense MARN and FAV satisfy their own responsibilities in terms of national level.

However, in order to realize the early warning and evacuation in Caracas, more local and precise information on meteorology and hydrology such as rainfall forecast timely are required.

Regarding the hydrological monitoring system related with MARN in Caracas, there are 4 stations within the Avila mountain at present such as Los Venados in the Anauco, Hotel Humbolt at the top of the Avila, Chacaito in the Chacaito Stream and Caurimare in the Caurimare stream. The stations of the Hotel Humbolt and Los Venados have function to transfer the observed rainfall data to UCV Campus via telemeter system. The measured rainfall data of Los Venados and Hotel Humboldt are reported to MARN periodically.

The existing stations around study area are shown in Figure S18-2.2.1.

The stations such as San Jose del Avila, Teleferico and Los Chorros, those had been operated by MARN for many years until 1980's, were desired to restart the observation from the viewpoint of data continuity.

As shown in Figure S18-2.2.1, the upstream of Tocome and Caurimare had no existing stations.

2. 2. 2. Activity of ADMC

The Civil Protection of ADMC has been receiving daily meteorological bulletin from the MARN. However there is no function to respond the anticipated situation from the bulletin when it contains a weather warning.

In principal, one of the roles of the ADMC regarding early warning and evacuation is to coordinate all the sectors in the entire Metropolitan District of Caracas with related organization of national level such as central governments and National Civil Protection. However, the necessary institutional framework when a sediment disaster is anticipated to happen in Caracas has not been established properly.

2. 2. 3. Activity of Municipality

They have high capacity for the emergency operation after a sediment disaster, however, they have few experiences of early warning and evacuation (pre-disaster).

In reality, the operation for early warning and evacuation and the operation for emergency could be done at the same time in Caracas depending on the time line progressive of the disaster. Also as shown in the debris flow hazard map in Caracas, the anticipated affected areas are not confined within single municipality, but are distributed between multiple municipalities.

It is difficult for a municipality to grasp condition of the other municipality. It is necessary to coordinate between municipalities.

2. 3 VENEHMET Project

“VENEHMET” is a project to modernize the system for measurement, monitoring and prediction of national hydrometeorology. This program is supported by MARN, FAV, Armada, EDELCA*, FONAIAP/INIA** and Universities (Figure S18-2.3.1).

*EDELCA: Electrification of Caroni (C.V.G. Electrificacion del Caroni, C.A.) **FONAIAP: National Fund of Agricultural Investigation (Fondo Nacional de Investigaciones Agropecuarias); INIA: National Institution of Agricultural Investigation of Venezuela (Instituto Nacional de Investigaciones Agricolas de Venezuela)

The financial source is Corporación Andina de Fomento (CAF). CAF contributed 55 million US dollars for the project period of 1998-2004. The national government of Venezuela also bore 29.1 million US dollars.

(Objectives of the program)

- Provide precise and opportune observations and weather and hydrological forecasts
- Provide warnings of severe meteorological events
- Provide accurate and opportune warnings and predictions on floods
- Provide hydrometeorological information in real time
- Maintain, protect and provide information of climatologic and hydrometric records
- Provide an Optimal System that guarantees the civil and military air operations

(Components of the program)

- National Warning and Hydrometeorological Forecast Center
- Formation and Human Resources Development System
- Meteorological Doppler Radars System
- Processors System
- Provisional Meteorological Service

- Airport Observation System
- High Atmosphere Observation System
- Satellites Imaging System
- Surface Observation System
- Inter and intra system, communication system
- Thunder Storm Location and Detection System

One of the significant functions in the VENEHMET is an installation and operation of meteorology radar for Caracas. Figure S18-2.3.2 shows the meteorology radar installed in Colonia Tovar to cover the entire Caracas Valley. The resolution of the radar is said to be 1 km according to official of VENEHMET. If the radar is operated, rainfall forecast can be possible and spatial distribution of local rainfall also can be cleared, resulting into the improvement of accuracy / reliability of early warning.

One of the output of the VENEHMET project is the establishment of INAMEH, which is a institution in charge of operation, maintenance for the installed equipment by the project and human resources development for hydrology and meteorology. Within the INAMEH, regional offices are planed to create as an interface with local government.

2. 4 Draft Agreement

Based on the above evaluation on the existing situation on early warning system in Caracas, the study team proposed a draft agreement on early warning and evacuation system among the related organizations. The entire text of the agreement is shown in Table S18-2.4.1.

The basic concept of the agreement was prepared referring to the Basic Law on Disaster Prevention in Japan. The Basic Law is covering the institutional arrangement for central government and local government as well as people to respond to anticipated natural disaster.

The main features in the draft agreement are as follows,

- to designate MARN as a primary function to monitor, analyze and distribute hydrological information and to create the Caracas Regional Office (CRO) in MARN –INAMEH.
- to designate ADMC (Operation Control Center) as a primary function to receive and manipulate the hydrological information from MARN and distribute it to the municipalities. ADMC is in

charge of issuing of local warning in accordance with the MARN and issuing of recommendation of evacuation.

- to designate municipalities as a local body closest to communities to transfer the information form ADMC to communities and to support the activities of communities.

It should be certain that the Operation Control Center (OCC) shall be activated when the necessity of issuing of local warning is anticipated. The schematic image of the timing for the activation and issuing of local warning is illustrated in Figure S18-2.4.1. The practical timing of the activation of Operation Control Center and the issuing of local warning is discussed in Chapter 3.

2. 5 Discussion

During the 5th study period in Venezuela, the study team held periodical meetings on early warning system with the related organizations. The draft agreement was distributed in advance to those organizations in order to have their comments and revise the draft agreement.

Officials from civil protection of a municipality suggested that the National Civil Protection should be involved in the agreement. The study team thinks that the involvement of the National Civil Protection is necessary to coordinate between the national level ministry such as MARN and the local governments. The National Civil Protection shall play a role as the secretariat during the discussion on the draft agreement in the future.

Officials from civil protection of a municipality say they have enough capacity to manage the emergency response (post disaster), however, they have few experiences of early warning and evacuation (pre-disaster). They expect ADMC to coordinate the entire activity across the municipalities. The study team understood that ADMC is more appropriate to issue local warning to municipalities and communities.

Official from MARN strongly recommended that the necessity of the regional office within MARN headquarter should be emphasized in order to convert the national and global information from MARN to the regional and local information for Caracas and Vargas (Figure S18-2.5.1). This concept was included in the draft agreement as the establishment of a regional office in MARN.

From the above findings Table S18-2.5.1 shows Evaluation of Present System, Limitation and Recommendation for Early Warning and Evacuation.

2. 6 Proposed System

Basically the institutional arrangement for early warning system in Caracas is highly depending on the progress of VENEMEHT project of MARN. On September 2004, the law related with the creation of INAMEH after the VENEMEHT was prepared for the submission to the congress in Venezuela. It is obvious that the creation of the INAMEH would promote the establishment of early warning system in Caracas, however, a sediment disaster could happen tomorrow in Caracas. In this sense it is recommended that the C/P organizations should start the minimum institutional arrangement as shown in the next section 2.6.1. It should be certain that this minimum institutional arrangement is just for a preparation of early warning system in Caracas in the future.

2. 6. 1. Urgent and Short Term Project

The following projects are proposed as urgent and short term project. The main intention of these projects is to share the rainfall data and distribute to the related organization in real time. It should be prioritized in Caracas to share the rainfall data among the related organization and to access the data in real time. When the system is established, any necessary actions can be started based on the individual decision of various sectors.

Title	Making of an agreement on inter-institutional arrangement for early warning and evacuation system for sediment disasters in Caracas
Objective	Establishment of the basic consensus on early warning and evacuation system in Caracas among the related organizations
Contents	The draft agreement prepared in this study (refer to section 2.3) shall be discussed among MARN, ADMC, 3 municipalities and UCV to make the basic consensus on early warning and evacuation system in Caracas for the future. This agreement is quite significant in order to promote the other proposed projects smoothly. The procedure can be recommended as follows, Step 1: The Civil Protection of ADMC prepares a draft agreement based on the recommendations of the JICA study and others. Step 2: The Civil Protection of ADMC shall discuss about the agreement with the National Civil Protection. Step 3: The Civil Protection of ADMC shall call a meeting among the related organizations and discuss about the necessity of the discussion on the agreement. If the necessity for the discussion is agreed among them, an agreement on the starting of the discussion shall be made. Step 4: Holding periodical meetings on the draft agreement. Step 5: Finalization of the agreement Step 6: Implementing of the proposed projects by the JICA Study
Implementation Organization	Civil Protection of ADMC
Implementation Period	2005 -2006 (within 2 year)
Project Cost	Assuming the number of meeting is twenty (20) and the number of meeting members as representative of the related organization is twenty (20). The

	allowance for some members from non-government institution such as UCV per day is US$100.00, so the total allowance is US$4,000. For the assignment of the secretariat in the Civil Protection of ADMC, three (3) staff is necessary. The cost shall be covered by their own budget including the fee for a lawyer.
Financial source	ADMC and 3 Municipalities (Libertador, Chacao and Sucre)

Title	Telemeterizing of rainfall stations operated by several organizations
Objective	Centralization and sharing of all the rainfall data in Caracas
Contents	1. The rainfall stations, Los Venados and Hotel Humboldt, which are operated by MARN-UCV, shall be connected via telemeter system between UCV and MARN. The telemeter system connecting those stations and UCV is same as that of the Campo Alegre station which was installed by the JICA study team. MARN can refer to the Campo Alegre system for the connecting of those 2 stations to the MARN HQ. 2. New installations in the Avila of Tocome and Caurimare rainfall stations shall be done and connected to MARN HQ in the same manner as the others. 3. Restarting and telemeterization of the previously operated rainfall stations such as San Jose del Avila, Los Chorros, Teleferico stations shall be done. If necessary, those rainfall gauge equipment should be replaced by the same type of the others. 4. Making an agreement with FAV, ADMADA and UCV with respect to real time sharing of rainfall data of La Carlota, Cagigal and UCV, respectively shall be done.
Implementation Organization	MARN Direction of Hydrology and Meteorology
Implementation Period	2005-2006 (within 2 years)
Project Cost	The installation or replacement including telemeter system cost US$20,000 per 1 station including the receiving equipment in MARN HQ. The number of station to be installed or replaced is five (5), so the cost is US$100,000. The annual maintenance cost per 1 station is assumed to be US$8,000 as subcontract with a local consultant from MARN. The number of station to be maintained is seven (7), so the cost is US$56,000.
Financial Source	MARN, ADMC and 3 Municipalities (Libertador, Chacao and Sucre)

Title	Establishment of Disaster Information Distribution System between MARN, ADMC and 3 Municipalities.
Objective	The system with which the Operation Control Center of ADMC can receive, manipulate and distribute the disaster information to the municipalities and the public shall be established.
Contents	Assuming that the project <Telemeterizing of rainfall stations operated by several organizations> is executed, the following arrangement should be

	done. 1. Setting up a computer system in the Operation Control Center (OCC) in the Emergency Command Center in order to receive the Disaster Information such as rainfall and meteorological conditions from MARN-HQ and to manipulate and distribute that information to the municipalities and the public. This computer system is composed of two (2) sets of personal computer unit including two (2) printers and two (2) UPS. 2. Wide Area Networking between MARN-HQ, OCC and the Emergency response room in the 3 municipalities. The network should be dedicated line in order to receive and distribute the urgent information in real time. 3. Assignment of 3 permanent staff of OCC who is in charge of monitoring, manipulation and distribution of the information from MARN-HQ.
Implementation Organization	ADMC
Implementation Period	2006 (within 1 year) In case that the construction of Emergency Command Center is delayed, this system will be installed in the Civil Protection of ADMC (Bandela) temporally.
Project Cost	1. US$10,000 for computer system as initial investment 2. US$10,000 for wide area networking as annual maintenance cost 3. US$30,000 for one staff as annual remuneration, so the total cost is US$90,000.
Financial source	ADMC and 3 Municipalities (Libertador, Chacao and Sucre)

2. 6. 2. Long Term Project

The following project is proposed as a long term project.

Title	Capacity Building of Regional Office of MARN
Objective	Caracas regional office of MARN shall be designated as a primary function to monitor and distribute hydrological information. Also the regional office should be in charge of hydrological analysis to evaluate the possibility of debris flow occurrence and to make mathematical model for flood hazard mapping, and to conduct hydrological measurement. For these missions, the capacity building of the regional office should be done.
Contents	1. Implementing of technical cooperation project with foreign donors such as JICA to accept technical experts dispatched long term for the field of meteorology and hydrology. Staff of MARN shall have technical knowledge and skill for hydrological analysis, measurement and flood analysis in the course of OJT and work shop. 2. Overseas training for MARN staff in Japan and other countries such as Mexico.
Implementation Organization	MARN
Implementation Period	2006-2008 (within 3 years)

Project Cost	1. US$300,000 including overseas training.
Financial source	MARN and international donors

Title	Operation of Operation Control Center and Maintenance of Emergency Command Center
Objective	Keeping of sustainability for Operation Control Center in Emergency Command Center
Contents	Assignment of permanent staff in Operation Control Center for operation of early warning Overseas training for OCC staff in Japan and other countries. Maintenance of Emergency Command Center
Implementation Organization	ADMC
Implementation Period	2006-2007 (Detailed Design and Construction) 2008-2020 (Operation and Maintenance)
Project Cost	US$X00,000 as annual maintenance cost.
Financial source	ADMC and 3 Municipalities (Libertador, Chacao and Sucre) and international donors

Table S18-2.3.1 Draft Agreement on Institutional Arrangement for Sediment Disaster Early Warning System in the Metropolitan District of Caracas

Draft Agreement on Institutional Arrangement for Sediment Disaster Early Warning System in the Metropolitan District of Caracas between National Civil Protection, Ministry of Environment and Natural Resources, Metropolitan District of Caracas, and the Municipalities of Libertador, Chacao and Sucre, and UCV.

CHAPTER 1 GENERAL

1.1 Purpose

- The purpose of the agreement is to establish the necessary institutional arrangement (or the basic frame work) on the sediment disaster early warning system in the Metropolitan District of Caracas in order to save life and mitigate the damage for property.

- The coverage of the agreement is limited to the institutional arrangement in order to distribute properly the necessary information for the early warning between National Civil Protection, Ministry of Environment and Natural Resources, Metropolitan District of Caracas, and the Municipalities of Libertador, Chacao and Sucre, and UCV.

1.2 Definition

- Sediment disaster means the sediment related disasters, namely the debris flow caused by the rainfall on the south slope of the Avila and the landslide / steep slope failure caused by the rainfall that impact the municipalities.

- MARN means the Ministry of Environment and Natural Resources.

- ADMC means the Mayor of the Metropolitan District of Caracas.

- UCV means the Central University of Venezuela.

- Municipalities mean the governments of Libertador, Chacao, Sucre, Baruta and El Hatillo.

1.3 Responsibility of National Civil Protection

- National Civil Protection is responsible for the national level coordination among MARN, ADMC and Municipalities.

1.4 Responsibility of Ministry of Environment and Natural Resources

- Ministry of Environment and Natural Resources (Caracas Regional Office of INAMEH, herein called INAMEH- CRO) has responsibility to collect and distribute the information on hydrology and meteorology such as weather synopsis, rainfall forecast by INAMEH radar system, real time rainfall amount and water level in river and mountain streams, which would become the factors on sediment disasters.

- INAMEH-CRO will issue the regional warning for the entire Caracas Metropolitan Area based on its own criteria.

- All equipment for the hydro-meteorological data measurement will be operated and maintained by INAMEH-CRO.

- INAMEH-CRO will make suggestions and recommendation on technical part for the disaster prevention plan prepared by the ADMC.

1.5 Responsibility of Metropolitan District of Caracas

- Metropolitan District of Caracas (herein after ADMC) has responsibility to establish an Operation Control Center (herein after OCC) within the Metropolitan District of Caracas. The function of the OCC is to issue the local warning on the sediment disasters. The OCC will be specified project in the Disaster Prevention Plan prepared by ADMC.

1.6 Responsibility of Municipalities

- Municipalities have the responsibility and the obligation to support the OCC directories in regards to operations and logistics.

- Municipalities shall support the creation of self-directed (managed) prevention groups in the communities.

1.7 Responsibility of Specific Organizations

- Specific organization such as Universities, public services will provide information and technical advises necessary for the operation of OCC.

1.8 Responsibility of Communities

- Communities groups in the municipalities have responsibility to create self-directed prevention groups.

- Communities groups shall appoint representatives to work with the OCC in emergency and organize the people and execute the prevention measures and evacuation.
- Communities shall observe water level and rainfall amount voluntarily both in normal time and emergency time and report those information to OCC.

CHAPTER 2 ORGANIZATIONS ON EARLY WARNING FOR SEDIMENT DISASTER

2.1 Establishment of Technical Committee on Early Warning

- ADMC will establish the standing technical committee on early warning whose secretariat is the Civil Protection Department.

2.1.1 Responsibility

- The committee has responsibility to review the current early warning system, evaluate the past operations of OCC on early warning and make recommendations to the director of OCC on the updating of the early warning system.
- The committee has responsibility to draft any legal instruments (degree or ordinance) for implementing the early warning.

2.1.2 Organization

- The committee shall be composed of a permanent representative of Protection Civil, Fire Fighter Department, MARN, Civil Protection of the municipalities and UCV. Other members can be appointed. The Protection Civil of ADMC shall serve as committee secretary.

2.2 Operation on Early Warning in Operation Command Center (OCC)

- ADMC will establish an OCC within the ADMC which can operate early warning for Caracas. The Early Warning system will be operated as a function of the Planning/Intelligence Section of the OCC and will have a separate operation room.

2.2.1 Making of Planning/Intelligence Section

- The Planning/Intelligence Section within the OCC maintains databases on the weather synopsis and past – cumulative hydrological information provided from the INAMEH-CRO.

- The information provided by the Planning/Intelligence Section will be distributed to communities organizations and private emergency organizations through a mechanism established by the Civil Protection of ADMC.

2.2.2 Organization

- The Major of ADMC appoints the OCC director.
- The organization of OCC is composed of one (1) management and four (4) sections, namely Operation Section, Planning/Intelligence Section, Logistics Section and Finance/administration Section.
- The head of the Planning/Intelligence Section is appointed by the OCC director.
- The Planning/Intelligence Section is composed of the staff capable of maintaining data bases, establishing early warning protocols and distribution of alerts to the operation division and communities groups.

2.2.3 Responsibility of Planning/Intelligence Section in OCC

- Planning/Intelligence Section receives the meteorological and hydrological information provided by INAMEH-CRO and prepares the necessary processing for the decision making of issuing of local warning.
- OCC director decides the issuing of local warning and recommendation of evacuation to the communities.
- Planning/Intelligence Section receives the hydrological information observed in communities and report them as they are to the INAMEH-CRO.

2.2.4 Transfer of the right of the mayor of Municipalities to OCC

- During the operation of Planning/Intelligence Section is activated in a certain level, some rights of the mayor of municipalities shall be transferred to OCC in order to concentrate the rights to OCC.

2.3 Dispatch of Human Resources to OCC

- When the Planning/Intelligence Section is activated in a certain level, INAMEH-CRO, Municipalities and the related organization will dispatch their staff to the Planning/Intelligence Section in OCC as supporting staff based on the request from the OCC to each organization.

- All the dispatched staff from the above organizations shall be under the command of the head of OCC resources.

- The necessary financial measures in terms of the dispatching of staff shall be specified in an agreement between the related organizations.

CHAPTER 3 EARLY WARNING GENERAL GUIDELINES

3.1 General

- Early Warning shall be issued in order to save the life and mitigate the damage of the property.

- The method to issue an early warning, distribute the early warning, recommend the evacuation and cancel of the issued warnings shall be specified by the committee on early warning through a written protocol adopted by the OCC.

- Nobody can use the similar early warning method.

3.2 Issue of Warning

- There are two (2) kinds of warning in terms of its locality, namely regional warning and local warning. The regional warning shall be issued by the INAMEH-CRO for the region of entire Caracas based on the definition of INAMEH. The local warning shall be issued by Planning/ Intelligence Section in OCC for specific areas in Caracas.

- The local warning shall be categorized into two (2) in terms of the seriousness. The categorization and the corresponding hydrological index such as critical rainfall shall be decided by the technical working group of the technical committee on early warning specified in section 2.1.

- When the head of OCC issues the local warning, he has to inform the issuing to the related organizations.

- When the municipal protection civils receive or knows the issued warning, they distribute this to their related organizations.

- If the issuing of warning needs the urgent operation, the OCC director may utilize public utilities such as telephone lines and TV broadcasting stations exclusively.
- If the OCC director and the OCC management group recognize the anticipated issuing of warning, they shall activate the operations Section for the filed activities.

3.3 Cancellation of Local Warning

- The Planning/Intelligence Section will cancel the issued local warning based on the weather synopsis provided by the INAMEH-CRO and the local hydrological information observed by communities. The Planning/Intelligence Section has to inform the cancellation to the public widely.

Caracas, December 15, 200X

Mr. A
National Civil Protection

Mr. X
Director of Caracas Regional Office of INAMEH
Ministry of Environment and Natural Resources

Mr. Y
Major of ADMC

Mr. Z1
Major of Municipality of Libertador

Mr. Z2
Major of Municipality of Chacao

Mr. Z3
Major of Municipality of Sucre

Mr. Z4
Major of Municipality of Baruta

Mr. Z5

Major of Municipality of El Hatillo

Prof. A

Central University of Venezuela

Mr. Nagata

Witness

JICA Expert

Table S18-2.4.1 Evaluation of Present System, Limitation and Recommendation for Early Warning and Evacuation

Organization	Evaluation of Present System	Limitation	Recommendation
MARN	● MARN is satisfying its responsibility as a national level in terms of monitoring, providing hydro-meteorological information to the public. ● The rainfall monitoring and measurement system of MARN is not appropriate to respond the needs of local government who will be in charge of early warning system.	● Since MARN is a national level organization, there is a limitation to execute more local and precise activity such as issuing of local warning or evacuation order. ● In reality it seems that there is insufficiency of number of engineer who can do hydrological and hydraulic modeling to make hazard map and meteorological forecast.	● Promoting of VENEHMET Project further with sustainability ● Establishment and strengthening of regional branch with MARN for the purpose of precise activity for Caracas and Vargas area to unite the present rainfall monitoring system and to update hazard map and to study hydrological features of Caracas such as critical rainfall. ● Assembling and normalization of all the protocols on early warning system in Venezuela
ADMC	● There have been human channels to receive meteorological information from MARN and others, however, there is no system to translate the information and taking action when necessary for early warning and evacuation. ● There is no access in real time to rainfall data measured by MARN and other organization.	● It is not practical to do the monitoring, providing hydro-meteorological information to the public.	● Construction, and operation / maintenance of Emergency Command Center ● Establishment of Operation Control Center to manage the disaster from the viewpoint of entire Caracas. ● Dispatch of human resources to IMANEH training program for hydrometeorology.
Municipalities	● They have high capacity for the emergency operation after a sediment disaster, however, they have few experiences of early warning and evacuation (pre-disaster).	● In reality, the operation for early warning and evacuation and the operation for emergency could be done at the same time in Caracas depending on the time line progressive of the disaster. It is difficult for a municipality to grasp condition of the other municipality.	● Issuing of recommendation of evacuation to community based on the information from ADMC and MARN. ● Education of community group

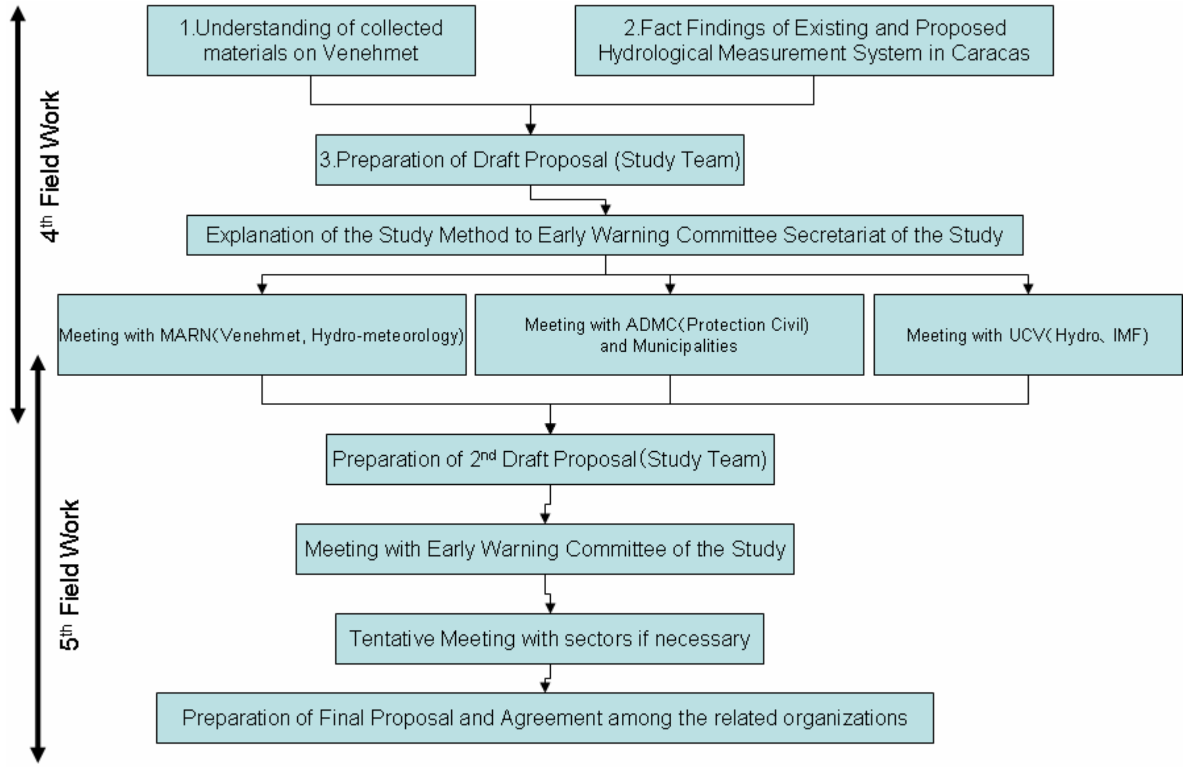

Figure S18-2.1.1　Work Flow Diagram for Study on Institutional Arrangement

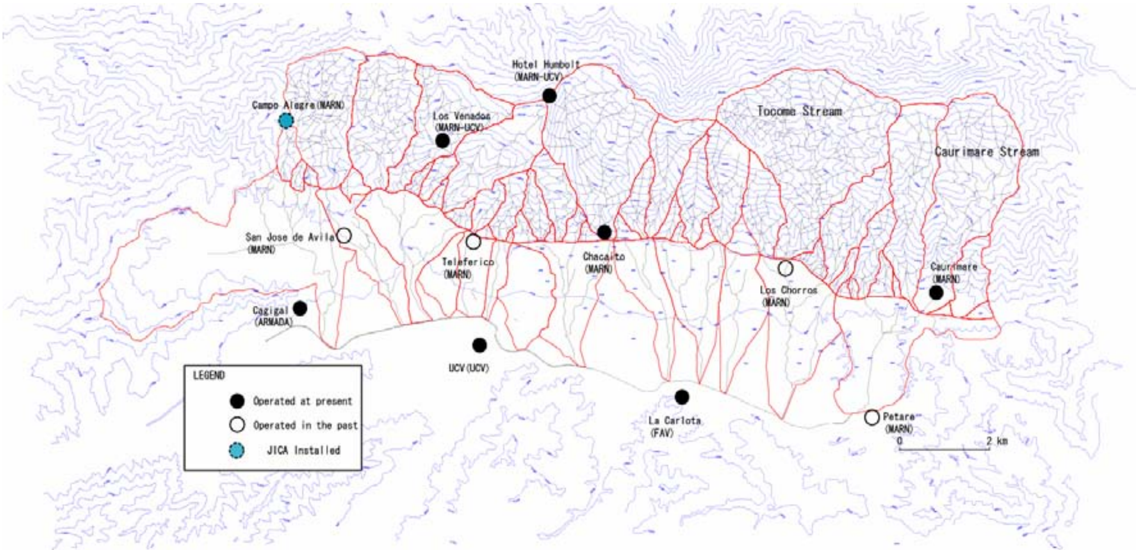

Figure S18-2.2.1　Existing Rainfall Stations in Caracas

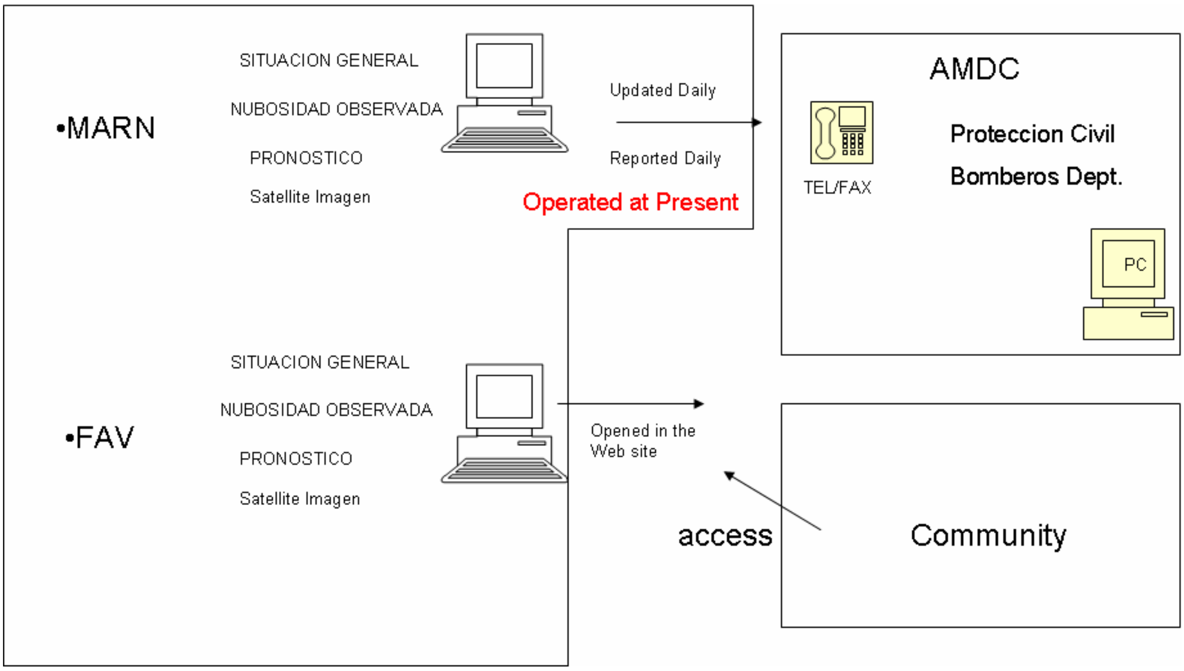

Figure S18-2.2.2 Existing Activities for Sharing of Hydro-meteorological Information

Figure S18-2.3.1 Participants and their Roles in VENEHMET Program (Source: MARN)

Figure S18-2.3.2 Meteorology Radar Installed in Colonia Tovar to Cover the Entire Caracas Valley (Source: MARN)

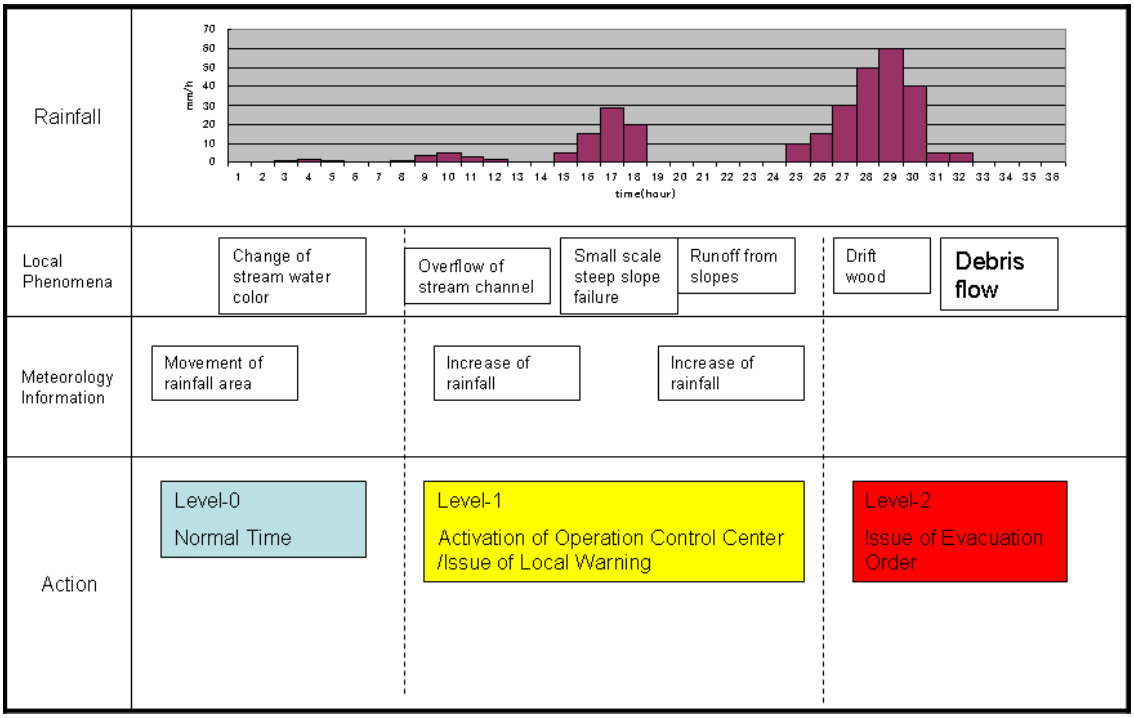

Figure S18-2.4.1 Timing of Activation of Operation Control Center

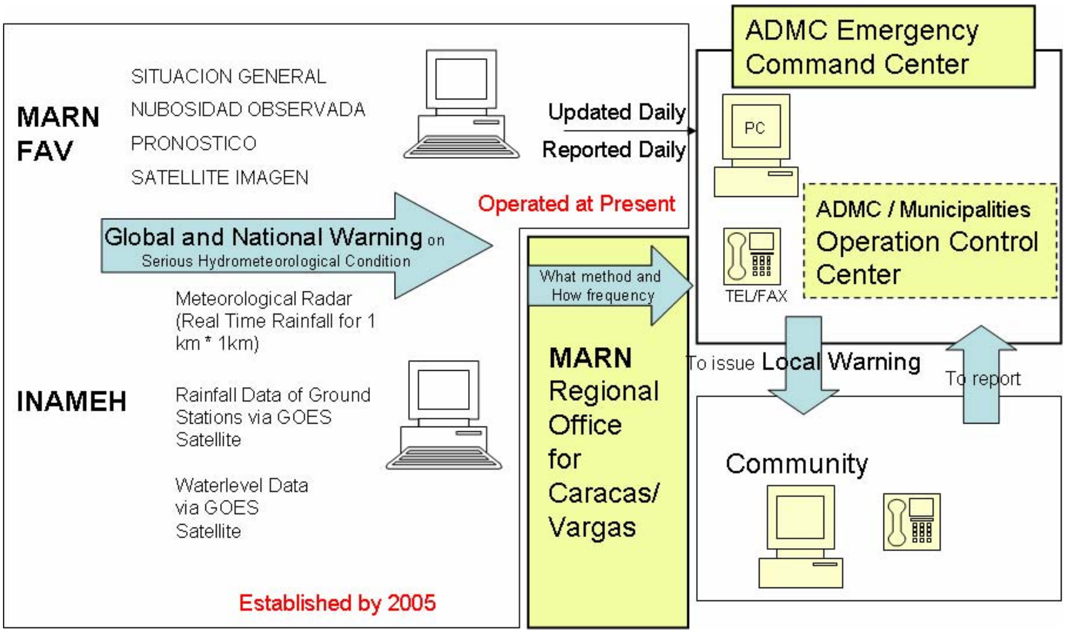

Figure S18-2.5.1　Position of MARN Regional Office in the Early Warning System for Caracas

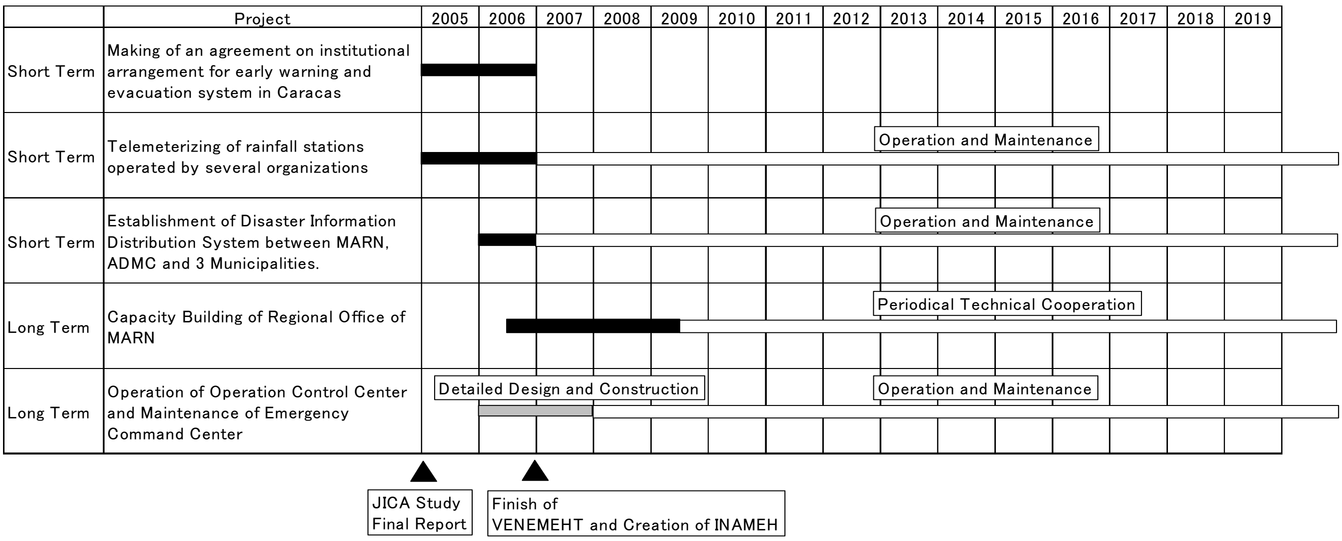

Figure S18-2.6.1　Implementation Schedule

CHAPTER 3. STUDY ON CRITICAL RAIFALL

3. 1 Critical Rainfall

Early warning system can play a significant role in debris flow hazard mitigation by alerting the public when rainfall conditions reach critical levels for hazardous debris flow activity. Such warning systems depend on comparing forecasts and real-time rainfall observations to threshold values required to initiate debris flow. Empirically derived from historical data on rainfall and debris flow occurrence, thresholds are combined values of rainfall intensity and duration that predict debris flow initiation at susceptible sites within a specified area.

Rainfall/debris flow thresholds depend on the thickness, character, and mechanical properties of the hillslope materials, which depend, in turn, on the geology, topography, vegetation, and climate of the area.

The study on critical (threshold) rainfall was done considering the situation of Vargas and Maracay (Limon River). For the data collection and the study on past debris flow, the study area was extended to Vargas and Maracay (Limon River). Maracay should be included because the area has suffered from debris flow disaster and also has an advanced early warning system of MARN.

It is possible to forecast the occurrence of a debris flow from the rainfall data, but its accuracy level differs largely depending on the level of data obtained. In Caracas, debris flow occurrence is very rare on record. Even in December 1999 event, the observed rainfall in the Avila does not exist. To make a practical forecast of sediment related disaster occurrence, gauging of hourly rainfall is a prerequisite.

In the area having both the hourly rainfall data and the past sediment –related disaster records, a sediment-related disaster forecast is feasible if those data are analyzed.

In Japan there are several methods to determine the critical rainfall for debris flow at present. Among them, Guideline Method called Method A was applied in this study taking into consideration of data availability , and another recent method in Japan was introduced in this chapter.

3. 1. 1. Method 1

The Guideline Method called Method A was presented in the “Guidelines (tentative) for setting of rainfalls for warning issuance and evacuation instruction against debris flow disasters” which was prepared by the former Ministry of Construction in 1984. This method is intended to forecast the occurrence of a debris flow using rainfall indexes which are obtained by combining a rainfall intensity and a total rainfall. This type of index was derived because it is known from the actual state of debris flow disasters that a debris flow tends to occur even when the total rainfall is small if the rainfall intensity is large, and that it tends to occur even when the rainfall intensity is small if the total rainfall is large. This method was originally developed for debris flows, but it is also applicable to steep slope failures because the occurrence process of a debris flow is similar to that of a slope failure.

Figure S18-3.1.1 is a schematic image of the critical line. The rainfall index is expressed by a combination of the rainfall intensity and the total rainfall (cumulative rainfall). As shown in the figure, the rainfall intensity is shown in the ordinate (Y-axis) and the total rainfall in the abscissa (X-axis). Debris flow causing rainfall and non-causing rainfall are plotted in the diagram by the different symbols. Then, those two rainfall groups are separated with a linear line or a curved line descending to the right. This boundary line is called the Critical Line (CL) which distinguishes the occurrence and non-occurrence of a debris flow. The lower left side of this line is the safe zone where a debris flow may not be caused. The upper right side of this line is the unsafe zone where a debris flow may be caused.

One hour rainfall for Y-axis and Working rainfall for X-axis are used for Method 1. The working rainfall is defined as follows. A series of rain between no rainfall periods more than 24 hours is called "Continuous Rainfall" and its amount is called "R_C". The rainfall period from about one week ago until the beginning of the continuous rainfall is called "Antecedent Rainfall" and its amount is called "R_A" (Figure S18-3.1.2). The debris flow is generally affected by not only the rainfall at the timing of occurrence but also the antecedent rainfall and its effect decreases according to the time difference from the debris flow occurrence.

The antecedent working rainfall from one week ago (R_{WA}) is:

$$R_{WA} = \alpha_1 d_1 + \alpha_2 d_2 + \alpha_3 d_3 + \cdots\cdots + \alpha_7 d_7 = \sum_{t=1}^{7} \alpha_t d_t \qquad (1)$$

Where α_t($\alpha_t < 1$): deduction coefficient of "t" days before, d_t: 24 hours rainfall at t days ago.

If the half life is one day, α_t is a half of α_{t-1}. The antecedent working rainfall in this case is:

$$R_{WA} = 0.5d_1 + 0.25d_2 + 0.125d_3 + \cdots\cdots \qquad (2)$$

If all debris flow causing rainfalls come in the unsafe zone in the upper right side and all non-causing rainfalls come in the safe zone in the lower left side taking the CL as the boundary line, it can be said that both rainfalls show a good "separability". The separability of the rainfall events with debris flow and without debris flow should be studied by testing some half decay periods such as 2 days, 3 days and so on. The relation of deduction coefficient and half life is:

$$\alpha_t = 0.5^{t/T} \tag{3}$$

Where T : days of half life, t : days before the beginning of continuous rainfall.

The working rainfall “R_w” of Method 1 is:

$$R_w = R_{WA} + R_C \tag{4}$$

The evacuation should be completed before the rainfall amount reaches ~~into~~ CL for the proper evacuation because the debris flow could occur when the rainfall amount reaches into CL conceptually. Therefore Evacuation Line “EL”, that is a timing for evacuation, and Warning Line “WL,” that is a timing for preparing evacuation, should be set. EL and WL are set according to the assumed rainfall amount during the time period necessary for evacuation and preparing evacuation. The timing of issuing warning and recommendation of evacuation should be set according to the local conditions. The example of timing and assumed rainfall amount is shown below. The historical maximum one hour rainfall (R_{H1M}) is used as assumed rainfall amount because it is a safe side to keep one hour for evacuation after the rainfall amount reaching into EL. The historical maximum two hours rainfall (R_{H2M}) is used as assumed rainfall amount from warning to evacuation after the rainfall amount reaching into WL.

Category		Timing of Issuing	Assumed rainfall amount
Warning	WL	Two hours before reaching CL	Historical maximum two hours rainfall (R_{H2M})
Evacuation	EL	One hour before reaching CL	Historical maximum one hour rainfall (R_{H1M})

Figure S18-3.1.3 shows how to set the Critical Rainfall.

It is noticeable that the rainfall amount will not reach into CL unless the rainfall, that exceeds the historical maximum one hour rainfall, happens after reaching into EL according to the table above.

Therefore, even though a warning is issued and an evacuation is recommended, a debris flow does not necessarily occur. It is a common problem for any methods that the possibility of this case will be higher if the critical rainfall is set as safer side.

3. 1. 2. Method 2

Method 2 is called the Committee Method proposed by the Committee for Studying Comprehensive Sediment Control Measures which was organized by the Ministry of Land, Infrastructure and Transport.

The operation method of the working rainfall in the Committee Method is different from that in the Guideline Method which calculated the working rainfall by the unit of day. Namely, all the rainfalls up to one hour before the occurrence of a debris flow are assumed as the antecedent rainfall. Those rainfalls are multiplied by the deduction coefficient and then integrated using the equations shown below. In the case of non-causing rainfalls, the working rainfall is operated at the time of a maximum hourly rainfall during a series of rain, in the same way as done in the Guideline Method.

Working rainfall, whose half life is set to be 1.5 hours, is used as short time rainfall for Y-axis and working rainfall, whose day of half life is 72 hours, is used as long time rainfall for X-axis in Method 2. Working rainfall in this method is to accumulate all of the rainfall with multiplication of deduction coefficient until one hour before the debris flow occurrence.

$$R_w = \sum \alpha_{1i} \times R_{1i} \qquad (5)$$

Where R_w: Working rainfall (mm), R_{1i}: one hour rainfall at the time i hours ago (mm), α_{1i}: deduction coefficient at i hours ago.

$\alpha_{1i} = 0.5^{i/T}$ Where T: half life in hour.

No matter what debris flow occurred or not, the line that connects the points of every hour working rainfall is called snake line. Early warning activity can be done looking at the behavior of snake line, EL, and WL by making the snake line even from normal time (Figure S18-3.1.4).

3. 1. 3. Comparison

The characteristics of Method 2 are compared with those of Method 1. Working rainfall of Method 1 keeps on increasing until no rainfall period more than 24 hours. On the other hand, Method 2 takes into account all of the rainfall with multiplication of deduction coefficient. Therefore, working rainfall of Method 2 decreases when the rainfall is weak, and it corresponds to the moisture condition of soil. Method 2 can be used for canceling the warning, because the snake line moves back to starting point according to the decreasing of rainfall. Furthermore, the continuous rainfall has to be set for Method 1, but it is not necessary for Method 2. This means that the system for continuous computation can be easy to be created and the comparison of present rainfall and past rainfall is possible by showing the snake line of all the period.

3. 2 Policy

Critical rainfall for early warning system of debris flow in the study area is studied. Method 1 is selected according to the reason shown below.

1) Although it is necessary to draw a snake line using hourly rainfall in Method 2, hourly rainfall data is difficult to be obtained. Although it is effective to use Method 2 as long as short time rainfall can be forecasted, forecasting short time rainfall itself is very difficult in the study area.

2) Critical rainfall is shown by only working rainfall at X-axis in Method 1. It is easy to be understood and operated.

3) Critical rainfall for Limon River in Maracay is the major one in Venezuela and it was set by using method 1.

Even if Method 1 is selected, this study is not easy because of the lack of information. The number of rainfall gauge stations in the study area is not enough and the hourly rainfall data, that is important for analyzing the critical rainfall, is also limited to recent data. Furthermore, the historical records of debris flow with rainfall data are not only very scarce, only say Feb.1951 and Dec.1999, but the information on the timing of debris flow occurrence and the hourly rainfall data is not much.

The study flow is shown in Figure S18-3.2.1.

3. 3 Hydrological Data

Table S18-3.3.1 and Figure S18-3.3.1 show the collected daily rainfall data and hourly rainfall data from the rainfall gauge stations in Caracas, Vargas and Maracay. Figure S18-3-3-2, Figure S18-3.3.3 and Figure S18-3.3.4 show the location of selected rainfall gauge stations.

Besides the observed rainfall data, the rainfall data calculated from the Geostationary Operational Environmental Satellite (GOES-8) was utilized. Every 30 minutes rainfall data at every 4km square mesh was calculated (Figure S18-3.3.5). The calculated results for Dec. 1999 were provided to the Study Team by USGS.

Figure S18-3.3.5 shows that the area that was heavily rained for 3 days is corresponding to the San Julian watershed that was most damaged in Vargas.

Hourly rainfall data during the disaster period on Dec.1999 at La Carlota station and Cagigal station in Caracas urban area are collected. Figure S18-3.3.6 and Figure S18-3.3.7 show the comparison of observed data and simulated data. There can be seen the differences on total rainfall, peak rainfall and its timing between observed data and simulated data. Although the rainfall data from satellite image is the average rainfall within 4km square area, and is simulated from the cloud top temperature, and is not enough calibrated, these data are very valuable because there are not enough spatial and temporal ground rainfall data at the timing of debris flow.

3. 4 Critical Rainfall in Maracay

Critical Rainfall was studied by using evaluation diagram shown in Figure S18-3.4.1 by a JICA expert team after the debris flow disaster at Limon River in Maracay on September 1987[1]. This critical rainfall is still used in the Limon River.

The evaluation diagram is made by Method 1 by using rainfall data at Rancho Grande station. Collected rainfall data and hyetograph on Sep.1987 at Rancho Grande are shown in Figure S18-3.4.2.

The point of rainfall event with debris flow in the evaluation diagram means that the hourly rainfall at Y-axis is about 45mm and the working rainfall at X-axis is about 158mm. The hourly rainfall at 16:00 on 6th of September, when the debris flow occurred, is 45.5mm according to the Figure S18-3.4.2 and this is corresponding to the point of evaluation diagram. Concerning the working rainfall of evaluation diagram, the hourly rainfall, when the debris flow occurred, is not added to the working rainfall of Method 1. Therefore, the working rainfall until 15:00 is to be about 158 mm. The cumulative daily rainfall from 1st of September until 6th of September is 30.5mm, the cumulative hourly rainfall until 15:00 on 6th of September is 127mm, and summation of these rainfall amounts is 157.5mm. Therefore, the working rainfall of the evaluation diagram in Maracay is found out to be accumulation of continuous rainfall not considering the antecedent rainfall (Figure S18-3.4.3).

$$R_w = R_C$$

EL and WL is set by using historical maximum one hourly rainfall 89mm and two hours rainfall 94mm at Rancho Grande, and they are shown in table below

	WL	EL
Limon River	88.0mm	93.0mm

3. 5 Rainfall in Caracas and Vargas

3. 5. 1. Policy

Critical rainfall for early warning system of debris flow disaster at Limon River in Maracay is the major one in Venezuela. The rainfall events that caused debris flow in Caracas and Vargas, and the rainfall events that did not cause the debris flow in Caracas are plotted on the evaluation diagram of Maracay. Working rainfall is defined as the accumulation of continuous rainfall without taking into account the antecedent rainfall to make consistent with the methodology of critical rainfall in Maracay.

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1 JICA,Report on the 3rd Sabo Work Shop in Venezuela, Sabo Work Shop Study Team, 1989

3. 5. 2. Rainfall Event with Debris Flow in Caracas

(1) Debris Flow Event on February 1951

The only available rainfall data concerning the debris flow on Feb.1951 is a mass curve at Subida Pico Avila Station at the middle of Tocome watershed. The hourly rainfall data was read from mass curve is shown in Figure S18-3.5.1.

Two (2) times of debris flow occurrence are assumed because the information on the timing of debris flow disaster is not available. Time period of case 1 is from 3:00 to 8:00 on 17th of February (around peak rainfall and hourly rainfall is more than 20 mm). Time period of case 2 is from 18:00 to 23:00 on 17th of February (around second peak rainfall and hourly rainfall is more than 10mm).

Evaluation diagram is shown in Figure S18-3.5.2. The locations of the plots are found out to be different much due to the unknown factor of the timing of debris flow by comparing the plots of case1 and case 2. The result of case 1 is used in this study.

(2) Debris Flow Event on December 1999

Rainfall data on December 1999 is available only at the stations in urban area such as Cagigal, UCV, La Carlota and Maiquetia that are not in the mountain but on the plain (Figure S18-3.5.3). Therefore the rainfall data that is simulated from satellite image are utilized (data from USGS explained at 3.3). The rainfall data around Catuche and Anauco area is plotted on the evaluation diagram.

The averaged daily rainfall of Maiquetia and Cagigal are used as the previous rainfall that should be included into the continuous rainfall, because the hourly rainfall data of USGS is after the 16:00 on 15th of December (Table S18-3.5.1). The representative mesh of USGS simulation for Catuche and Anauco area is shown in Figure S18-3.5.4.

Result of interview survey and previous report are used for the information on the timing of debris flow. According to this information, time period from 21:00 to 23:00 on 15th of December could be the timing of the first debris flow arriving at the urban area.

The hyetograph by USGS and the timing of debris flow at the Catuche and Anauco area are shown in Figure S18-3.5.5. Not so big rainfall can be seen around the time period when the first debris flow is assumed to arrive at the urban area.

On the other hand, the time of peak rainfall of the observed rainfall data at Cagigal station, that is close to Catuche and Anauco catchment, is comparatively corresponding to the result of interview survey. Therefore, the rainfall distribution pattern of Cagigal station is used and adjusted its total rainfall into the total rainfall of USGS data (Figure S18-3.5.6) as the rainfall in Catuche and Anauco catchment. Figure S18-3.5.7 shows how to calculate the working rainfall. Figure S18-3.5.8 shows the evaluation diagram. The rainfall data before adjustment is also shown in the evaluation diagram.

Although the time period of the debris flow occurrence is comparatively clear, the observed hourly rainfall data does not exist in this case. The locations of the plots are found out to be different much due to the unknown factor of the hourly rainfall.

3. 5. 3. Rainfall Event with Debris Flow in Vargas

Rainfall events with debris flow at San Julian basin and San Jose de Galipan basin that are comparatively heavily damaged are plotted in the case of Vargas area.

Hourly rainfall data of USGS and the result of interview survey by USGS (Table S18-3.5.2) for the information on timing of the debris flow arriving at urban area are used.

Daily rainfall of Maiquetia is used as the previous rainfall that should be included into the continuous rainfall, because the hourly rainfall data of USGS is after the 16:00 on 15th of December (Table S18-3.5.3). The representative mesh of USGS simulation for San Julian and San Jose de Galipan are shown in Figure S18-3.5.9.

The continuous rainfall and the timing of debris flow at San Julian and San Jose de Galipan are shown in Figure S18-3.5.10 and Figure S18-3.5.11. Figure S18-3.5.12 shows the evaluation diagram.

3. 5. 4. Rainfall Event not causing Debris Flow

Daily rainfall and hourly rainfall data at Los Venados station and Hotel Humboldt station are used for rainfall event not causing debris flow in Caracas. Rainfall events, of which total amount of continuous rainfall is more than 80mm or maximum hourly rainfall is more than 20mm, are selected as the rainfall events without debris flow. Table S18-3.5.4 shows the selected rainfall events.

Maximum hourly rainfall and working rainfall before maximum hourly rainfall are plotted on the evaluation diagram as the rainfall events without debris flow for Method 1. 50 % of the maximum daily rainfall is assumed to occur as the maximum hourly rainfall at the date of maximum daily rainfall according to the result of the study shown below in the case that the hourly rainfall data does not exist.

Figure S18-3.5.13 shows the evaluation diagram.

[Study on Hourly Rainfall Distribution of Daily Rainfall]

Hourly rainfall distribution in a day was studied by using hourly rainfall data of Cagigal, La Carlota, Los Venados that are well collected comparatively.

Rainfall events of which daily rainfall is more than 30mm are selected from rainfall data of each station (Table S18-3.5.5). Most rainfall events are found out to finish in one or two hours according to the mass precipitation curve (Figure S18-3.5.14). The averaged rate that maximum hourly rainfall occupies the daily rainfall is 55% for Cagigal, 52% for La Carlota and 50% for Los Venados (Table S18-3.5.6).

3. 6 Comparison of Characteristics of Maracay, Vargas and Caracas

3. 6. 1. Hydrology

The rainfall data of Rancho Grande in Maracay, Maiquetia in Vargas, Cagigal, La Carlota, Caurimare, Los Venados and Hotel Humboldt in Caracas are used for comparing the hydrological characteristics of Maracay, Vargas and Caracas.

Figure S18-3.6.1 shows the monthly rainfall at each station. Annual rainfall of Rancho Grande is as about twice as that of Cagigal, three times of Maiquetia. Difference of rainy season and dry season is significant at Rancho Grande. Although the number of data is not much, annual rainfall of Los Venados and Hotel Humboldt in the Avila mountain are 20% more than that of Cagigal.

It is found out that 3 hours rainfall is occupying more than 70 – 80 % of 24 hours rainfall for the four (4) stations (Table S18-3.6.1)

Rainfall amount of Rancho Grande is more than that of Caracas area and Vargas area.

It is found out that 1 hour rainfall is occupying more than 50% of 24 hours rainfall and 3 hours rainfall is occupying more than 70% of 24 hours rainfall except for Maiquetia (Table S18-3.6.2). This means that the heavy rain concentrates on short time duration

As it is studied in 3.5.4, the average ratio of the maximum hourly rainfall to the daily rainfall is 55% for Cagigal, 52% for La Carlota and 50% for Los Venados. This also means that the heavy rain concentrates on short time duration.

Although the annual rainfall and monthly rainfall are different for 3 areas, the rainfall pattern that the heavy rainfall concentrates on short time duration seems to be common for 3 areas. It is difficult to see the difference of rainfall events that cause debris flow in 3 areas because such events are only on 1951, 1987 and 1999.

3. 6. 2. Topography and Geology

Figure S18-3.6.2 shows the findings in terms of the slope failure when the debris flow occurred in the 3 areas (Maracay, Vargas and Caracas). The seriously collapsed area is not always corresponding to the heavy rainfall area. It is regarded that vegetation weakness is one of the key factors on debris flow generation.

3. 7 Trial on Setting of Critical Rainfall in Caracas

It is difficult to see the difference of rainfall events that cause debris flow in 3 areas according to 2.6.

3. 7. 1. Setting of Critical Line (CL)

It is necessary to set the CL on the evaluation diagram of Figure S18-3.5.13 for setting Critical Rainfall. CL is drawn according to the policy shown below (Figure S18-3.7.1).

1) To precede the data in Caracas

2) The gradient of CL is " -1 ". The summation of cumulative rainfall and hourly rainfall at any points on CL is always same and it is easy to be understood that the summation is the critical rainfall for debris flow.

The plots of Maracay and Vargas are shown on Figure S18-3.7.1 as a referential data.

Rainfall events with debris flow in Vargas are the simulated data by USGS. Plots at the lower left of CL mean that there are unknown factors on the rainfall data itself and time period of debris flow occurrence.

3. 7. 2. Result of Attempt

Historical maximum hourly rainfalls are collected to set the critical rainfall according to the method of Figure S18-3.1.3. The historical maximum hourly rainfall, that are collected at the rainfall gauge stations in the study area and Rancho Grande as a referential data, are shown in Table S18-3.7.1.

Maximum one hour rainfall is 91mm at Teleferico and two hours rainfall is 87.3mm at Los Venados because there are no records for 2 hours rainfall at Teleferico.

Figure S18-3.7.2 and Figure S18-3.7.3 show the evaluation diagram for case1; Critical rainfall for warning by using one hour rainfall 91mm at Teleferico, and the evaluation diagram for case 2; Critical rainfall for warning and evacuation by using one hour rainfall 51mm and two hours rainfall 87.3mm at Los Venados. The results are shown below.

	Critical Rainfal for Warning	Critical Rainfall for Evacuation
Case1	96.0mm	—
Case2	99.7mm	135.7mm

3. 7. 3. Recommendation

The reliability of evaluation diagram is depending on the accuracy of the timing of debris flow occurrence and accuracy of the hourly rainfall and cumulative rainfall at that time. This analysis is based on many assumptions for these important factors and the differences in the case of different assumption are also shown. For example, the critical rainfall (WL) is about 44mm according to the Figure S18-3.7.4 by using the rainfall event in Figure S18-3.5.5. Therefore, the results of this study are just only referential value and this value should be modified by accumulating the data in the future. And although the working rainfall in this study is the accumulation of continuous rainfall without considering antecedent rainfall, study on the half life in Caracas and study on Method 2 are recommended to be conducted by MARN.

Table S18-3.3.1 Collected Rainfall Data

Serial	Station	Area	Elevation (m)	Daily Data	Hourly Data
0426	Rancho Grande	Maracay	1,160	1987, 1994, 1996, 2002	1987.9 event
0503	Maiquetia (FAV)	Vargas	75	1961 - 2003	-
0514	Los Venados	Caracas	1,540	1994 - 2003	2001 - 2003
0519	Hotel Humboldt	Caracas	2,129	1959 - 1974, 2000 - 2002	2001.8 - 2002.5
0531	Cagigal	Caracas	1,035	1891 - 1988 (all year), 1997, 1999 - 2003 (from May to Dec.)	1997, 1999 - 2003 (from May to Dec.)
0544	La Carlota	Caracas	835	1964 - 2003	1996 - 2003
5024	Subida Pico Avila	Caracas	1,250	-	1951.2 event
5027	Caurimare	Caracas	965	1949 - 2003	-

Table S18-3.5.1 Additional Daily Rainfall Data as Continuous Rainfall

Daily Rainfall (mm)

Number of Date before Event	Date (1999)	Maiquetia	Cagigal	Average
14	12/1	6.0	0.3	3.2
13	12/2	77.3	0.0	38.7
12	12/3	121.2	2.7	62.0
11	12/4	11.8	0.0	5.9
10	12/5	0.0	1.9	1.0
9	12/6	1.1	0.6	0.9
8	12/7	5.0	1.7	3.4
7	12/8	8.1	19.1	13.6
6	12/9	10.4	4.1	7.3
5	12/10	0.0	0.4	0.2
4	12/11	23.2	0.4	11.8
3	12/12	21.8	15.0	18.4
2	12/13	7.1	5.0	6.1
1	12/14	120.0	14.2	67.1
Summation of Continuous Rainfall (mm)		172.1	59.9	127.8

▭ Continuous Rainfall

Table S18-3.5.2 Result of Interview Survey by USGS

Date	Time	Drainage(Location)	Description
12/16/99	9:00 a.m.	Camuri Chiquito	Major debris-flow event in drainage burying bus along eastern margin of fan.
12/16/99	7:20 a.m.	Osorio (La Guiara)(E)	Water flooding on eastern part of fan.
	8:00 a.m.		Water flooding on eastern part of fan.
	9:00 a.m.		Rocky (debris-flow) event.
12/16/99	5:00 a.m.	Osorio (La Guiara)(W)	Flooding.
	9:00 a.m. - 3:00 p.m.		Rocky debris flow followed by water flooding.
12/15/99	8:00 p.m.	San Julian (Caraballeda)	First wave of flood water, 1.5m high.
	8:30 p.m.		Crashing of rocks (debris flow?).
12/16/99	2:00 a.m.		Water flooding shortly followed by large bouldery debris flow.
	2:00 a.m. - 3:00 a.m.		Water and mud (flows) observed.
	6:00 a.m.		Three (debris) flow episodes, with the last one at 6:00 a.m.
	10:00 a.m.		Flooding recedes.
12/16/99	2:00 a.m.	Camuri Grande	River levels (running) high.
	6:00 a.m.		Rumbling sounds like (debris-flow) boulders crushing buildings.
12/15/99	8:00 p.m.	San Jose de Galipan (Macuto)	River flooding over banks; flow travelled down street.
	8:00 p.m. - 12/16/99 3:00 a.m.		Rumbling noise of vibration of rocky (debris flow); row of houses removed.
12/16/99	6:00 a.m. - 7:00 a.m.		Surge of debris flow destroyed houses.
	9:00 a.m.		Major (debris-flow) event, with pulses of sand, but no boulders.
12/15/99	Evening	Seca	Flooding during night.
12/16/99	1:00 a.m. - 2:00 a.m.		Rising water levels and flooding.
	5:00 a.m. - 6:00 a.m.		Debris flow.
	6:00 a.m.		Single debris-flow event carrying cars; most people near stream evacuated their homes and fled up hills.
	6:00 a.m. - 7:00 a.m.		Debris (flow) with boulders.
12/16/99	1:00 a.m.	Cerro Grande	Torrent with lots of sediment.
	6:00 a.m. - 7:00 a.m.		Debris flow with four large surges (Shucheng and others, 2000)
12/16/99	6:00 a.m.	Uria	Flooding following by large surge (Shucheng and others, 2000)

Table S18-3.5.3 Additional Daily Rainfall Data as Continuous Rainfall

Daily Rainfall (mm)

Number of Date before Event	Date (1999)	Maiquetia
14	12/1	6.0
13	12/2	77.3
12	12/3	121.2
11	12/4	11.8
10	12/5	0.0
9	12/6	1.1
8	12/7	5.0
7	12/8	8.1
6	12/9	10.4
5	12/10	0.0
4	12/11	23.2
3	12/12	21.8
2	12/13	7.1
1	12/14	120.0
Summation of Continuous Rainfall (mm)		172.1

(boxed) Continuous Rainfall

Table S18-3.5.4 List of Non-causing Rainfall

Hotel Humboldt

Total rainfall is more than 80mm

Date			Hourly	Working
Y	M	D	(mm)	(mm)
1960	4	20	11.8	11.8
1960	4	23	23.7	62.1
1960	6	13	10.3	10.3
1960	6	15	21.7	42.6
1960	8	5	10.1	27.1
1960	8	10	13.0	70.8
1960	8	11	37.0	120.7
1960	8	12	14.4	172.1
1960	8	24	45.9	51.1
1960	12	4	10.2	10.6
1960	12	6	23.1	58.8
1960	12	11	13.5	111.3
1961	8	2	10.1	66.6
1961	9	15	14.9	14.9
1961	9	19	32.5	98.2
1962	5	30	10.3	15.3
1962	5	31	15.6	41.1
1962	8	23	15.7	17.1
1962	8	27	14.5	67.2
1963	5	8	14.4	19.6
1963	5	9	25.7	59.7
1963	5	17	25.1	25.1
1963	5	24	11.5	70.1
1963	6	3	15.1	28.7
1963	6	7	19.3	85.1
1963	9	11	23.8	24.6
1963	9	14	17.2	88.5
1967	7	23	21.8	29.2
1967	9	5	12.1	22.0
1967	9	7	11.5	50.6
1967	10	24	10.9	24.1
1967	10	25	20.8	55.7
1967	11	5	16.4	67.9
1967	11	24	21.1	50.1
1967	11	25	10.3	81.5
1968	9	23	25.0	26.6
1968	9	24	13.7	65.3
1969	8	16	10.3	10.3
1969	8	17	14.8	35.3
1969	10	22	21.9	29.5
1969	11	15	10.9	11.7
1969	11	16	42.9	65.4
1970	7	13	12.3	79.9
1971	8	26	36.8	41.4
1971	8	27	12.5	90.6
1971	10	14	13.9	30.2
1971	10	15	14.5	58.6
1972	5	1	13.0	13.0
1972	5	3	11.3	41.1
1972	5	8	11.1	77.3
1974	7	30	26.1	58.9
1974	8	15	10.8	65.0
2000	9	19	12.5	12.5
2000	9	20	12.5	37.5
2000	11	12	21.5	35.5
2000	11	14	12.0	72.0
2000	11	15	23.0	107.0
2001	10	14	20.0	39.0
2001	10	18	12.0	91.0

Hourly rainfall is more than 20mm

Date			Time	Hourly	Working
Y	M	D	(hour)	(mm)	(mm)
2001	9	9	12:00	21.0	0.0
2001	9	22	20:00	28.0	18.0

Los Venados

Total rainfall is more than 80mm

Date			Hourly	Working
Y	M	D	(mm)	(mm)
1994	9	9	34.7	46.1
1994	10	21	15.4	45.2
1994	10	22	29.6	90.2
1995	3	21	13.3	13.6
1995	3	22	15.6	42.5
1995	3	23	20.8	78.8
2000	9	19	10.9	10.9
2000	9	21	21.5	57.7
2000	9	24	16.1	99.3
2000	11	12	34.1	45.3
2000	11	15	23.3	115.4
2001	12	15	12.2	55.9
2002	4	7	12.7	25.2
2002	4	10	37.6	80.6

Hourly rainfall is more than 20mm

Date			Time	Hourly	Working
Y	M	D	(hour)	(mm)	(mm)
2001	5	8	11:00	29.3	1.8
2001	7	26	17:00	47.5	7.2
2001	8	29	18:00	39.8	54.7
2001	8	29	3:00	24.0	1.9
2001	9	22	20:00	38.5	8.5
2001	10	14	17:00	20.4	26.2
2002	6	22	14:00	22.2	0.6
2002	10	1	19:00	21.3	17.2
2003	4	12	20:00	20.1	0.0
2003	4	13	12:00	27.8	20.3
2003	4	22	20:00	24.5	0.0
2003	4	23	19:00	42.1	28.4
2003	4	26	20:00	22.8	8.4
2003	5	23	17:00	26.0	13.8
2003	7	12	16:00	20.3	77.5
2003	9	19	18:00	28.1	19.7
2003	10	13	12:00	26.8	8.7
2003	10	22	16:00	22.4	10.7
2003	11	25	16:00	51.3	13.4

Table S18-3.5.5 List of Rainfall Event (Daily Rainfall is More than 30mm)

No.	Cagigal		La Carlota		Los Venados	
	Date of Event	Daily Rainfall (mm)	Date of Event	Daily Rainfall (mm)	Date of Event	Daily Rainfall (mm)
1	1997/6/1	40.3	1996/1/19	47.0	2001/5/8	47.3
2	1997/6/18	31.1	1996/6/3	41.1	2001/7/26	87.6
3	1997/7/21	43.6	1996/6/4	35.0	2001/9/22	47.0
4	1997/9/7	33.9	1996/6/17	32.6	2001/9/27	44.1
5	1997/9/17	34.9	1996/7/14	33.4	2001/11/2	32.9
6	1999/7/31	36.5	1996/10/12	49.6	2001/10/14	64.6
7	1999/8/21	39.1	1996/11/9	52.7	2002/4/10	75.2
8	1999/9/13	36.8	1996/11/20	36.7	2002/5/23	33.8
9	1999/11/29	37.9	1996/11/23	32.9	2002/6/22	36.2
10	1999/12/15	66.5	1997/6/18	39.9	2002/10/1	45.7
11	2000/8/18	49.7	1998/6/16	39.6	2003/4/23	49.4
12	2000/9/20	30.8	1999/7/31	45.5		
13	2000/11/2	32.6	1999/10/5	43.4		
14	2001/8/20	51.7	1999/10/6	39.4		
15	2001/10/15	51.6	1999/12/15	46.9		
16	2001/10/25	53.2	1999/12/16	34.6		
17	2002/5/23	31.5	2000/7/25	37.9		
18	2002/6/21	30.3	2000/7/28	50.9		
19	2002/9/9	33.2	2000/10/8	34.5		
20			2000/10/30	41.4		
21			2001/7/22	32.0		
22			2003/7/18	42.0		
23			2003/10/11	37.3		
24			2003/10/28	36.1		

Table S18-3.5.6 Percentage of Maximum Hourly Rainfall

Rainfall Event at Cagigal Station

Date of Events	Daily Rainfall (mm)	Maximum Hourly Rainfall(mm)	Ratio (%)
1997/6/1	40.3	28.2	70.0
1997/6/18	31.1	10.7	34.4
1997/7/21	43.6	13.1	30.0
1997/9/7	33.9	24.7	72.9
1997/9/17	34.9	34.4	98.6
1999/7/31	36.5	21.5	58.9
1999/8/21	39.1	10.1	25.8
1999/9/13	36.8	26.1	70.9
1999/11/29	37.9	17.4	45.9
1999/12/15	66.5	20.9	31.4
2000/8/18	49.7	18.8	37.8
2000/9/20	30.8	20.7	67.2
2000/11/2	32.6	27.3	83.7
2001/8/20	51.7	22.2	42.9
2001/10/15	51.6	21.6	41.9
2001/10/25	53.2	37.6	70.7
2002/5/23	31.5	17.3	54.9
2002/6/21	30.3	13.3	43.9
2002/9/9	33.2	22.8	68.7
		Average	55.3

Rainfall Event at La Carlota Station

Date of Events	Daily Rainfall (mm)	Maximum Hourly Rainfall(mm)	Ratio (%)
1996/1/19	47.0	41.0	87.2
1996/6/3	41.1	7.2	17.5
1996/6/4	35.0	13.5	38.6
1996/6/17	32.6	6.7	20.6
1996/7/14	33.4	13.1	39.2
1996/10/12	49.6	47.9	96.6
1996/11/9	52.7	27.9	52.9
1996/11/20	36.7	19.7	53.7
1996/11/23	32.9	18.6	56.5
1997/6/18	39.9	11.0	27.6
1998/6/16	39.6	24.1	60.9
1999/7/31	45.5	17.2	37.8
1999/10/5	43.4	39.2	90.3
1999/10/6	39.4	18.0	45.7
1999/12/15	46.9	12.2	26.0
1999/12/16	34.6	6.1	17.6
2000/7/25	37.9	27.4	72.3
2000/7/28	50.9	21.7	42.6
2000/10/8	34.5	8.3	24.1
2000/10/30	41.4	12.9	31.2
2001/7/22	32.0	15.2	47.5
2003/7/18	42.0	40.0	95.2
2003/10/11	37.3	24.1	64.6
2003/10/28	36.1	35.0	97.0
		Average	51.8

Rainfall Event at Los Venados Station

Date of Events	Daily Rainfall (mm)	Maximum Hourly Rainfall(mm)	Ratio (%)
2001/5/8	47.3	29.3	61.9
2001/7/26	87.6	47.5	54.2
2001/9/22	47.0	38.5	81.9
2001/9/27	44.1	15.9	36.1
2001/11/2	32.9	9.9	30.1
2001/10/14	64.6	20.4	31.6
2002/4/10	75.2	14.4	19.1
2002/5/23	33.8	12.3	36.4
2002/6/22	36.2	22.2	61.3
2002/10/1	45.7	21.3	46.6
2003/4/23	49.4	42.1	85.2
		Average	49.5

Table S18-3.6.1 Comparison of Historical Maximum Rainfall and its Percentage Against 24 Hours Rainfall

Historical Maximum Rainfall (mm)

Station	1 hour	3 hours	6 hours	12 hours	24 hours
Rancho Grande	89.0	141.0	146.0	146.0	177.0
Maiquetia	44.0	91.0	97.0	106.0	106.0
Cagigal	76.0	85.0	98.0	98.0	100.0
Caurimare	61.0	84.0	113.0	113.0	113.0

Percentage against 24 Hours Rainfall (%)

Station	1 hour	3 hours	6 hours	12 hours	24 hours
Rancho Grande	50.3	79.7	82.5	82.5	100.0
Maiquetia	41.5	85.8	91.5	100.0	100.0
Cagigal	76.0	85.0	98.0	98.0	100.0
Caurimare	54.0	74.3	100.0	100.0	100.0

Table S18-3.6.2 Comparison of Probable Rainfall and its Percentage Against 1440 min Probable Rainfall

Probable Rainfall (100 years return period) (mm)

Station	60 min	120 min	180 min	360 min	540 min	720 min	1440 min
Rancho Grande	113.6	141.4	154.0	176.0	182.8	183.8	199.6
Maiquetia	79.6	105.7	131.8	157.1	184.7	189.5	301.3
Cagigal	78.1	81.9	85.7	93.9	96.9	98.7	122.3
Caurimare	78.5	91.0	103.5	128.4	131.8	131.4	143.1

Percentage against 1440min Probable Rainfall (%)

Station	60 min	120 min	180 min	360 min	540 min	720 min	1440 min
Rancho Grande	56.9	70.8	77.2	88.2	91.6	92.1	100.0
Maiquetia	26.4	35.1	43.7	52.1	61.3	62.9	100.0
Cagigal	63.9	67.0	70.1	76.8	79.2	80.7	100.0
Caurimare	54.9	63.6	72.3	89.7	92.1	91.8	100.0

Table S18-3.7.1 Historical Maximum Hourly Rainfall

Station	Duration	1 hour (mm)	Date	2 hours (mm)	Date
Los Venados	2001-2003	51.3	2003.11.25 15:00-16:00	87.3	2001.7.26 16:00-18:00
Hotel Humboldt	2001-2002	28.0	2001.9.22 19:00-20:00	45.0	2001.9.22 18:00-20:00
Cagigal	1997-2002	37.6	2001.10.24 14:00-15:00	40.4	2001.8.19 20:00-22:00
La Carlota	1996-2003	47.9	1996.10.12 18:00-19:00	49.3	1996.10.12 18:00-20:00
Cagigal	1938-1977	76.0	1972.3	-	-
Caurimare	1979-1995	61.0	1986.11	70.0	1988.8
Chacaito	1977-1983	50.0	1981.9	54.0	1981.2
Los Chorros	1968-1983	71.0	1983.9	86.0	1975.10
San Jose del Avila	1966-1982	59.0	1970.9	65.0	1980.9
Teleferico	1968-1980	91.0	1971.4	-	-
Rancho Grande		89.0		94.0	

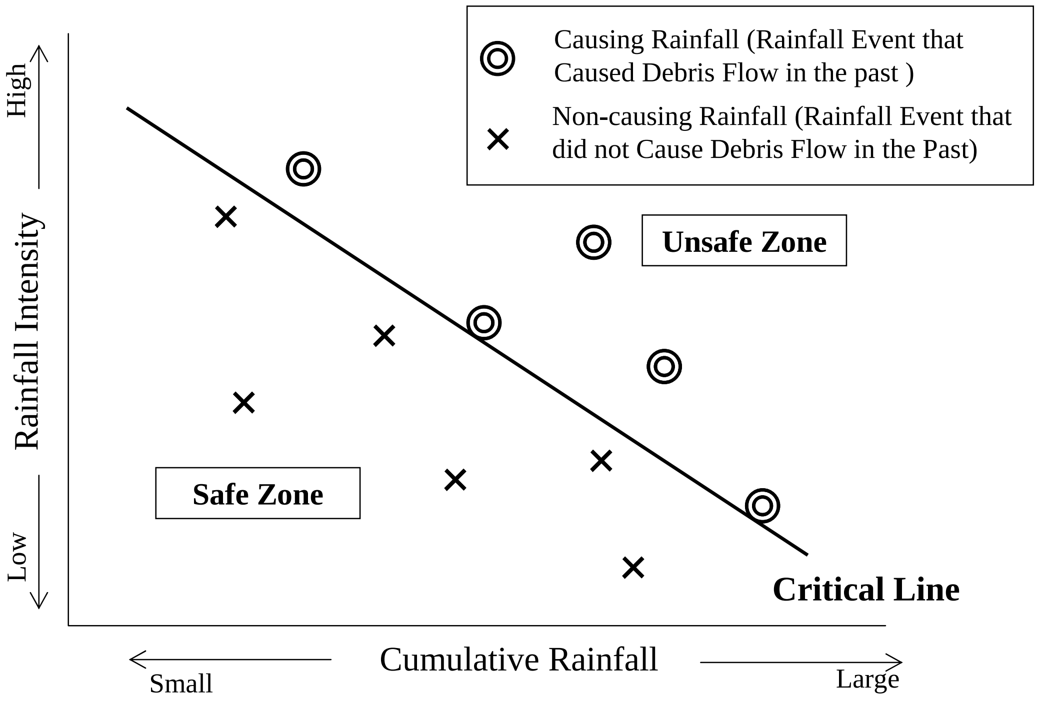


Figure S18-3.1.1　Concept of Critical Line

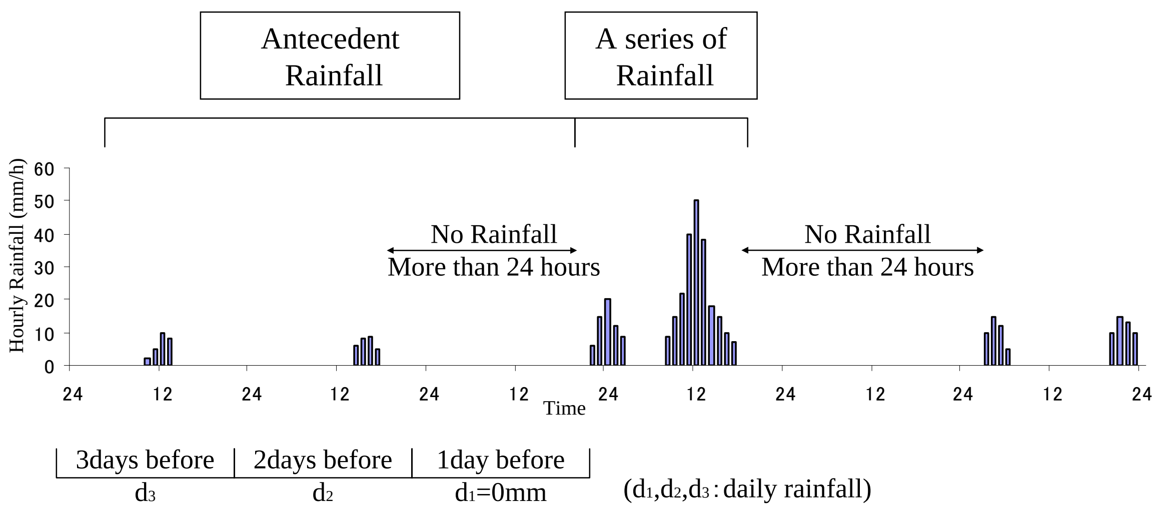


Figure S18-3.1.2　Concept of Antecedent Rain and A Series of Rain

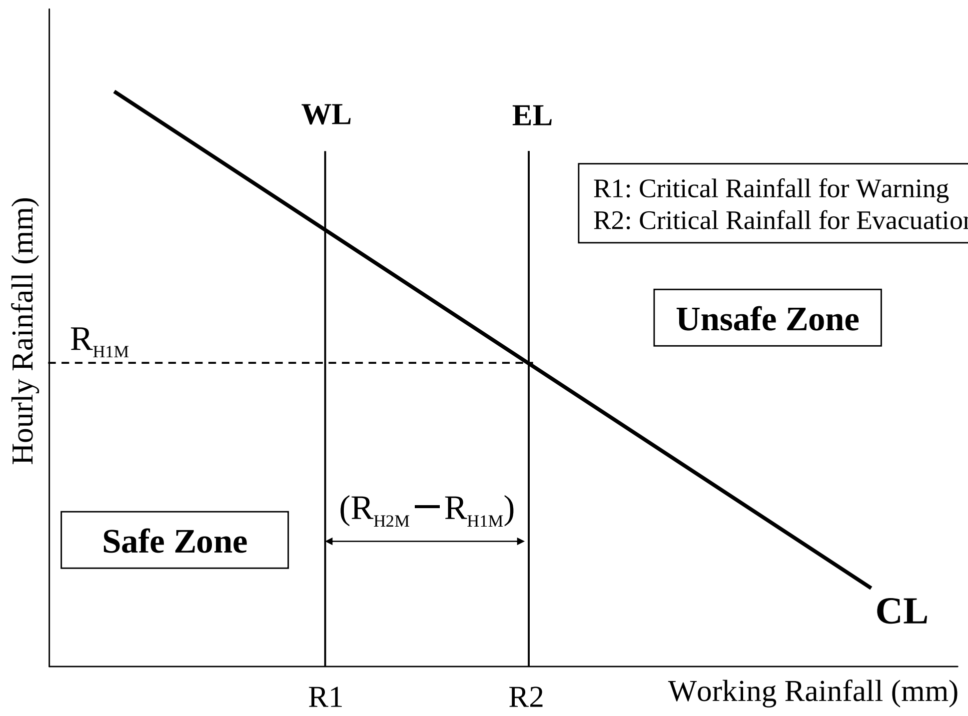


Figure S18-3.1.3　Concept of Warning Level and Evacuation Level (Method 1)

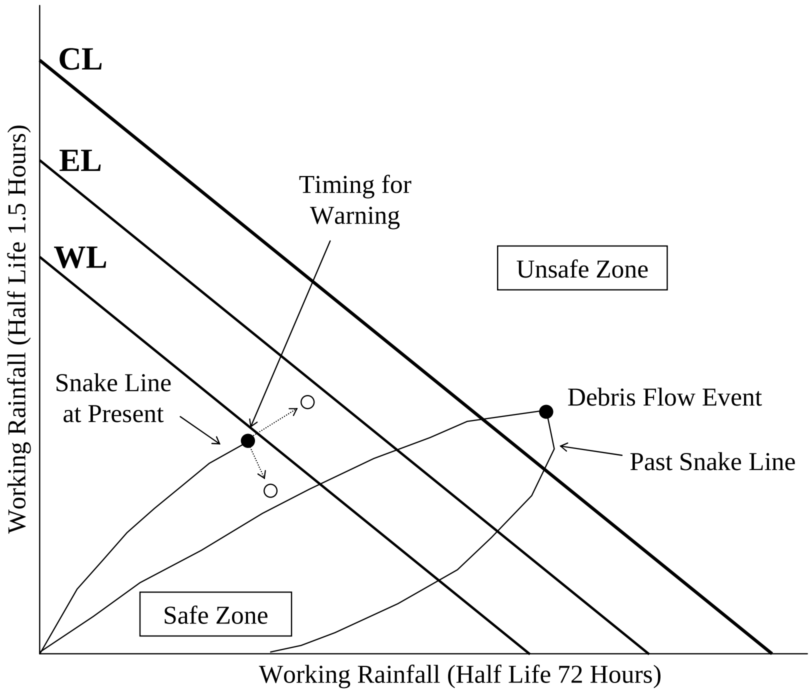


Figure S18-3.1.4　Concept of Method 2

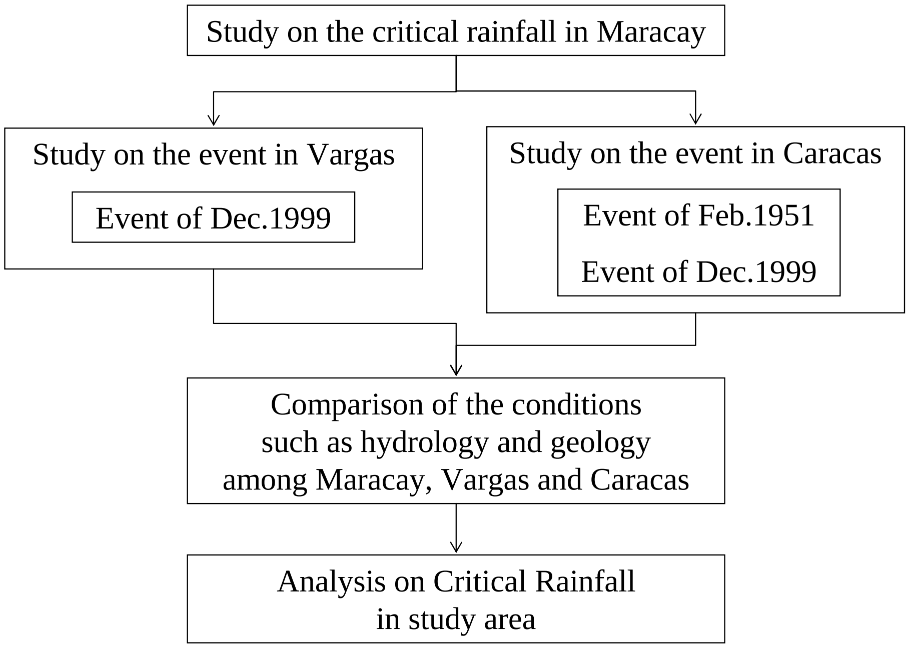


Figure S18-3.2.1　Study Flow on Critical Rainfall

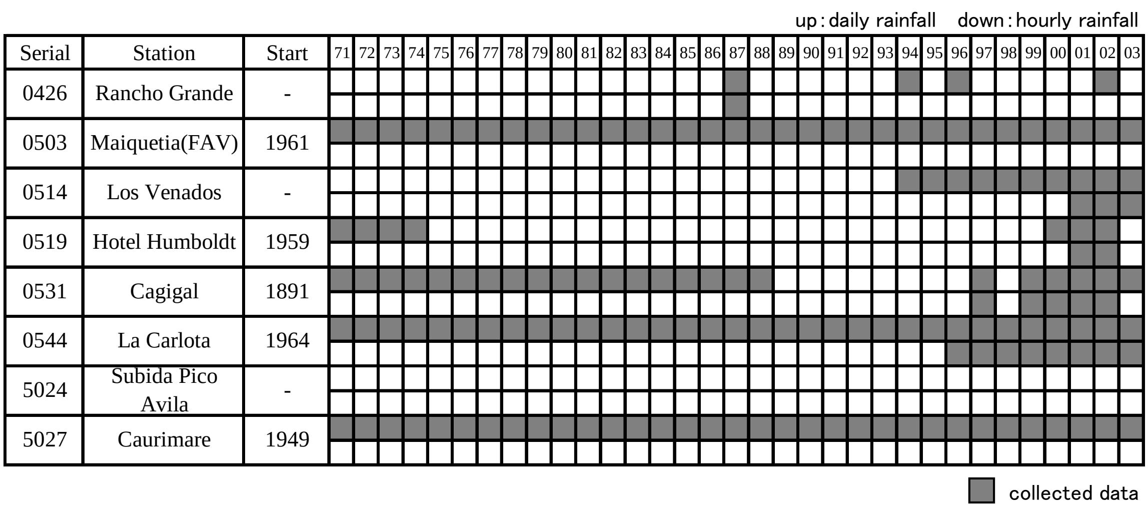


Figure S18-3.3.1　Collected Rainfall Data

Figure S18-3.3.2 Location of Caracas, Vargas and Maracay

Figure S18-3.3.3 Location of Rainfall Gauge Stations

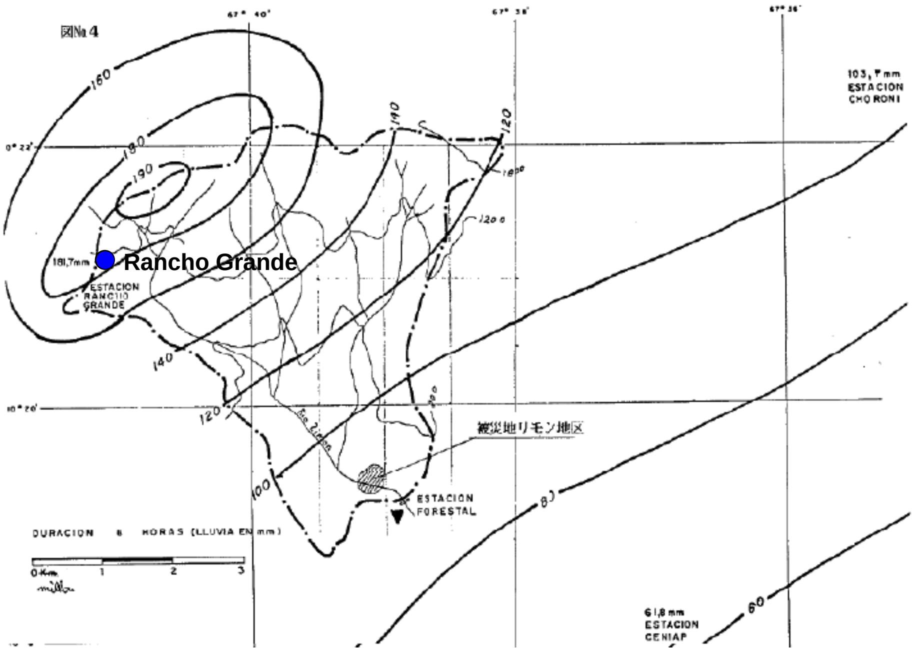


Figure S18-3.3.4　Location of Rainfall Gauge Station (Rancho Grande)

(Contour lines for 6 hours rainfall on 6th of September 1987)

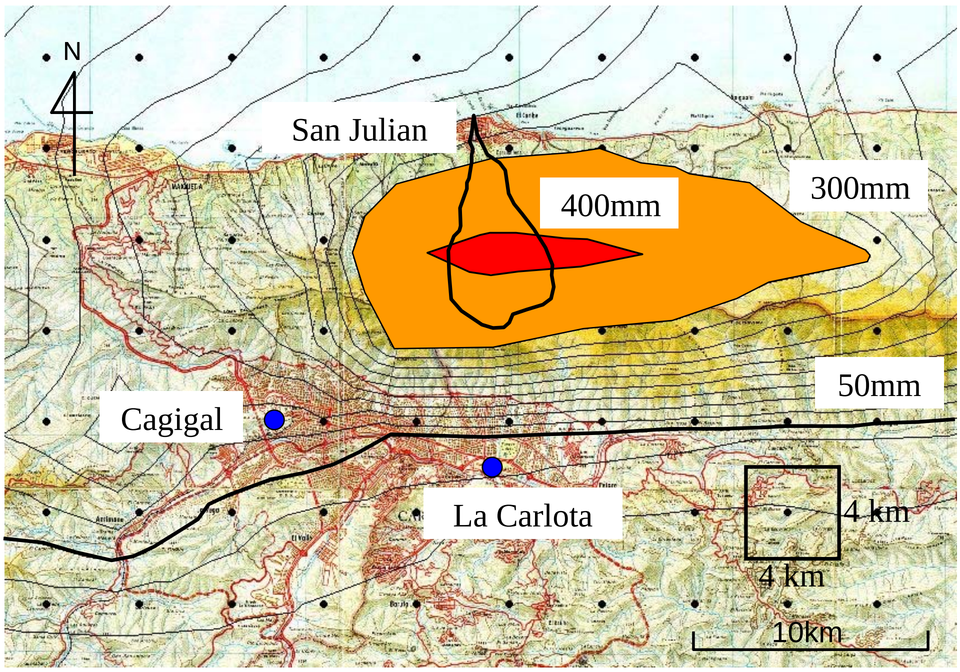


Figure S18-3.3.5　Grid of Calculation by USGS

(Contour lines for 3 days rainfall from 15th to 17th of December 1999)

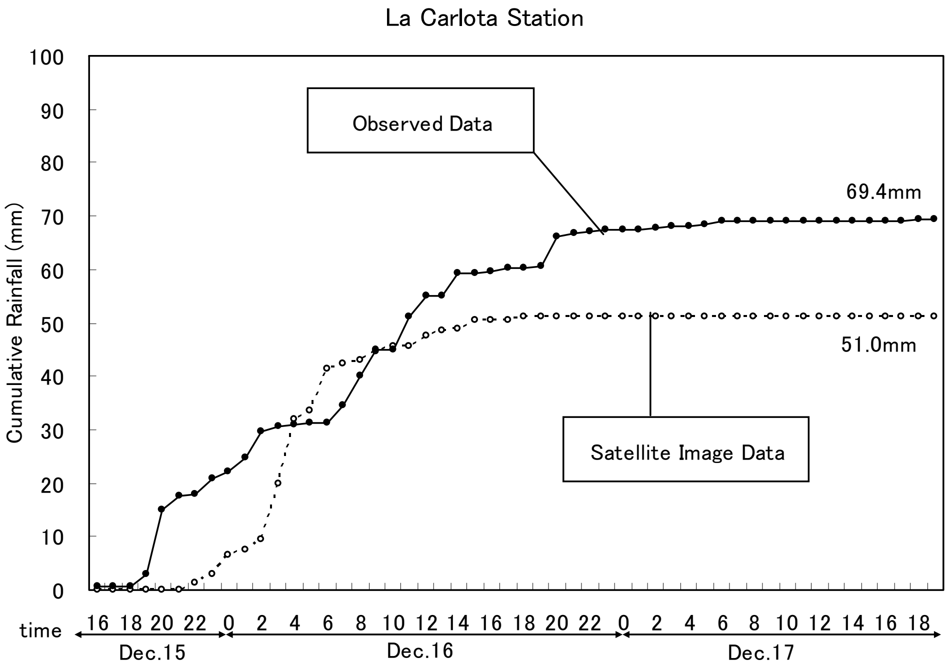


Figure S18-3.3.6　Comparison of Observed Data and Calculated Data (La Carlota Station)

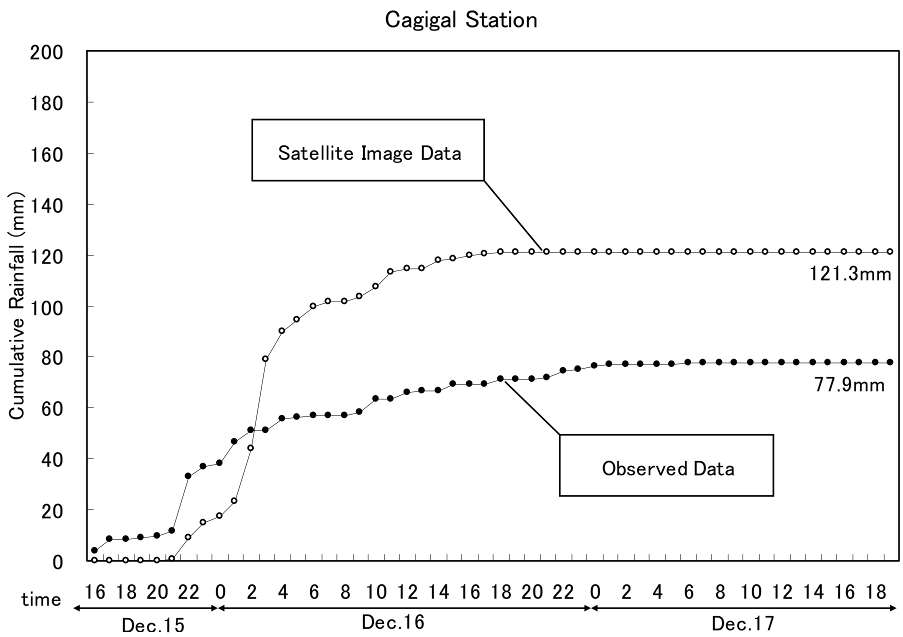


Figure S18-3.3.7　Comparison of Observed Data and Calculated Data (Cagigal Station)

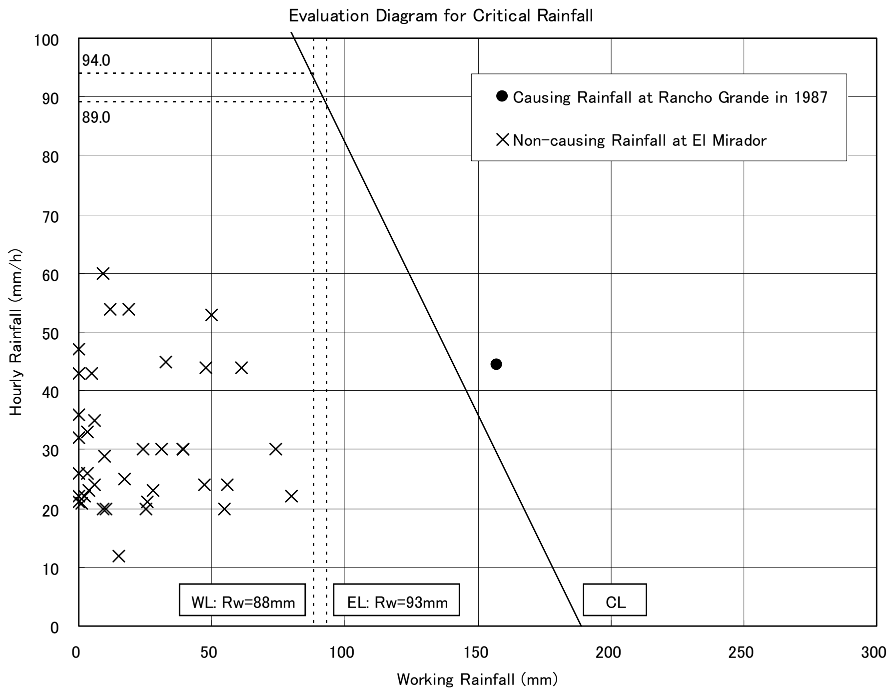
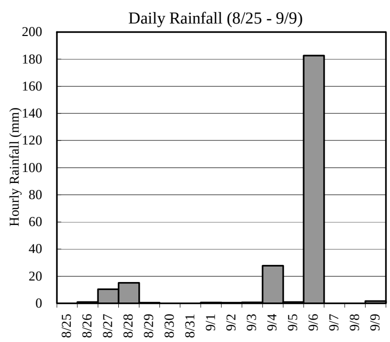


Figure S18-3.4.1 Warning Level and Evacuation Level of Limon River

Daily Rainfall Data

Date (1987)	Daily Rainfall (mm)	Event
8/25	0.0	
8/26	0.9	
8/27	10.4	
8/28	15.1	
8/29	0.4	
8/30	0.0	
8/31	0.0	
9/1	0.6	
9/2	0.5	
9/3	0.8	
9/4	27.7	
9/5	0.9	
9/6	182.7	Debris Flow
9/7	0.0	
9/8	0.0	
9/9	1.7	



Hourly Rainfall Data

Hour (1987.9.6)	Hourly Rainfall (mm)	Event
11:00	0.0	
12:00	13.0	
13:00	57.0	
14:00	23.0	
15:00	34.0	
16:00	44.5	Debris Flow
17:00	7.0	
18:00	3.0	
19:00	0.0	
20:00	0.0	
21:00	0.0	
22:00	0.0	
23:00	0.0	

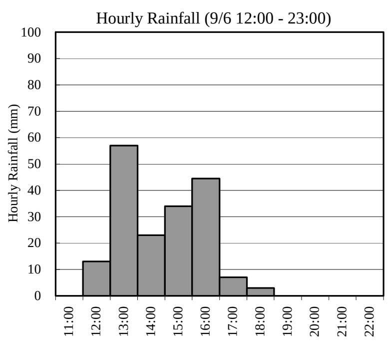


Figure S18-3.4.2 Rainfall Data and Hyetograph of Event on Sep.1987 at Rancho Grande

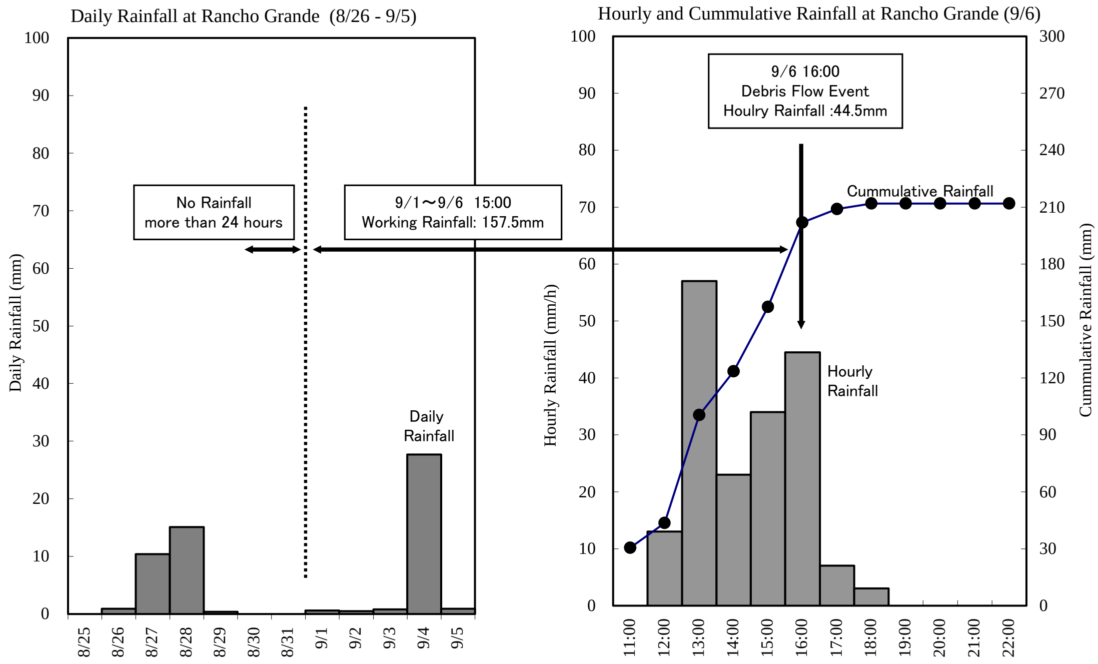


Figure S18-3.4.3 Concept for Working Rainfall of Event on Sep.1987

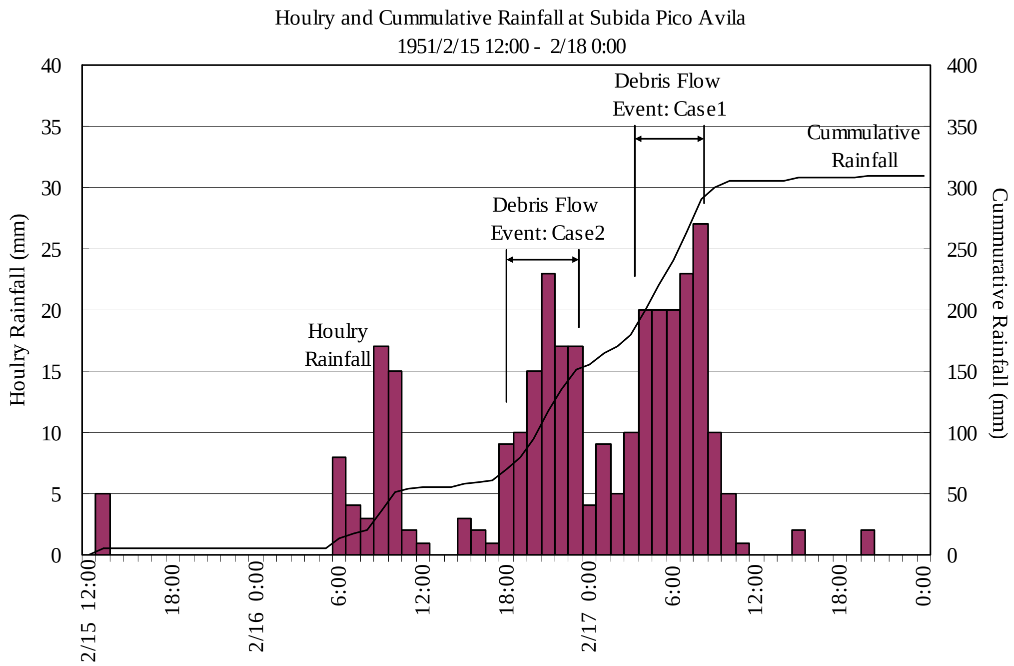


Figure S18-3.5.1 Hyetograph of Event on Feb.1951 at Subida Pico Avila

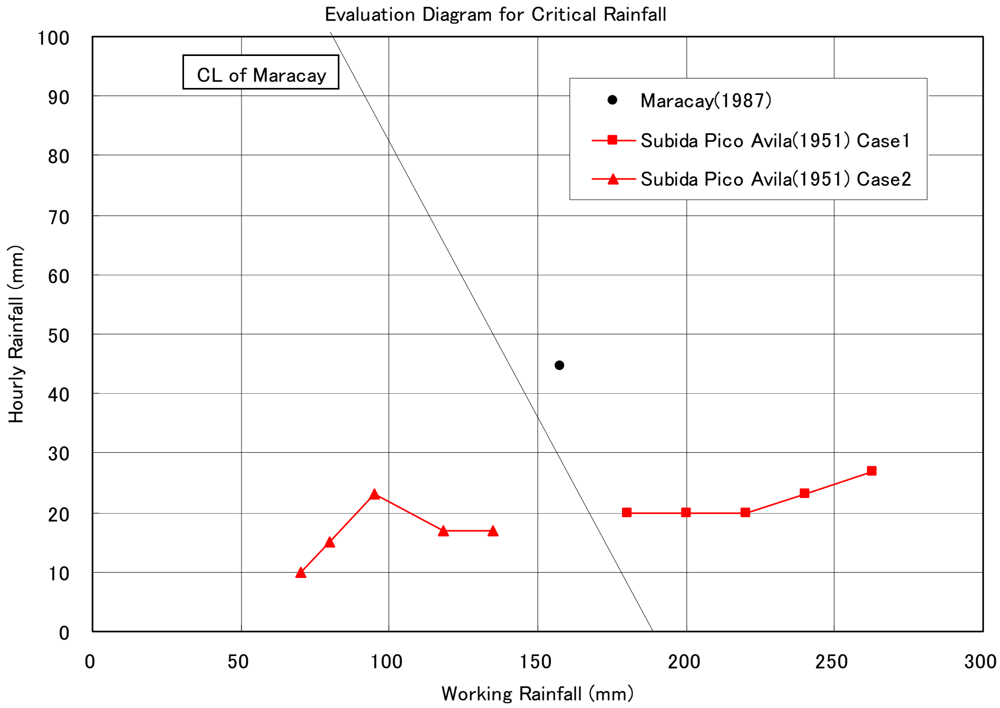


Figure S18-3.5.2 Plots of Event on Feb.1951 at Subida Pico Avila

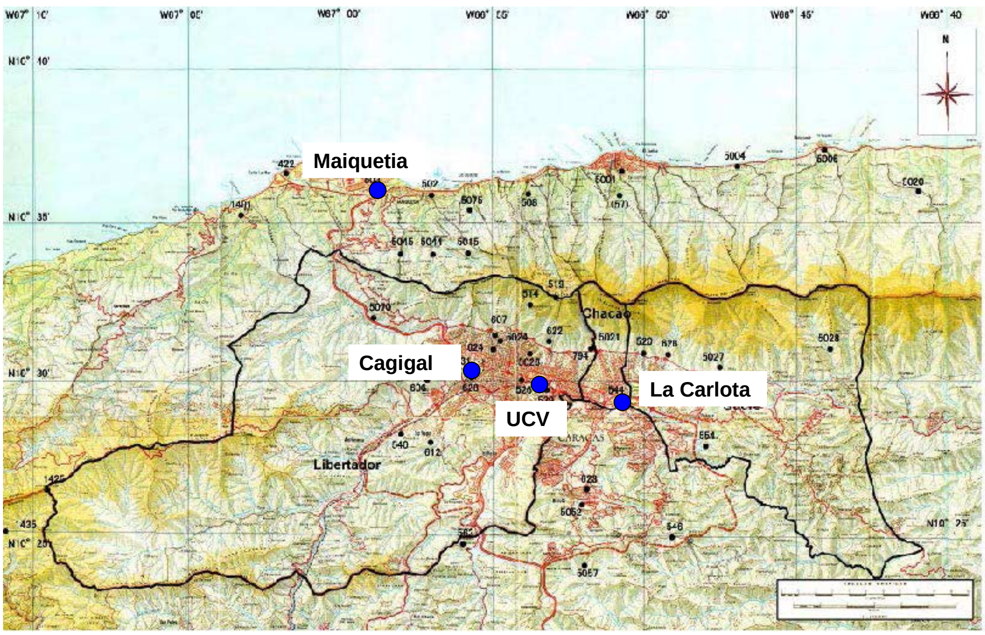


Figure S18-3.5.3 Availability of Rainfall Data on Dec.1999

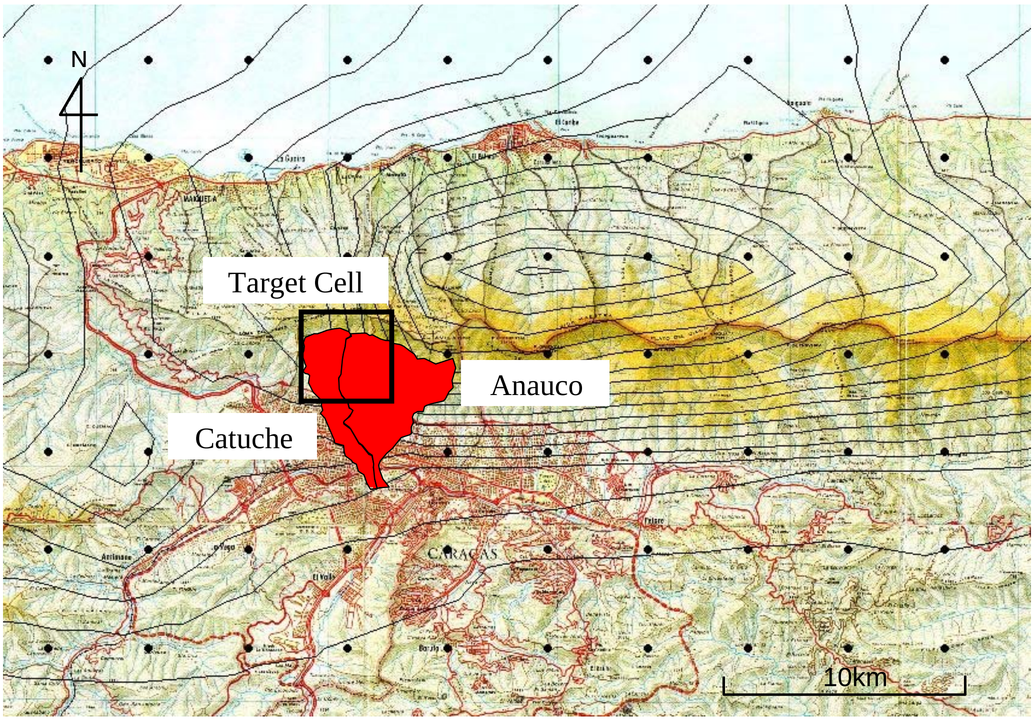


Figure S18-3.5.4 Target Cell of Calculation for Catuche and Anauco Catchment

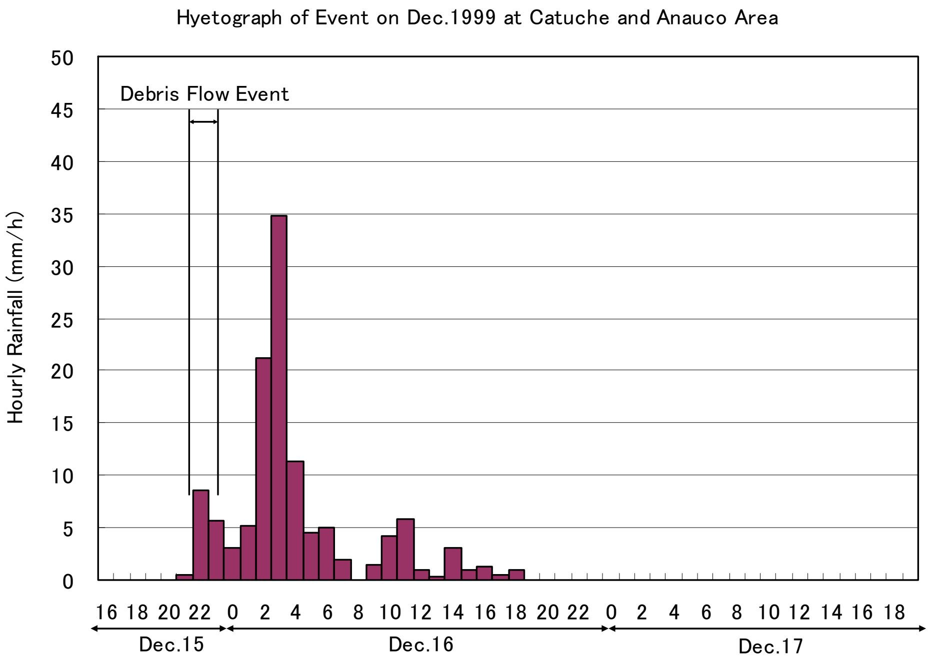


Figure S18-3.5.5 Hyetograph of Event on Dec.1999 at Catuche and Anauco Catchment

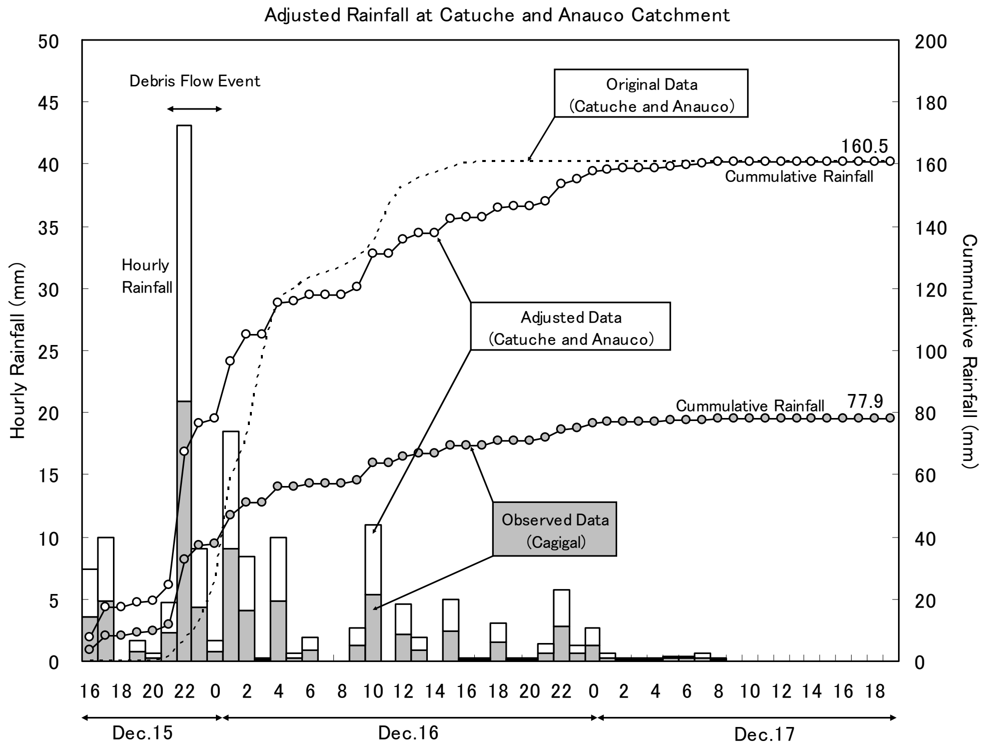


Figure S18-3.5.6 Adjusted Rainfall at Catuche and Anauco Catchment

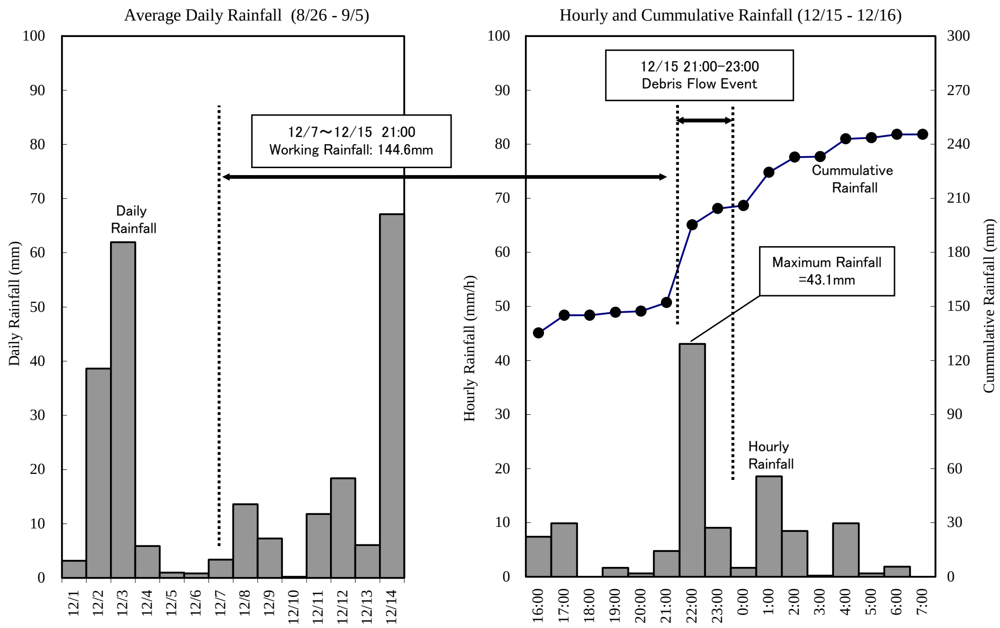


Figure S18-3.5.7 Concept for Working Rainfall of Event on Dec.1999

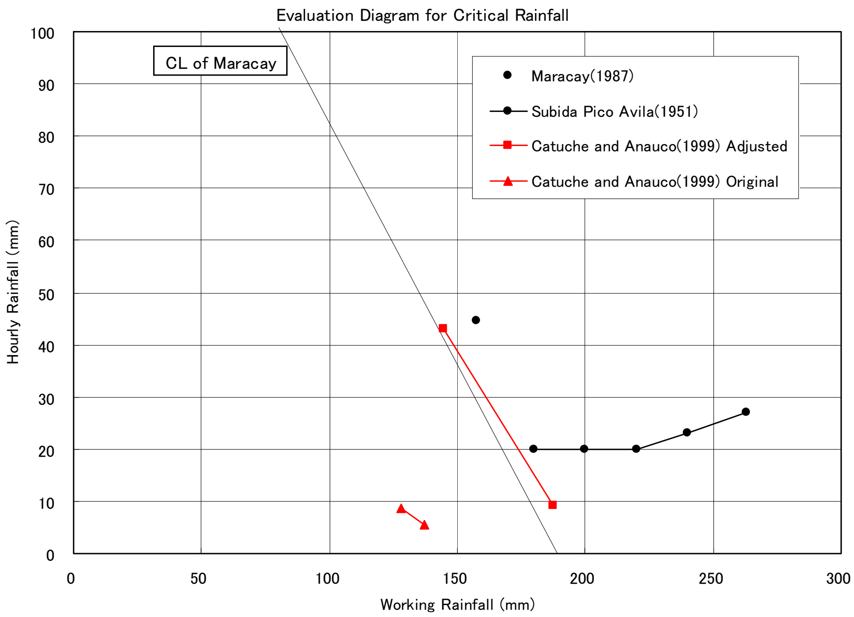


Figure S18-3.5.8 Plots of Event on Dec.1999 at Catuche and Anauco Catchment

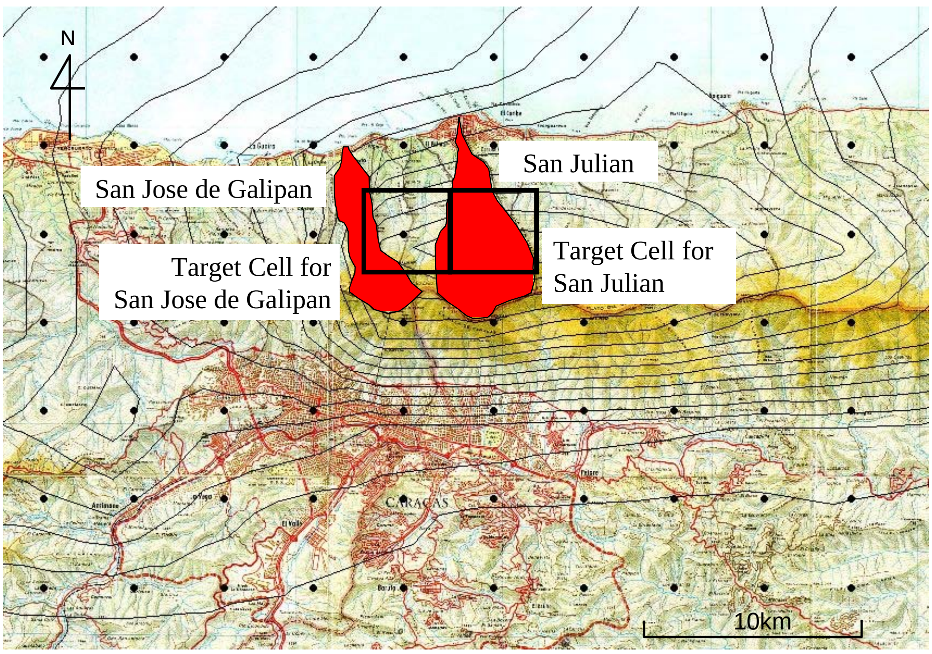


Figure S18-3.5.9 Target Cells for San Julian and San Jose de Galipan Catchment

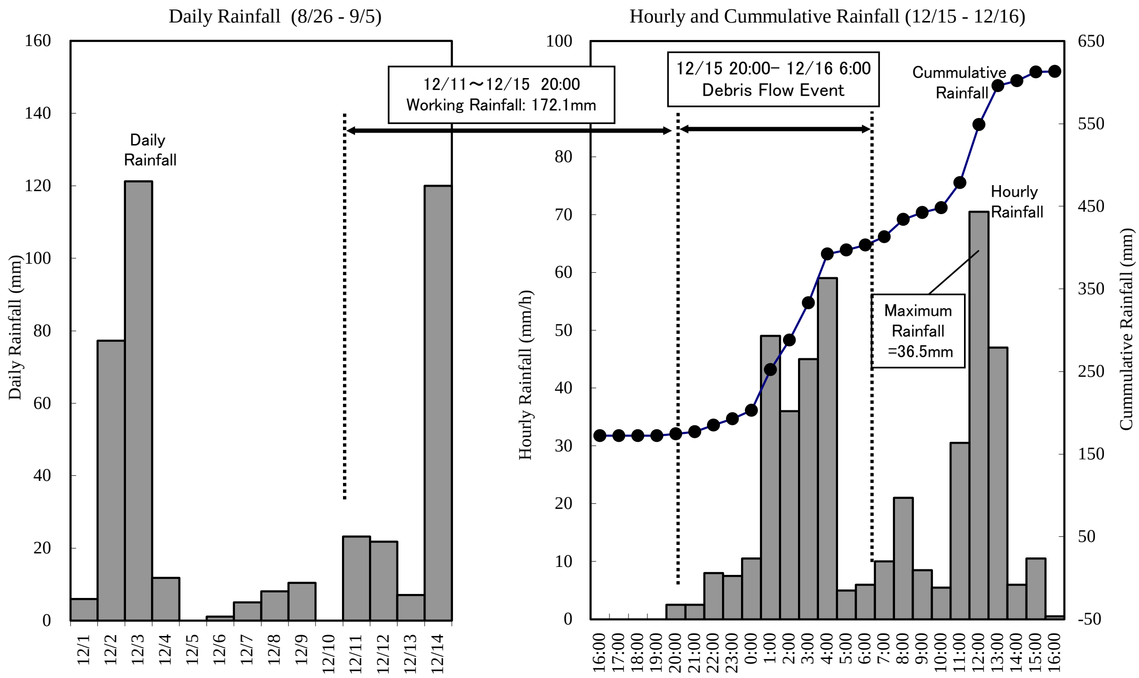


Figure S18-3.5.10 Rainfall Event on Dec.1999 at San Julian Catchment

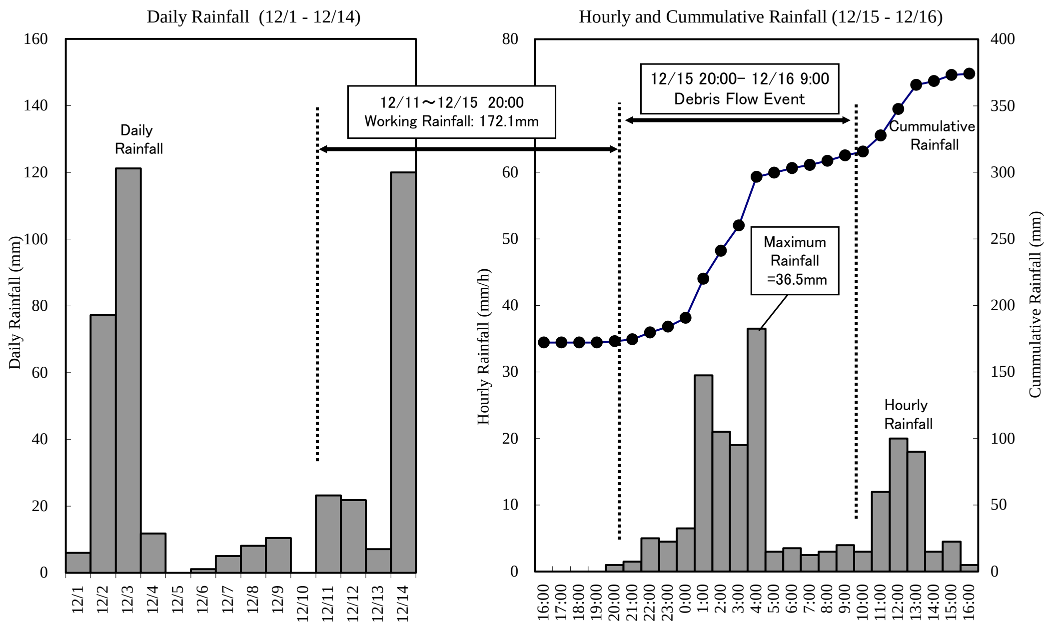


Figure S18-3.5.11 Rainfall Event on Dec.1999 at San Jose de Galipan Catchment

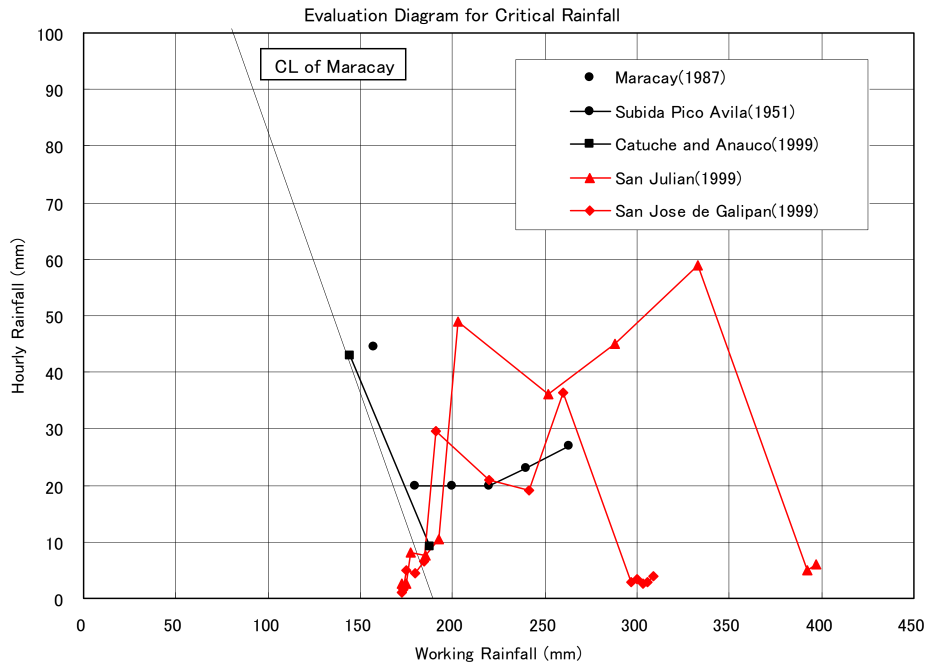


Figure S18-3.5.12 Plots of Event on Dec.1999 at San Julian and San Jose de Galipan Catchment

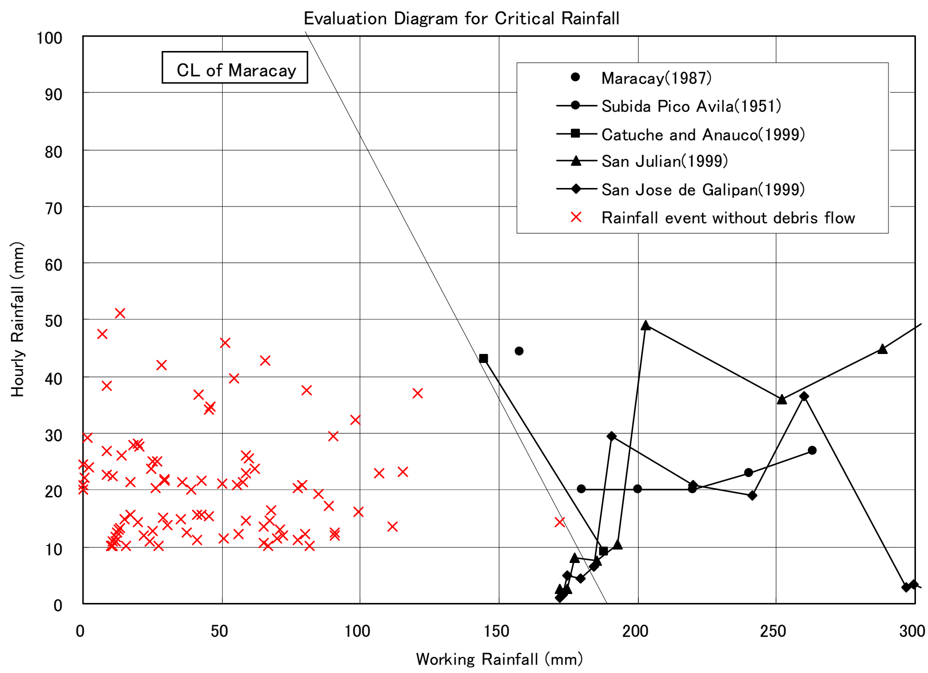


Figure S18-3.5.13 Plots of Non-causing Rainfall

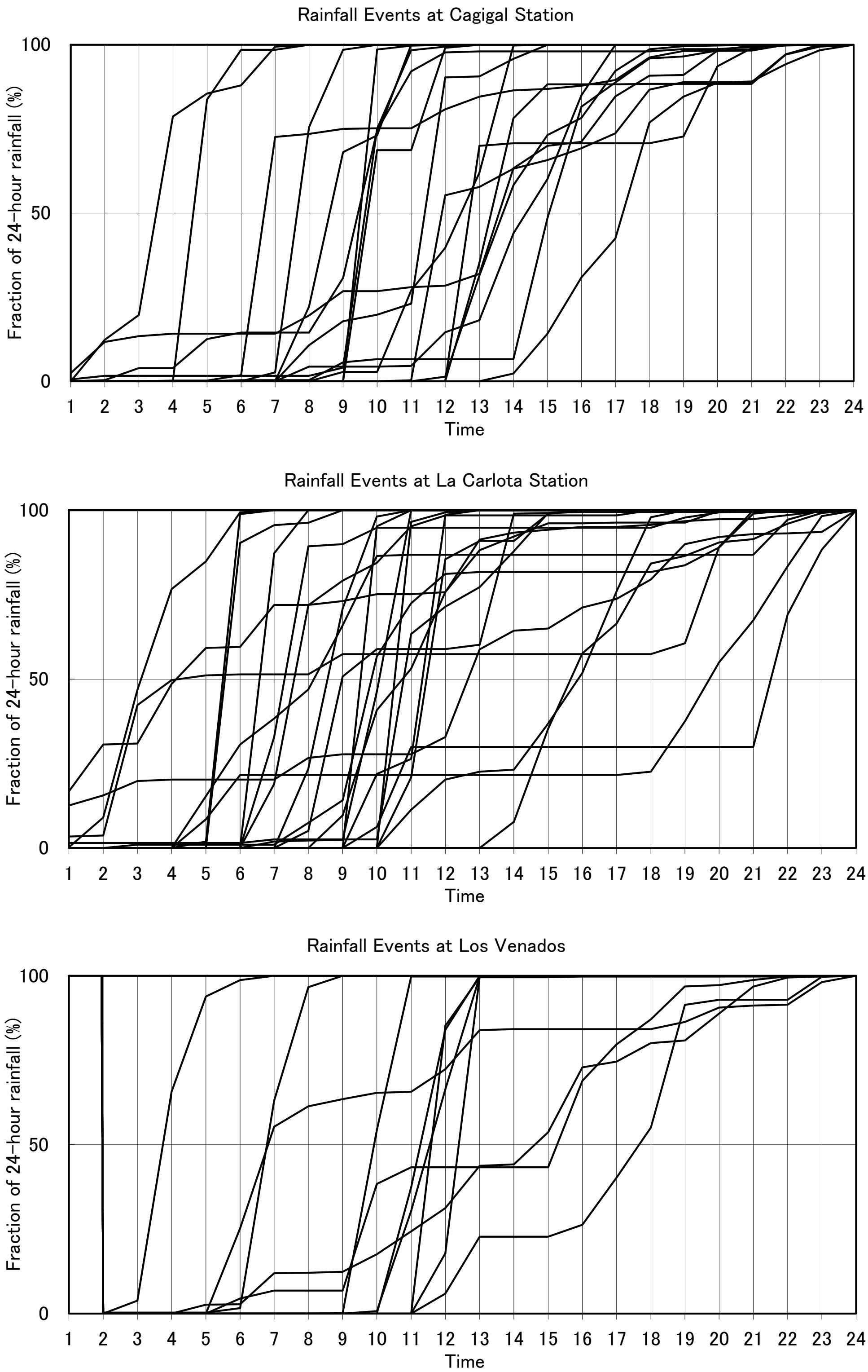


Figure S18-3.5.14 Hourly Rainfall Distribution in a Day

Comparison of Monthly Rainfall (mm)

Station	Duration	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
Rancho Grande	1940-1986	37.4	27.7	34.3	84.2	167.8	210.3	244.6	290.6	240.1	198.8	143.3	75.5	1754.6
Maiquetia	1950-1999	49.0	32.0	23.0	34.0	44.0	69.0	67.0	73.0	60.0	65.0	64.0	76.0	656.0
Cagigal	1938-1977	19.9	11.4	12.6	35.3	80.5	106.2	106.4	113.1	104.9	114.6	85.6	41.5	832.0
Los Venados	1994-2001	24.9	16.6	4.0	32.6	51.9	103.9	151.4	126.8	163.3	179.2	65.7	60.9	981.3
Hotel Humboldt	1960-1974	33.9	18.7	54.3	69.1	78.7	74.7	124.4	137.8	115.1	115.5	95.3	58.2	975.2

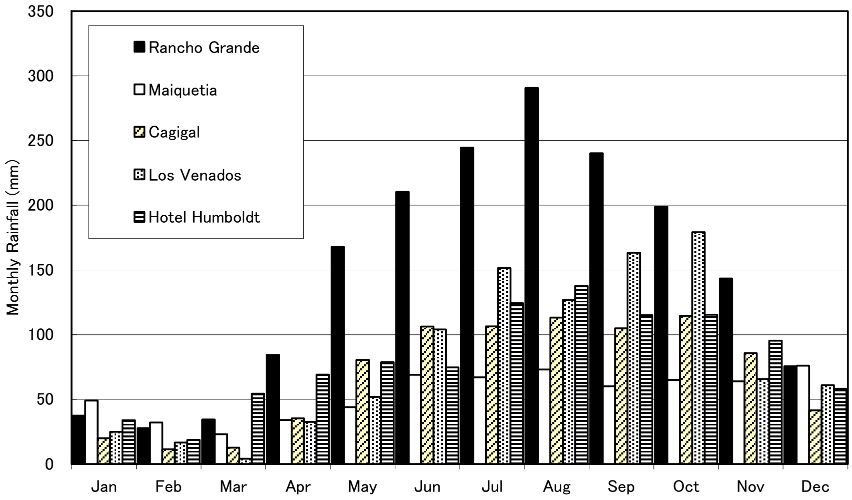


Figure S18-3.6.1 Comparison of Monthly Rainfall

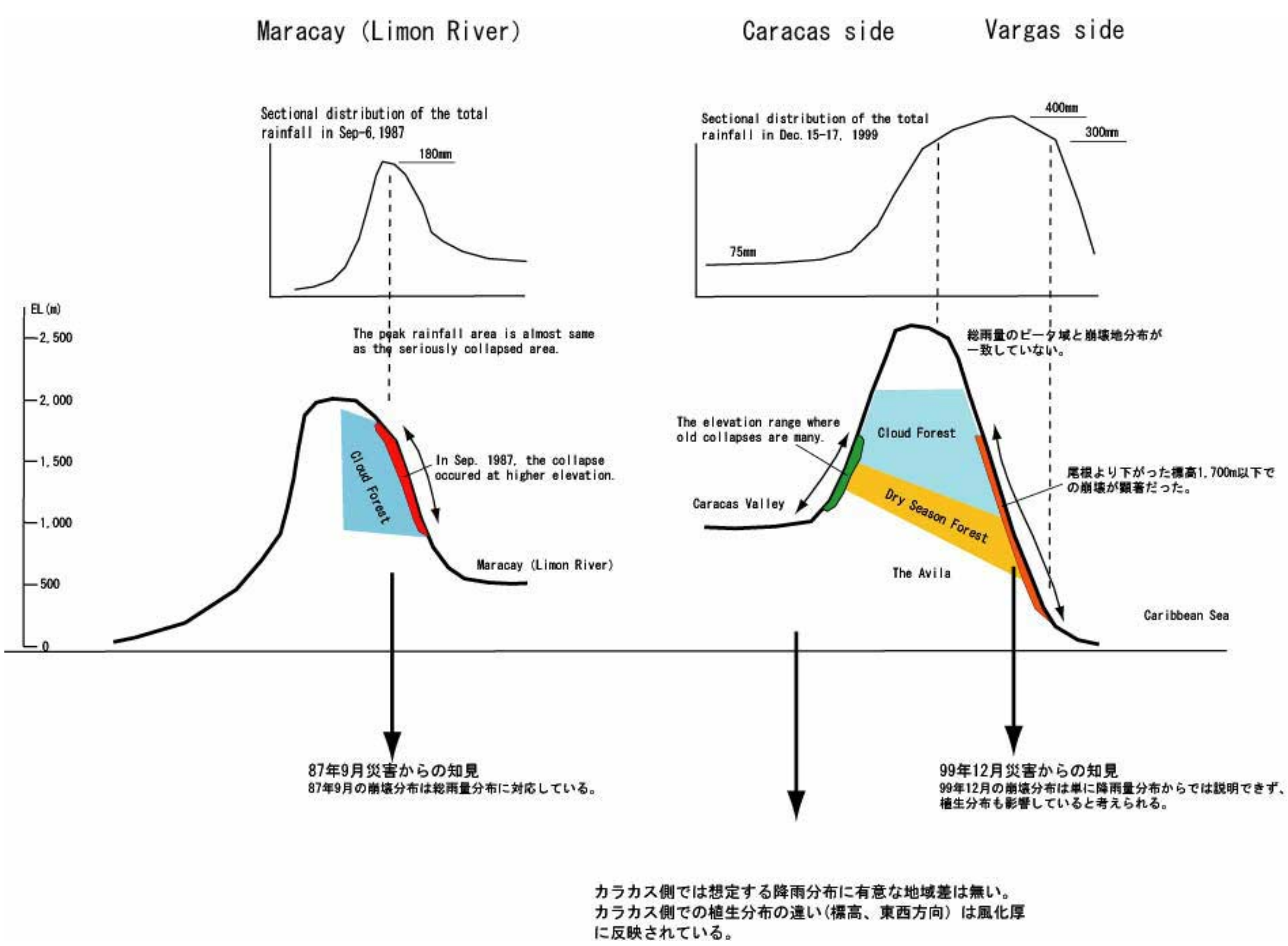


Figure S18-3.6.2 Findings on Slope Failure when Debris Flow Occurred in the 3 Areas

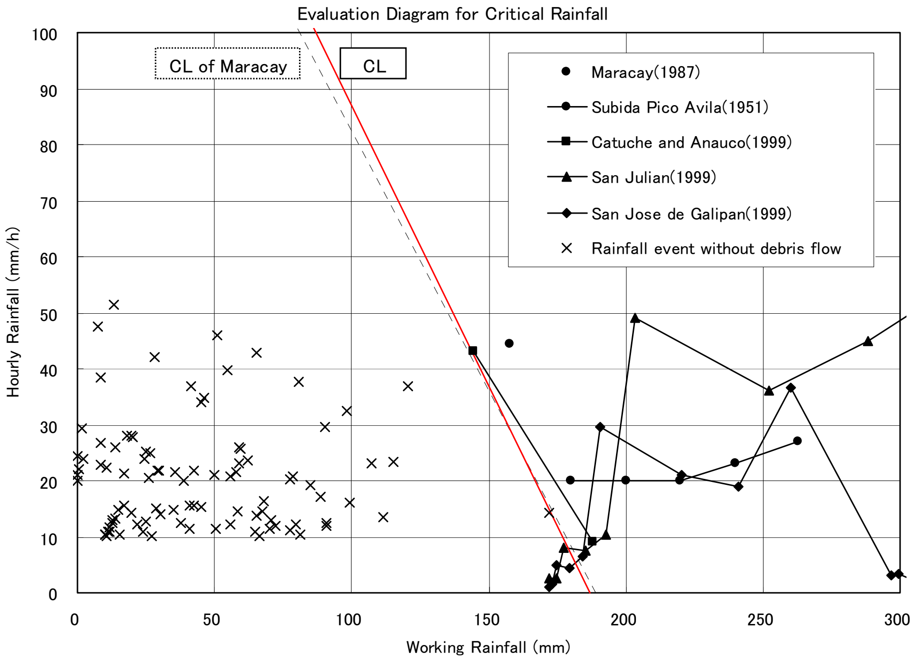


Figure S18-3.7.1　Drawing of Critical Line

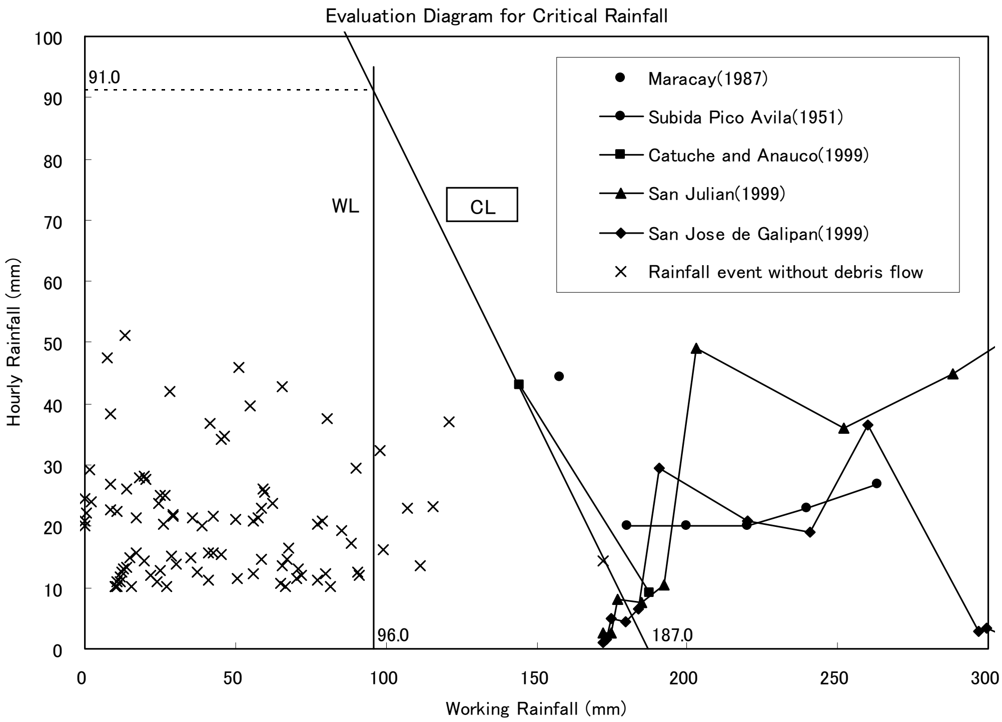


Figure S18-3.7.2　Setting of Critical Rainfall (Case1)

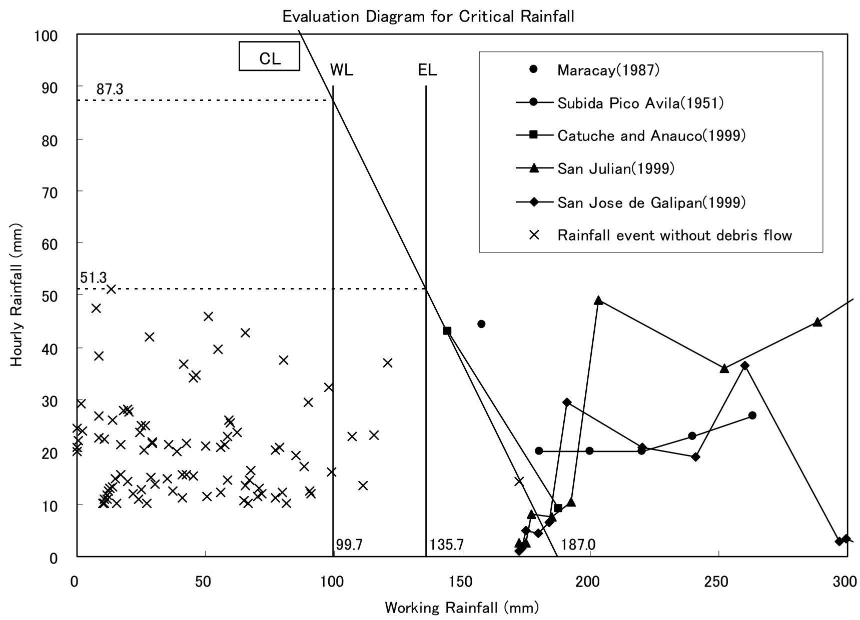


Figure S18-3.7.3 Setting of Critical Rainfall (Case2)

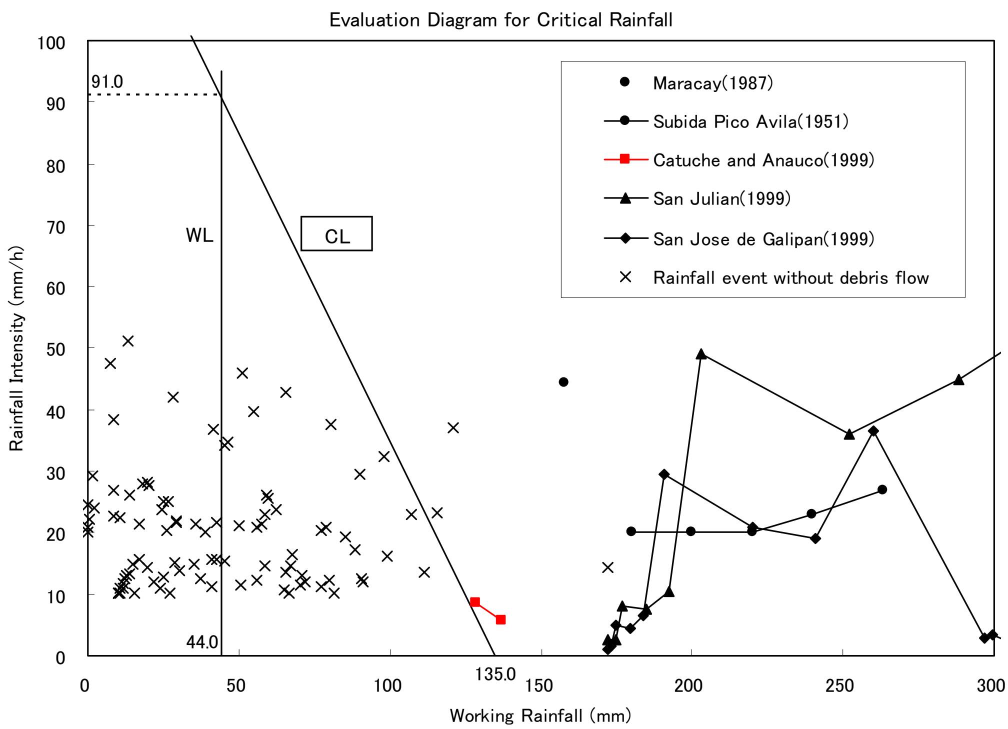


Figure S18-3.7.4 Variation of Critical Rainfall

CHAPTER 4. COMMUNITY-BASED EARLY WARNING SYSTEM

4. 1 Justification of Community – Based Early Warning System

Described already in former sections, scientific techniques for monitoring and forecasting meteorological phenomena are attractive tools to mitigate any damage resulting from likely floods, debris flows or landslide etc. For consistently certain early warning system for proper action, however, these sophisticated tools plays mighty functions only when accompanying with appropriate communication and information system which allow warning information to reach community in sufficient time with understandable message, and lead individuals to proper decision for preparation and evacuation. Therefore, it is crucial for technical and institutional agencies and policy makers to take into account how to transform scientific warning information to local warning message that can be interpreted by community people, and then, in which exact moment and to whom, to disseminate the local warning information to community in suitable way. An approach without recognition of above mentioned issues, looking at the subject only from own preferred view from scientific approach, from top to down and one-way communication won't be relevant to community-based early warming system.

In order to obtain a principle to address these issues, JCIA Study Team have considered bilateral approach as an important factor, namely bottom-up, which directly target diverse community and investigate viewpoints of varied communities such as its belief, opinion, idea, as external resource. And also, it is highlighted to work together *with* community toward common goal for adaptation of ideal community-based early warning system. For this reason, it is necessary to understand to what extend of existing community capacity, and even how to empower community furthermore. This would be vital role which drive to effective community-based early warning activities like proper interchanging with governmental agencies and disseminating warning information for preparedness or evacuation, and simple meteorological measurement as an local indicator of early warning system etc., in sustainable manner.

The above-mentioned details context is covered in the section of Social Surveys in the S 24, *the Pilot Study of Community-Based Early Warning System*, JICA Study Team, (forthcoming) which pursued applicability of early warning system from points of community. The whole process of the Pilot Study brought about an idea on significant role of strategy for promotion of this approach to fit into real situation of community by integrating governmental agencies and community in bilateral way.

4. 2 Strategy for Community-Based Early Warning Systems for Proper Action

In this section, strategies for effective early warning system for major larger groups of stakeholders, governmental agencies and community, which starts from participatory planning on that topic with community, are presented. The strategies are reflected all findings and results analyzed based on the case of pilot communities, Los Chorros, urban area and 12 de Octubre, Barrio area in which urban development characteristic of Metropolitan Caracas is highly considered.

4. 2.1. Introduction of Participatory Planning in a Topic of Community – Based Early Warning System

The method is based on group dissuasion, which is the most reasonable with simple manner to examine how to establish the most suitable community – based early warning system, firstly within community by focusing on effective information flow. That is, the main actors, community people are brought together on a same platform to discuss and reach common goal of a better decision on the topic with compromising sometime and adjusting by group dynamic. In addition, it is not only for keep the equity by encouragement of community participation, but also, the idea behind this methods is to encourage the community motivation and ownership in terms of sustainability on the topic.

In the participatory planning meeting, first of all, the concept of and expecting effectiveness of early warning system were explained as a prevention measurement for occurring disaster in the community. In addition, as basic risk information on related disasters, the alarm system, sediments concept, debris flow, land collapses, landslide, others also illustrated to community participants. Secondary, the participants were divided to two groups for the purpose of providing the global institutional framework to promote the discussion in the community. As the main topic of the discussion, early warning system, particularly at the moment of 1) Level 0 (normal)-Level 1 (Alarm), 2) Level 1 (Alarm)-Level 2 (Evacuation) among community regarding the process and channels for warning information were highlighted.

4. 2. 2. Results of the Participatory Planning of Early Warning System Proposed by JICA Study Team

As achievement of the workshop, constructive development of the participatory planning with community on the early warning system was completed as shown in Figure S18-4.2.1. In 12 de Octubre, community participants concluded that taking advantage of existing active community organization actors such as Sector Coordinators (12 persons), CTU (20) and Bolivarian Circle (5), these actors functions under neighborhood association which is considered as direct contact to Emergency Operation Center for effective warning information flow to each sectors (more than 20 sectors) at any level of warning for evacuation. On the other hand, in Los Chorros, as shown in Figure S18-4.2.2, from Level 0 (normal)-Level 1 (Alarm), community participants showed the availability of Internet and Web side of meteorological information site and give information to technical institution as local observation as well. In this community also, likely suggested center function of neighborhood association and sector coordinators under of that. Interesting point is that formation of "Community Technical Committee (5 persons)" was suggested by these participants from the necessity through the constructive meetings. The role of these technical members is considered with specific skills of early warning for evacuation. In addition in Level 1 (Alarm)-Level 2 (Evacuation) moment, the committee merged into neighborhood organization as disaster prevention committees to strengthen the capacity and against coming disaster (See Figure S18-4.2.3).

In addition to a finding in ethnography part of the social vulnerability survey that any community are not homogenous, it was proved dissimilarity of the characteristics among two communities, Barrio and urban during the participatory planning process. This is to say, it is ultimately important for all stakeholders related with disaster management from policy- makers till community people to take into account this aspect for better implementation of the proposed early warning system. Apparently, it indicates physical resource and demanded information are different among these different communities although both communities required simple local messages to receive and was willing to provide local information to governmental agenesis as well.

4. 2. 3. Strategy for Governmental Agencies - How to Penetrate Early Warning System in/with Community

There exist various physical and socio-cultural vulnerabilities, which are fundamentally determined by complicated urbanization development process in Metropolitan District of Caracas and factors to affect community during any kinds of disaster like debris flow and landslide etc proved in Vargas tragedy, 1999. However, cohesive community organization under appropriate monitoring occurring hazard conditions and response in community through reliable decision of evacuation by competent leadership proved that it was core body community-based early warning system (See the section of S24. *Social Vulnerability Study* and *A case study of successful experience of Social Risk Management,* JICA Study Team).

As a result of the Pilot Study, in order to work *with* community horizontally liked with for the early warning topic, following elements are discussed as strong points for applicable strategy in the sections. 1)*Socio-Anthological and Community Promoting/Facilitating approach* in which Intermediate Organization", (BL Consultant) played important role to get themselves dedicated to community as well as get community involved in by constructive approach. And then 2) *Community Organizational Empowerment*, and after that 3) Strengthening *Community-Based Early Warning System* and, as preparation, 4) *Monitoring Hazard Area* is also considered.

(1) Role of Intermediate Group

Through the Pilot study, the Intermediate Group (BL Consultants)'s contribution revealed mutual attitude encouraged to construct link with community and governmental agencies or others, and improved interrelationship among then as well as strengthening and enlarging capacity of community as well. In other wards, the Intermediate Group brought interesting aspects of own contributions to constructive mutual trust and interrelationship within community and brought up to community voice to municipality.

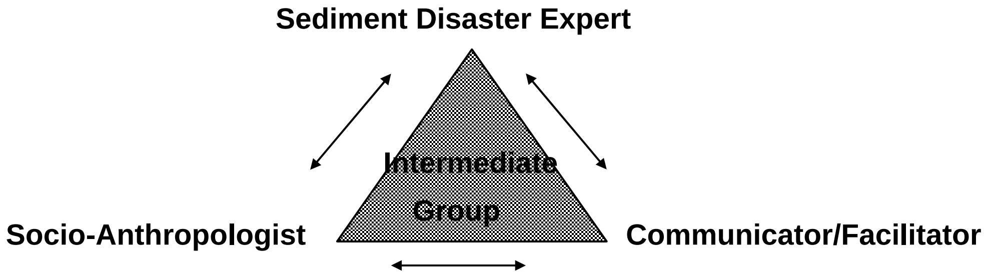
1) Contribution of the Intermediate Group and its specific skills

Intermediate Group enabled to:

- get into community and also accepted by the community, and then introduced the community newly the topic, early warning system and encouraged and motivated community to constantly work sharing with common goal, early warning system. ⇔ **Communication Skills**
- bring interactive group dynamic within the community and through constructive workshop and meetings like new digging up hidden leaders were shown up ⇔ **Facilitation Skills**
- make link and connection between community and PC municipality, other agencies. ⇔ **Negotiation Skills**
- stimulate consolidation of community by integrated existing community resources ⇔ **Community Promotion Skills**
- conduct mutual stakeholder analysis on the topic ⇔ **Mutual Position as a Outsider**

2) Structure of the Intermediate Group Members

The intermediate group was composed of, Socio-Anthropologist, Facilitator/Communicator as on disaster training. This type of grouping of soft side specialists contributed to good communication and community empowerment, however, in terms of early warning system for sediment disaster, it was proved in the Pilot study that the most concern for community was real and possible risk, hazard information and vulnerable own environment after all.



The above figure show effectiveness of "Triangulation" which is results of the Pilot Study. It means if 3 different actors come together and they have something share, which become powerful and trustworthy than being single thinking, and besides, if the 3 different actors with knowledge in different field were group, it is reasonably confidential and powerful for impartiality. Therefore, this approach strengthens integration of technical part, which is familiar with natural phenomena and social parts, which is familiar with human system to meet community needs.

3) Mutual Position but Wearing Two Hats

(Intermediate Group Members – some are from Governmental agencies: Fire Fighters, PC municipality etc)

As already mentioned, the Intermediate Group members need to be professionally enough to be mutual avoiding political bias to any kind of community since there exist deeply no routed influenced by political party or distrust for these governmental agencies based on complicated factors.

But also, wearing two hats are effective since the group members could commit continuous work and following up support like the constrictive participatory work after they go back to official work. Even more, the techniques are acquired by the Pilot Study will have potential to share among related agencies as well.

4) How to Promote the Intermediate Group

- Defining basic formation format of the general Intermediate Group and common agreement
- Discussion and secure the budget for work with Intermediate Group
- Registration of the Intermediate Group and examination of the validity specified in law.
- Announce community the effectiveness of Intermediate Group

- Periodical Interactive course to improve the quality of the techniques of Intermediate group among themselves and even with other technical volunteers,
- It is assumed that the main role of the promoter of Intermediate Group corroboration and its coordination would be appropriate by Civil Protection according to Law. However, there is still needs to be discussed like which level of Civil Protection would be in charge.

(2) Community Organization

As strategy for governmental agencies, JICA Study Team consider two aspects 1) Community Organization, 2) Leadership the most powerful factors to be address at the first stage, which include potential for improvement of better community – based early warning system

Very simple flow chart in Figure S18-4.2.4 shows, an approach, which is *the process for empower community organization*. The point is if you would like to work with community for empowerment of community organization, just not giving training course for certain period to community, which dose never match community needs, rather need to corroborating work with active participation of community actors in the process of design, planning, implementing, monitoring and evaluation. Therefore, the role of Intermediate Group become so important to built *partnership* with community and other stakeholders in bottom –up approach.

The right part in the flow chart in Figure S18-4.2.4 indicates that degree of social vulnerability is pretty large in terms of level of organized community. However, by following the flow chart, suitable methods can be applied these less organized communities with special attention and time by corroboration of Civil Protection and Intermediate Group. In addition, it is vital to keep community interest and participation in the community empowerment process.

In sum, achieving this integration, the following activities are proposed:

- Civil protection and municipality are in charge of the empowerment of community organization and proceed the mentioned activities with community, for example, participatory making community census, risk and vulnerability map, Disaster Imagination Game (DIG: a participatory disaster prevention tool, referring the section of S24 for the methodology and details) community disaster prevention plan in corroborating way.
- The minimum duration for empowerment process of community organization shall estimate three months duration although this is totally depending on to the certain extend of community capacity and scale of the organization. As a matter of course, the organization of community is not final goal, but the first entrance to next community activities such as community – based early warning system.

- It can estimate totally more than two year project for community-early warning system including starting from community organization, and capacitating for the early warning system and monitoring by targeted a community with about 25 members more or less considering gender balance, scheduling, community availability etc.

(3) Strengthening of the Early Warning System

In order to establish and maintain community-based early warning system, it is interesting to keep in mind the term " system", which is holistic organization and functions as framework of the target, early warning issue. For the system function in early warning, it requires process a framework of information flow and decision making that enable technical warning information from certain governmental institution to be transformed into risk reduction for preparation or evacuation at community level. The efficient information flow through the organizational structures is vital to well - informed to activate warning information at exact time.

For examination of information flow, community organization structure and networking system are necessary to be inquired. The examination of these fundamental factors is more effective to be followed up after community organization work. This is because individual community is diverse and possesses different characteristics of development process, and even physical and human resources as well. In this context, a method of *Participatory Planning and Action*, which was already explained earlier, is useful tool to cover these aspects and reach participatory planning on early warning system, which was constructed idea by community. The details of the results are referred in the section of S24. In this section, summary of the findings are presented practically as a source of strategy for adaptation of community –based early warning system (See Table S18-4.2.1).

(4) Monitoring and Evaluation of Hazard Area- To Integrate Local Management Plan

For effective early warning system and its preparedness, daily local risk monitoring and evaluation are of great importance, which enable to mitigate any risk and vulnerability before any occurrence of ant disaster.

Therefore, for related policy-maker and related governmental agencies need to take into account integrated following issues as local management plan.

1) Daily Local Condition of Monitoring and Evaluation System

Preliminary Stakeholders	Civil Protection, Municipality and Community
Activities	Daily Monitoring and Evaluation of local condition
(PC Municipality) (Community)	To inspect gulches land collapse, risky (PC Municipality) To observe subtle change own community by rain or hurricane etc. To apply rapid low cost and handy metrological observation, if community like
Secondary Stakeholders	Civil Protection, ADMC (Emergency Operation Center)
	Information Operation
The third Stakeholders	Related agencies: FUNVISIS, MARN, Fundacome and ADMC
Activities	Technical Cooperation and Investigation in depth

2) Environmental Monitoring of Garbage Dump and Waste Disposables

In order to maintain the gulches and other waterbeds clear of rubbish and sediments, it is also of great importance to promote monitoring of environment.

Preliminary Stakeholders	Community
Activities	Daily Monitoring of Clean Environment without Waste Disposals
(Community)	To learn and diffuse that no waste disposals reduce over flow of flooding and other risk To maintain waterbed without waste disposals- community organization activity like picking up waste disposals free walk.
Secondary Stakeholders	Civil Protection, Municipality
Activity	Raising Awareness Campaign -Cleaning Competition Environmental Education

4. 2. 4. Strategy for Community- How to Act in Early Warning Moment as Own Community

In this section, briefly mentioning about manual for community-based early warning and preparedness, which was produced for community to use for emergency, particularly sediment disaster based on all analyses and findings of the pilot study. JICA Study Team is confident of the effectiveness and contribution of the manual for particularly community. All stakeholders are recommended to have a look it to get idea what community likes to have.

The manual is specially paid attention to and unique in following points

- No more general description like only first aid or pamphlet, which are already common, but practically useful
- Participatory questions, by using, reader check own risk and vulnerable condition and then approximately can learn preparedness which can be done within household, community
- Using data results form targeted community, so the community people feel it is own property, which encourage community participation etc.

- Handy and good appearance
- Understandable for any level of community, easy words to understand but very meaningful

4. 3 Conclusions and Recommendations

As the strategy of community-based early warning system, it is dared to note importance of community participation, which enlarge ownership of the process and enable to address the real issue and core problems for community. This approach is attribute to several experiences that early warning system won't function much if community people are considered as passive subjects who just only receive warning information regardless they are active and main actors to take final decision for preparation and evacuation in deed.

By leaning from experience, community people are centered in this strategy proposed JICA Study Team, and actually Pilot communities in both urban and Barrio area proved that these communities got nicely involved in process of planning, designing, implementing, monitoring and evaluation in participatory early warning planning on community –base early warning system supported by facilitation of intermediate group. Therefore, based on the strategy presented in this section, related and responsible agencies need to take a step forward to, 1) having common platform to bring all issues among stakeholder (any level) and 2) define division of duty, and 3) implementation of all strategies, 4) Evaluation for their improvement.

In the end, it is recommended to governmental agencies and community about specific topic through the Pilot Study. To governmental agencies, they need to recognize the importance of *friendly Access and Availability of Information and Resources for anybody* and to put it into practice. Community needs to know how to get access to useful information, in which organization have such kinds of information, data, and cooperation service, support programs and even donation etc. In short, any kinds of excellent planning and programs won't be meaningful if these attempts don't equitably reach community and if they could not learn from the program.

On the other hands, to community, improvement of "Communication and Negotiation Skills" is key reach better information for improvement of the current condition, which drives governmental agencies to move on to tale care. Regarding a topic of early warning system, in order to get information of disaster prevention activities, community also initiatively take action for better opportunity for corroboration with governmental agencies.

Table S18-4.2.1 Findings for Strengthening of the Early Warning System

	Features	Common	UNIQUE (TO BE CONSIDERATION)	
			Urban	**Barrios**
1	**Warning Information**	**Current:** No information		
2	**Local message**	**Expectation**: Simple and Understandable message (Color to indicate dangerous level and timing for evacuation etc.		
3	**Source of Warning Information**	**TV, Phone, Radio**	Web Internet, E-mail, Communication (preparation stage)	Accurate and Timely Indication for Evacuation from Civil Protection, Municipality/Emergency Operation Center (if we have)
4	**Contact Institutions**	**Expectation Often**	MARN through Internet PC municipality	PC Municipality
5	**Timely decision - maker**	**1) Representative of Neighbor Association (supported by technical committee)**		
6	**Two-Way Communication**	**Institution-Community (Neighbor Association)**	Expectation Technical Committee	Expectation (Technical Committee)
7	**Information Channels and Preparations**	**Before Participatory Panning :** No		
	After Participatory Panning	List of information channels Evacuation and Resource Map		
Applicability of Simple Metrological Measurement of Local Condition initiated by Community (one of idea)				
	Governmental Support	Participatory and Practical Training and Instruction Regularly	PC	PC
	Community Responsibility	Neighbor Association	Technical Committee To consider individual Community Condition	Technical Committee

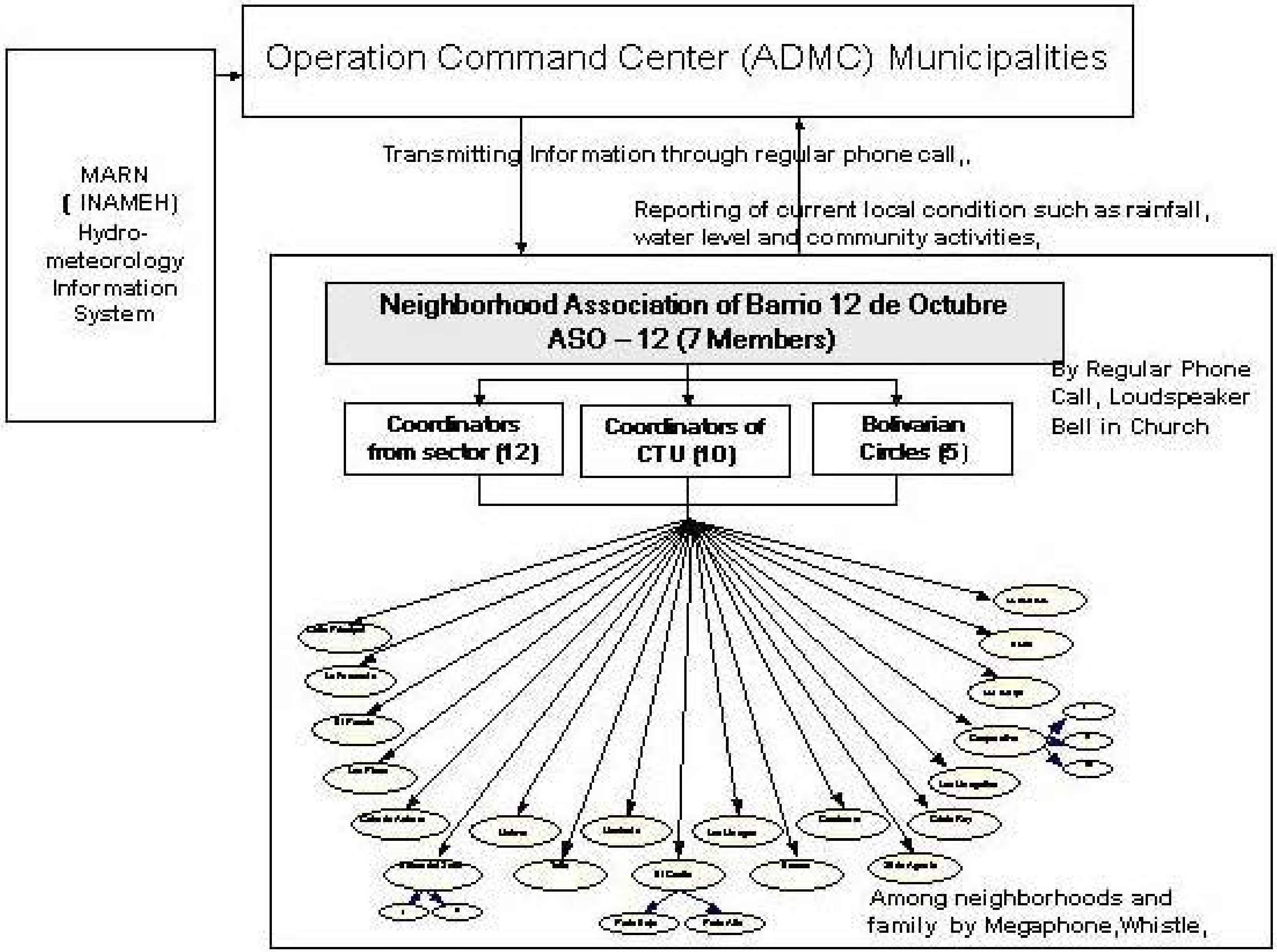


Figure S18-4.2.1 Proposal of Modification of Early Warning System at Level 1 and Level 2 in 12 de Octubre

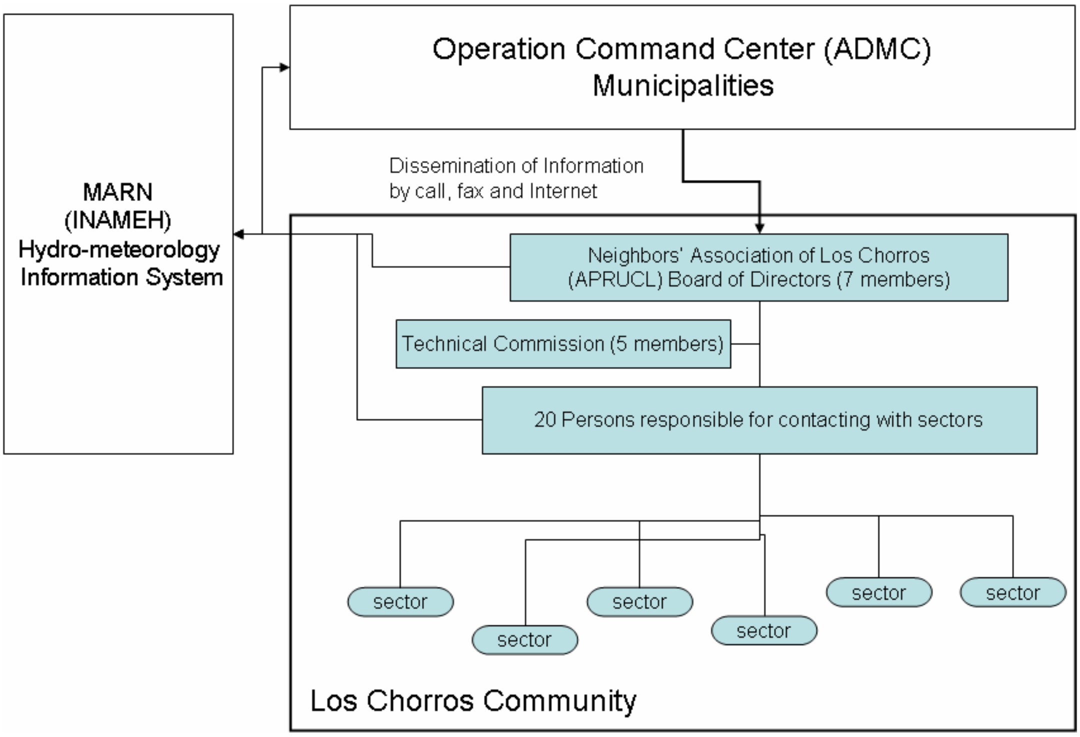


Figure S18-4.2.2 Proposal of Modification of Early Warning System in Level-1 in Los Chorros Community

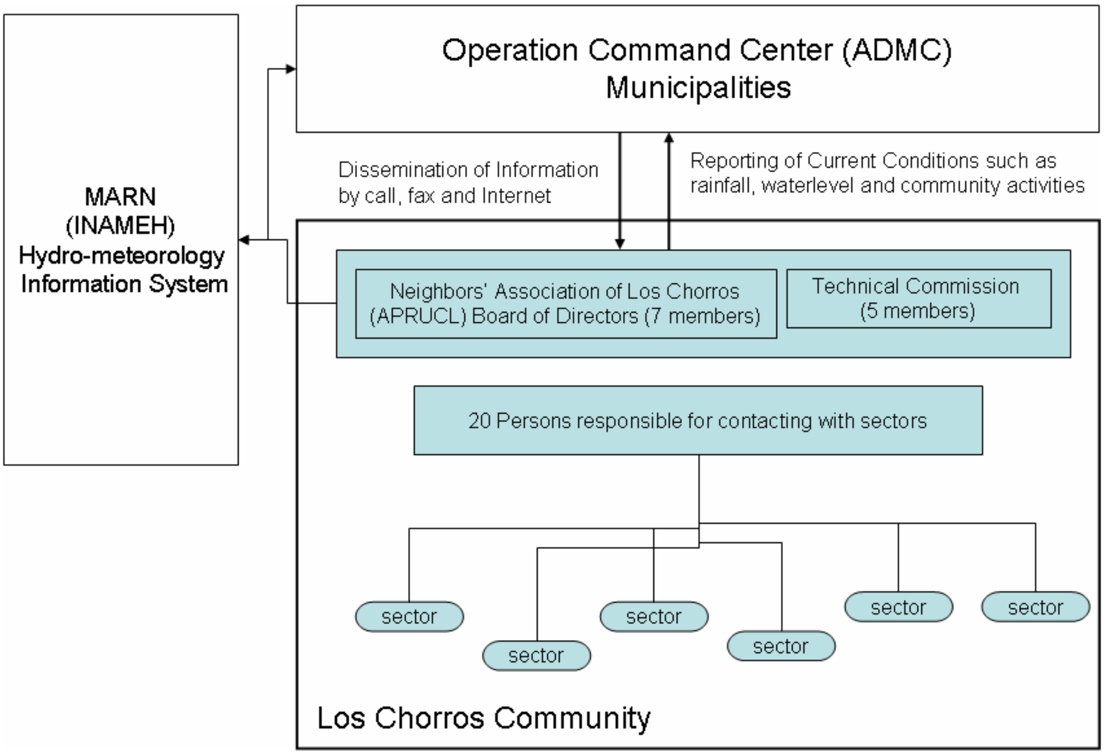


Figure S18-4.2.3 Proposal of Modification of Early Warning System at Level-2 in Los Chorros Community

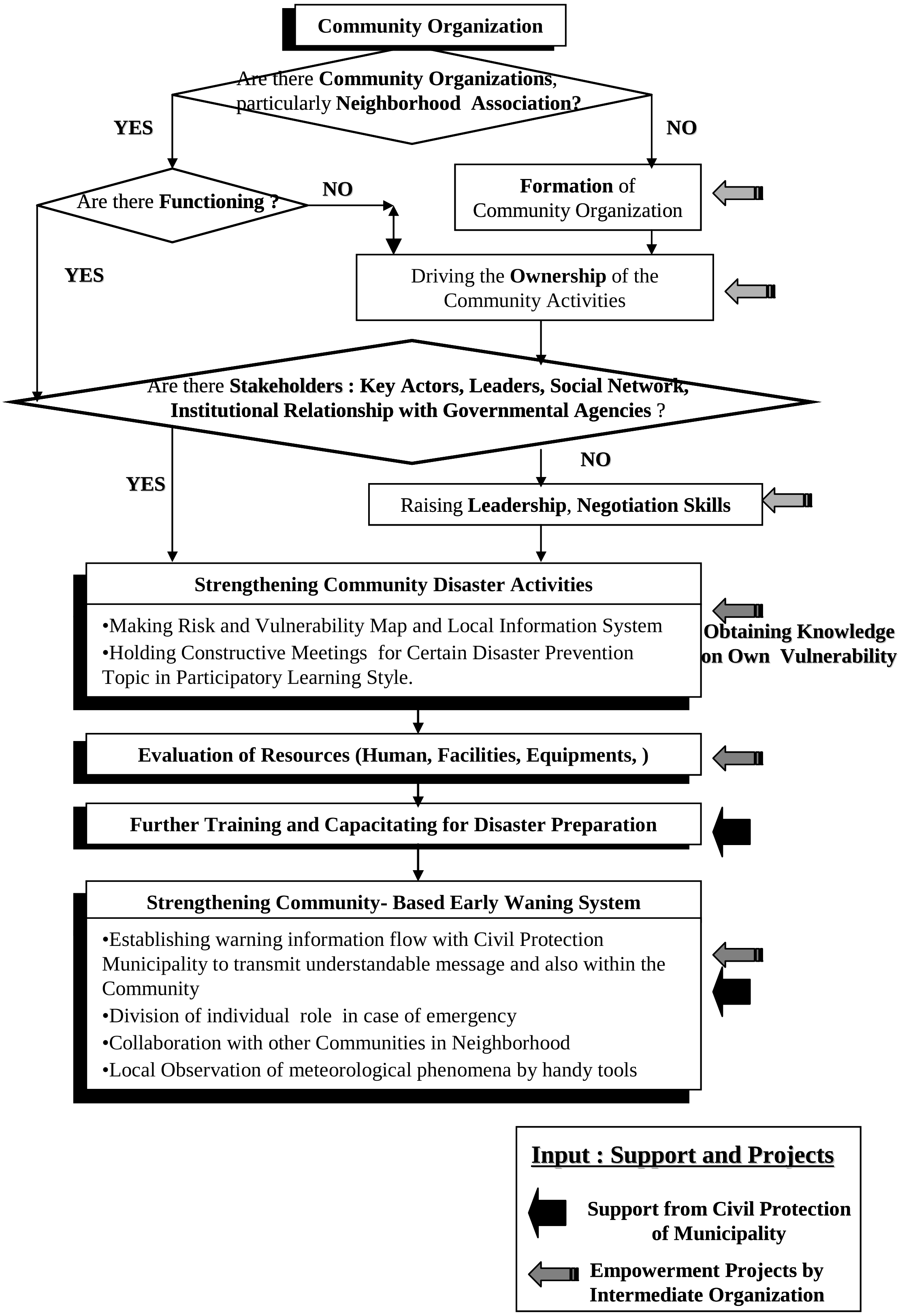


Figure S18-4.2.4 Development Program of Community-Based Early Warning System

S19

GIS SYSTEM DESIGN/DATA BASE

"Yes, we love Caracas, where we live.

Everybody, now let's make Caracas safer hand in hand"

Toshiaki Kudo

STUDY ON
DISASTER PREVENTION BASIC PLAN
IN THE METROPOLITAN DISTRICT OF CARACAS

FINAL REPORT

SUPPORTING REPORT

S19

GIS SYSTEM DESIGN/DATA BASE

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S19 GIS SYSTEM DESIGN/DATA BASE

CHAPTER 1. GEOGRAPHICAL INFORMATION SYSTEM (GIS) AND DATABASE SYSTEM

1. 1 Introduction

Geographic Information System (GIS) is the important tool to capture, store, analyze and present geographical and non geographical information. In fact, the use of this system has been increased in recent year and it has been extremely popular in almost all of the fields of applications. A proper design of database and GIS is vital for the success of the project as well as for the continuity of its use. The main objective of making the standardized GIS and database is to develop uniform GIS data sets and processes to facilitate the sharing of data and develop automated processes in future.

Viewing this importance of having proper GIS and database system in place, the JICA study team prepared and presented the GIS and database standard to the counterpart teams. The study team and counterpart team discussed and analyzed these standards to develop the common standard for receiving, storing and exchanging GIS and other attribute data. Although the study team presented GIS standards which are universal in nature, it has made the use of the existing Venezuelan standards and norms in the course of the study period when they are available.

The study team has visited a large number of institutions in the metropolitan district of Caracas to know the current choice and use of GIS and database by these institutions. Although, many useful GIS layers and database for the study purpose has been collected and prepared by the study team, the counterpart team should continue this collection process.

On the other hand, the study team has recompiled and prepared a large number of GIS maps and database for the study purpose. A base map in GIS format has been prepared in the scale of 1:25,000 and working map has been prepared in the scale of 1:5,000 for the urbanized area. Some parts of study area also have the working map in the scale of 1:1000. Digital image processing of satellite images (Aster and Landsat) has been carried out for getting the regional view of the study area. Aerial photographs in some parts of study area were orthorectified for the digital interpretation and overlaying with the existing maps. Many GIS analysis have been done to create new layers. Digitization of paper map has been also carried out.

Database development has been done for population data and building inventory data based on census of 2001. Also database analysis has been carried out to develop physical and social vulnerabilities. Finally, the analysis of damage scenarios and damage estimation has been integrated to the GIS system.

1. 2 GIS System Design

The study team has prepared a basic GIS standard, data format, system platform to be used in the project. Based on the discussion with the counterpart team, these standards were finalized on the following aspects.

- System platform,
- Units of measure,
- Datums,
- Map projections,
- Terminology,
- Cross-platform data translation processes
- Available data sets
- Symbol sets,
- Data storage and naming convention

1. 3 Database System Design

1. 3. 1. Design, Structuring of Database System

The database design and structuring was based on the following principles.

- 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.

1. 3. 2. Conceptual Database Design

The conceptual database design was prepared based on the discussion with the study team experts. Initial processes and flow diagram has been modified to accommodate the detail analysis process. The database thus produced was eventually linked with the thematic maps.

1. 4 GIS System Developments

The collected data were converted to GIS system using the standard GIS design developed for the project. Following processes were applied to the data received from different institutions.

(1) The paper format maps were screen digitized by scanning and georeferencing the scanned images.

(2) All the digital maps received in CAD formats were checked and edited for respective topology and converted to GIS format topological models. Additionally, they were converted to La Canoa coordinate system by using the coordinate conversion routine developed by JICA Study Team.

(3) The received GIS format maps were checked for the topology and attribute accuracy as well as relevance. The coordinate conversion was done when applicable.

1. 4. 1. Base Map Preparation

The JICA Study Team uses the topographic map of 1994, scale 1:25000 developed by IGVSB as its base map for the study. Additionally working topographic maps in scale 1:5000 and scale 1:1000 (year 2000) are being used for the detail analysis. The working topographic map in scale 1:5000 covers the urbanized area of ADMC.

(1) Base map of Scale 1:25000

A base map in the scale of 1:25000 in CAD format is purchased from IGVSB. The base map is being used for the preparation of all the relevant maps. This base map is obtained from IGVSB in La Canoa coordinate system.

This base map is already converted to GIS format and GIS compatible layers with attribute data. These layers has been edited and updated in the course of study period depending on the availability of the recent and more precise scale map and other information.

Table S 19-1.4.1 shows the list of the GIS layers created from the base map.

Base Maps were also prepared in AutoCAD format for interchange of the data (some of the Government Institutions did not have GIS software so they could not use GIS format to use this base map). Also, the base map is reprojected to Loma Quintana coordinate system for the purpose of interchange of data.

(2) Working map of Scale 1:5000 and 1:1000

For the urbanized area, a working map of 1:5000 scale is obtained from Hidrocapital. Similarly working map of 1:1000 scale is obtained from Municipality of Sucre. These maps were originally in Loma Quintana system and were reprojected to La Canoa system using standard conversion routine developed by the study team.

Scanned topographic maps of the year 1984 and scale 1:5000 (source IGVSB) were also obtained and these maps were georeferenced for using it in screen digitization process as well as for quality checking for vector maps.

The vector maps of scale 1:5000 were sub classified in 26 different layers and converted to four different formats namely, Microstation, AutoCAD, MapInfo and ArcGIS due to data requirements in particular formats by different institutions and consultants.

For the sediment study area, the base map was further clipped in to sub watersheds as well as study area of sediment study. Due to requirement of local consultant for sediment study, these maps were reconverted to Loma Quintana system and in some cases back to AutoCad format. For this reason, it is quiet natural that the same base map will be stored in different formats, different coordinate system and different coverage.

The 1:1000 scale working maps was used for the area where there is no coverage for 1:5000 scale maps.

(3) Digital Elevation Model (DEM)

DEM was prepared for the scale of 1:25000 and the scale of 1:5000 based on the corresponding contour maps. Further, a DEM of 2m pixel size (scale 1:2000) for the urbanized area was developed. The process of DEM development is given below.

1. 4. 2. Development of Coordinate Conversion Routine

Owing to the two distinct coordinate systems being used for the map preparation in the study area (La Canoa system and Loma Quintana system), it is necessary to have a coordinate conversion tools for easy transformation of one system to other. The study team consulted a number of institutions, official gazette from IGVSB and some other related person before developing conversion routine for coordinate system. Some maps were also found to be in geographical coordinate system (Latitude and Longitude) which were also converted in La Canoa system. The coordinate conversion routine was fundamental for the study as some of the currently available conversion routines were not found to be accurate enough for the study purpose as they could not accommodate the accuracy outlined by IGVSB (7.5 m for the scale 1:25000). The coordinate conversion routine was developed for four different softwares namely; Microstation, AutoCad Map, Ilwis and ArcGIS.

1. 4. 3. Orthorectification of Aerial Photos

Aerial photos taken in March 2002 were purchased (in paper format) from IGVSB and scanned with high resolution (1200 dpi). Some of the aerial photos in barrio and rural areas were georeferenced and subsequently orthorectified using the DTM of scale 1:5000. These orthorectified aerial photos are used for interpretation of buildings and houses as well as expansion of the barrio area.

1. 4. 4. Digital Image Processing

Different satellite images spanning the different year were obtained for the study, the most important among them being Aster image and LandSat images. Aster image covering ADMC was obtained for April 2003 and LandSat images were obtained for the years 1986, 1990, 1992, 1997 and 2001.

(1) Aster Image

Aster Image of April 2003 was geo-referenced and a color composition was made combining band1, band2 and band7 as red, green and blue color respectively. Aster Image has a spatial resolution of 15 m. and it covers the whole study area (except the small area in south eastern part of Municipality of Sucre).

(2) LandSat Image

LandSat images of the following year were acquired by the study team: 1986, 1990, 1992, 1997, 2001. LandSat Image of 1986 and 2001 are already processed. These two temporal images contrast the change in land use and urban growth in Caracas in past 15 years.

1. 4. 5. Administrative Boundaries Definition

The Study Team received municipal limits in the scale of 1:100000 which on detail inspection were not found to be suitable for the scale being applied for the study purpose. Further, the parroquia boundaries and other small administrative units such as Urbanization/Barrio and Manzana were needed to be established for the data distribution and analysis. Several sources of data were received and the following procedure methodology was used to establish administrative units.

1. 4. 6. Microzone

Microzone, by definition, is the spatial units which divides the Metropolitan area in some sort of sectorization and where database (like Building, Population, Open Spaces, Road Networks and other Public Facilities) can be established. Further, these microzones could be used for presenting risk map as well as the results of damage scenarios.. In future, these units can be used for planning purposes as well for evaluating the existing resources vs. degree of danger.

These units are the existing spatial divisions that exist in Caracas Metropolitan area with following sub units.

1. Urbanized Area

2. Barrio Area

3. Rural Area

4. Parks and Open Spaces

The preparation of Microzone for the study area was carried out using the following procedure.

1. Preparation and updating of Barrio Map

The existing Barrio map of Conavi (Study on Barrio Inventory, 1993) and Metropolitan Planning Secretary Barrio map was used as input for preparing Barrio map. The Barrio Map from Conavi is divided along UPF (Physical Planning Units) and these UPFs are further subdivided into UDUs (Urban Development Units). Though, Conavi has further sectorization of Barrio UDUs, for the study purpose, the UDU divisions are considered fairly representative units (in terms of size). The interpretation of Barrio area by Conavi since 1993 has been the fair representation in that year. However, the Barrio Area in ADMC has been tremendously increased since 1993 (year of Conavi Barrio inventory). Also, The Barrio inventory map (1993) of Conavi for whole ADMC is not available in digital format, so the study team decided to use and digitize the paper format map of Canavi Barrios. The paper map was scanned, digitized and georeferenced. These digital maps were overlaid on existing base maps where the expansion of Barrio areas was clearly seen. The study team thus decided to interpret and map these expanded area of Barrios. The aerial photos of year 2002 were scanned and orthorectified for Barrio Area. Altogether, 23 aerial photos were orthorectified which covers all the Barrio UDUs of Municipalities of Libertador and Sucre.

The orthorectified photos were used for correcting existing Barrio area limits as well as interpreting expanded area of the Barrio. Field visits were done together with Conavi personal to verify the interpreted limits.

Owing to the small area of Barrios in Municipality of Chacao, they are not still consolidated in Barrio UDUs in Conavi study. For the small Barrio area for these three Municipalities, existing Barrio Map of Secretary of Planning (ADMC) was used.

2. Updating of existing Urban sectorization Map

The existing urban sectorization maps were verified along with the other existing administrative units (Manzana, Parroquia, and Municipality). This map was updated jointly with Planning Secretary (ADMC) personal in the following aspects.

3. The urban area where there were lack of nomenclature were put up by ADMC personal

4. Some parts of the urbanization limits were corrected by JICA Study Team with previous discussion with ADMC. They are outlined as:

   - When Urbanization limits divides Manzana they were corrected along the Manzana borders

   - When Urbanization Limits were found slightly different than existing Municipal and Parroquia limit, they were corrected along municipal and Parroquial limits.

   - The urbanizations which are distributed along different municipalities and parroquias were identified.

   - The urbanizations which were completely replaced by barrios were also identified.

5. Updating of existing Parks and Open Spaces map

This process uses the actual land use map to replace the so called official boundaries. Boundaries of parks and other open spaces were fixed using the ADMC landuse map and aerial photographs. Interpreting Rural area and uninhabited areas

The rural area was identified by JICA Study team based on the aerial photo interpretation.

6. Recompiling into Microzone Map

These prepared maps were recompiled into one microzone map assigning the microzone code and type. It is important to note that microzone maps are being made for all the five municipalities. However, Barrio area revision and interpretation were done for only three municipalities.

When recompiling these maps (urban, rural and park) into one microzone map, the following precedence was given, Barrio, Parks, Urban, Rural to reflect the actual occupancy of the land.

Table S19-1.4.3 gives the summary of distribution of Microzone in the study area.

1. 5 Detail GIS System Design Procedure

1. 5. 1. System Platform

Several different GIS, CAD (Computer Aided Drafting), Image Analysis and DBMS (Data Base Management System) platform are currently used within different entities in metropolitan district to capture, edit, analyse and display spatial data.

Due to this broad range of spatial application software and a vast amount of data to be collected and generated, some specific data format have to be identified and data conversion process has to be defined to ensure that the data can be migrated from one platform to another. An example below shows the different GIS and Database systems currently being used in different institutions.

The study team also observed that the most commonly used GIS software at present is ArcGIS, i.e. ARC/INFO and ArcView; with the mapping package MapInfo being used in some agencies as a display and query tool. Some of the MapInfo users, for example Hidrocapital, are planning to migrate to ArcGIS platform. Following this current trend of GIS system use, the study team and the counterpart team decided the use of following GIS software and system platform.

A common extension for ArcGIS, the Spatial Analyst is also implemented for the GIS analysis.

(1) CAD System Platforms

The platform for the CAD system is decided based on the popular use of each system and the use of this system on the topology generation. AutoCad 2004 was selected for this purpose.

(2) Digital Image Analysis and Aerial Photo Processing Platforms

Digital images (Satellite and aerial photographs) have been acquired and processed using basically two different softwares.

(3) DBMS Platforms

Numerous different DBMS packages are used currently in different institutions. In view of the usability and accessibility, Microsoft Access is the most commonly used DBMS package for desktop PCs.

The study team currently employ Oracle for Windows and MS Access as two DBMS software.

Oracle for windows is used primarily for the big database like building and population. The analysis result of Oracle will be subsequently transferred to Access database.

Some of the direct database consulting has been implemented in the GIS interface through database engine incorporated inside GIS system. These dBase database queries and editing tool has been used as a complimentary way of database consulting while a structured database query has been developed in the Oracle and Access system utilizing SQL language.

1. 5. 2. GIS and Attribute Data Development Phase

In the course of the project development, there would be three stages of data storage and conversion.

(1) Input Data: All the collected digital data will be kept inside this directory structure as they will be received. They are catalogued and saved as it was received.

(2) Temporary conversion data: The received input data will be analysed and the useful digital data will be converted to compatible file format and coordinate system.

(3) Final Output data: The processed and resulting data will be stored apart and the detail metadata will be created for this final product.

1. 5. 3. GIS Interchange Format

Most GIS and CAD software use proprietary file formats for their internal data storage. As a result, the data files created by a software package cannot be readily used by another software package. For this project, ASCII File format such as E00 and DXF files will be used to facilitate the exchange of data between users of different software.

For the interchange of data in ArcView, shape files will be used both as interchange files and as internal storage files. The shape files are unique to ArcView and actually consist of three files: the geometric shape file (.SHP), the shape index file (.SHX) and the attribute data file (.DBF). The .DBF file is a dBase compatible data file. With the Spatial Analyst extension, ArcView can also build and read grids from ARC/INFO ASCII GRID files.

1. 5. 4. CAD Interchange File Formats

Two of the most common CAD interchange file formats are the AutoDesk DXF and Microstation IGDS formats. Neither is perfectly convenient for converting to GIS data format but the process is similar for both. CAD data to GIS conversions will be done using DXF files from outside sources.

1. 5. 5. Units of Measure

Metric units will be used in all GIS work. This applies to both the digital data and the graphical hard-copy outputs.

The Table S19-1.4.9 shows some of the measurement units that will be applied.

All numeric dates are written in the order: year, month and day. The format of the date can be basic (AAAAMMDD) or extended (AAAA-MM-DD), depending on the usage. The extended form is used in written documents while the basic form is recommended for data files. For example: October 6th, 2003 would be 2003-10-06 in the extended form; and 20031006 in the basic form.

1. 5. 6. Horizontal and Vertical Datums

(1) Horizontal Datums

All of the data being collected by the study team and currently possessed by the national government and non government agencies is either of the two different horizontal datum, La Canoa or Loma Quintana. However, Venezuela is adopting a new coordinate system called REGVEN based on the SIRGAS coordinate system. It was initially proposed that the study team would be converting the existing maps to REGVEN system. Later it was found that no conversion routines (softwares) are available freely and there is a need to develop the conversion routine from the scratch. Efforts were made to obtain the complete technical specifications of this new system (REGVEN) from IGVSB. The official gazette obtained from IGVSB describes the technical details of the new system. It was, however, realized that to develop the new conversion software (routine), more technical details are required than mentioned in the gazette. Efforts were made to contact the IGVSB personnel to obtain the complete technical specifications but it was not possible to obtain as such.

Since all the input data for the study period are in the two previous coordinate systems (La Canoa and Loma Quintana) and none of the available data are in REGVEN system, the study team and counterpart team continue to use La Canoa system for the study period.

(2) Vertical Datum

A traditional, MSL (Mean Sea Level) which is the average rise and fall of tides over about 18.6 years of water level measurements (the length of the sun and moon cycles that influence tides) will be used for the vertical datum.

1. 5. 7. Scale, Accuracy and Precision

(1) Scale

The original scale for all the final maps will be always referred so as to know the scale of the map original map capturing.

For the study purpose, all the maps will be produced in the scale of 1:25000 using base map of scale 1:25000 covering the whole study area.

Some parts of study area are being studied using the map of the scale of 1:1000 and 1:5000 depending on data availability.

(2) Positional Accuracy

The Venezuelan standard for the positional accuracy will be adopted which is summarized below.

(3) Attribute Accuracy

Attributes can be continuous or discrete variables. The accuracy of continuous variables is similar to that of *positional accuracy* while the accuracy of discrete variables depends on the classification scheme used.

1. 5. 8. Precision in Internal Storage in GIS and Cad Software

ArcGIS can use either *single* (32-bit floating point) or *double* (64-bit floating-point) precision coverage. To ensure that all data are converted into double-precision coverage, ArcGIS's precision setting will be set so the precision is always forced to double-precision. For AutoCAD DXF, floating point will be used for 16 decimal places.

1. 5. 9. Cross-Platform Conversion Processes

To save time and effort, processes will be defined to convert the various data themes from one software application to another. The geodata set interchange is illustrated in the Figure S19-1.8.17.

1. 5. 10. Data Model in ArcGIS

The ArcGIS coverage will be the base of the GIS data. Every other format will be eventually converted to this topological format. Although, ESRI (the vendor of Arc/Info) has already launched the geodatabase model, it is not yet adopted by the national Venezuelan agencies. Topological model will be still in use for some time and, if required, they could be easily converted to new geodatabase model. All the ARC/INFO coverage will be subjected to clean to be acceptable under the most basic quality standards. For the polygon coverage, this constitutes the followings:

- The projection, datum and units for the coverage is defined in the .prj file.

- Each polygon in polygon coverage has one and only one label point.

- No dangles (over-shoots) are included in polygon coverage’s.

- No fuzzies (under-shoots) are included in polygon coverage’s.

1. 5. 11. Metadata

Among the different version of metadata, the FGDC (Federal Geographic Data Committee) metadata format will be used. It is brought to the notice that the national cartographic institute has already developed the condensed version of the FGDC metadata.

1. 5. 12. Data Capture and Digitizing Standards

The digitizing is being done in the following software.

(1) AutoCAD
(2) Arc Info
(3) ArcView
(4) MicroStation
(5) Ilwis

The digitizing in Microstation software will use the existing digitizing manual developed in national cartographic institute. If done on other software, they will be checked for the followings.

(1) Preparation of the original material to be digitized
(2) Orientation of the map
(3) Layer definition for the elements
(4) Layer topology for each element
(5) Scale and coordinate system definition
(6) Control points
(7) GIS compatible node system
(8) GIS compatible attribute system

1. 5. 13. Data Presentation

(1) Symbology and Color scheme

Existing Color scheme and symbology will be used for each type of the map. The data presentation scheme for base maps developed by national cartography for the Microstation will be referred. For thematic maps symbology, each corresponding institute will be consulted.

(2) Data Storage and Access

It is very important to have the location of data and the name of the data to be uniform to ensure that all GIS users can work in a familiar environment and data and the application can be easily ported from one GIS workstation to other.

(3) Directory Structure

A uniform directory and file storage system will be developed so as all the application run and accessed in the same way. The directory structure as well as all the other naming conventions will be initially made in English. For example: application that will be stored in the directory “application”. Thematic maps will be stored in the directory “Thematic”. The uses of special characters are avoided in naming directory structure so as to avoid cross platform conversion problem.

(4) Naming Conventions

Due to the limitation of Arc/Info for file name size (16 letters in total, 13 alphabets for name and three alphabets for extension), the file name will be limited to 16 characters in total. The standard geodata set name will convey information about the geographic extent of the data set, the accuracy of the data, the projection and the thematic content. By structuring the data set name so that the thematic content is specified last, all spatial parameters can be set to a path and the various themes are added as required. This will greatly improve the simplicity and understanding of automated processes.

The proposed format of the geodata set name is as follows. This structure will be later ratified with the further consultation with the national cartographic institute.

Filename = XXXPASSTTTTTT

Where	XXX	is the Extent Code (to insert an underscore if the Extent Code is ≤ 2 characters)
	P	is the Projection Code (1 numeric character)
	A	is the Accuracy Code (1 alphabetic character)
	SS	is the scale of the map (2 numerica character)
	TTTTTT	is the Thematic Content Code (7 characters)

1. 5. 14. Methodology for GIS Data Preparation

The following will be basic steps for the GIS/database preparation.

- GIS/Database Collection

- GIS/Database Quality Checking
    - Attribute Database Quality
    - Spatial Database Quality
    - Relevance to Present Study

Revision and correction of GIS and Attribute Database

(1) Base Map Preparation

(2) Coordinate System definition

(3) Study area limit preparation for GIS

(4) Building and Population Database creation for Seismic Disaster

(5) Building and Population Database creation for Sediment Disaster

(6) Definition of Microzone for seismic disaster

1. 5. 15. Spatial and Database Analysis

Different spatial and database analysis have been carried out to evaluate the different damage scenario. Some of the examples of the damage scenarios are listed below.

- Building Damage Estimation and Human Casualty
- Property Damage (based on Real estate Value, if available)
- Sediment Damage Estimation
- Landslide Damage Estimation
- Regional evacuation places selection
- Damage to lifeline
- Damage to important buildings
- Evacuation route selection

1. 6 Field Visits and GIS Data Collection

With the objective of knowing existing GIS/database structure, GIS/Database system platform and obtaining of these database and GIS maps, the study team visited a number of institutions and met with a numbers of key persons. Database is collected from some of these visited institutions and from other institutions. During the visits in these institutions, the team had very positive experience in the data collection. These institutions have collaborated with the study team by providing their existing GIS and attribute database. Followings are the list of the institutions visited by the study team for the collection of GIS data and observation of existing GIS system.

- Risk Map Project - IGVSB
- GIS Division - Metropolitan Firefighting Department
- Cadastral Office – Municipality of Sucre
- Seismological Department – Funvisis
- Cadastral Office – Municipality of Libertador
- Cadastral Office – Municipality of Chacao
- Engineering Division – Hidrocapital
- INE
- Investigation Division – Ingeomin
- Private Sector Consultants: Hidroambiente, EIASA, Estereofoto SA
- IMF – Central University of Venezuela
- Secretary of Planning and Urban Development – Metropolitan Municipality
- National Directorate of Civil Protection
- Risk Map Division, Municipality of Baruta
- CANTV
- PDVSA Gas

1. 7 GIS and Database Maintenance

The JICA study team has collected a large number of data in this study period. Around nineteen different institutions (National, Regional and Local governments) have provided existing data to study team. Eleven different organization (private and public) work together with or for the study team. These collected data have been processed and brought to GIS platform. The creation of a GIS database has been a huge, expensive and time consuming task. The Study team expects that these GIS and Database system will be put into maintenance mode in order to retain its value. This is often only slightly less labor-intensive than the initial creation of the database and regains the benefit of the database.

Some data layers do not change and require little maintenance except when software versions are updated. Other layers such as parcel or ownership change on a daily basis and require constant attention. Usually the best course of action within the Counterpart team is to assign an "owner" to oversee to the maintenance on a regular basis. This person (or organizations) is responsible for obtaining updates of the information and transferring it to the digital version of the layer in order to make it available for general use.

Maintaining accurate, up to date and reliable GIS data is critical in a successful operational GIS. Data maintenance includes updates of, additions to, deletions from and conversion of the database. In order to maintain the GIS data integrity, these changes have to be performed in a very careful manner.

The counterpart team can learn from the experience of the JICA study team about collection, processing and analysis of these huge GIS database. In this context, JICA Project can be seen as a model in terms of institutional participation for data sharing. The basic policy of study team was followings.

- Data will be shared with all the counterpart team unless it is restricted.
- Acknowledgement of received data in the final report.
- Result will be published only with the agreement of C/P team.

The counterpart team may need to design the detail procedure and protocol for the continuity of the GIS database maintenance in the following aspects.

- Data use
- Data Update/ Modifications
- Data Security
- Data Analysis
- Result Publication

1. 8 Disaster Management Information (DMI) System

As mentioned before, the GIS system developed in the JICA project has been able to recompile a large number of data layers and has produced a lot of thematic maps required for planning and decision making for disaster related activities in the metropolitan area of Caracas.

During the discussion with counterpart members, it has been agreed that this GIS system should be maintained and used as one of the component of proposed Disaster Management Information System. Development of GIS system from the beginning is very costly; however, maintenance requires fewer resources than development. In this regard, GIS development in JICA project can be seen as another value added product.

It is necessary to define the purpose, objectives and goals of the proposed Disaster Management Information System. This will broaden the conceptual requirement as well as give the insight of future of the system as a whole.

1. 8. 1. Purpose, Objective and Goals

<u>Purpose</u>

1. Effective diagnosis and management of disaster cycles
2. Aid to effective decision making during disaster
3. Aid to Effective coordination

<u>Objective</u>

To help disaster prevention and attention (management) in all of the disaster stages, namely before: Mitigation/Preparation; during: Response; and after: Recovery and Reconstruction.

<u>Goals</u>

Uniform and consistent Metropolitan Spatial Database

Spatial data that is reliable/precise for the given time period and Scale

Spatial Data infrastructure that can be used by legitimate user any time, all the time and from anywhere

<u>Expected Results</u>

GIS based disaster information management system in place

Development of related data collection schemes

Establishment of data interchange and data managements protocols

Data analysis and use protocols

Publication of hazard and risk maps for public use

Distribution of scenario analysis among different agencies

<u>Expected Functions</u>

Real Time Data Analysis - Disaster Response, Early Warning, Disaster Scenario (15-20 Minutes)

Short Term Data analysis - Forecasting (1-2 Days)

Mid Term Data Analysis - Research and Diagnosis (Hazard and Risk map updating), Planning (Mitigation /Preparation)(1-2 Years)

Long Term Data Analysis - Disasters Scenarios (Continuous)

1. 8. 2. Proposed DMI System

The proposed DMI system will have three sub systems.

- Integrated communication system
- Information management system (based on GIS and database system)
- Decision making and disseminating system

(1) Integrated communication system

The integrated communication system is the important initial requirement for DMI system. The JICA study team observed the existing communication infrastructure in metropolitan district.

Existing Communication System in Caracas

The metropolitan district has a unified metropolitan emergency trunking communication system (called in spanish “Sistema Unificado de Comunicacion Troncalizada de la Alcaldia del Distrito Metropolitana de Caracas”) which was implemented in the year 2000. This is a central system located in the Metropolitan Police station in Parque Caobos with a central server in El Volcan. This system is based on Motorola Smartzone APCO 25 Digital with a total capacity of 48000. There is around 6155 communication radio presently operating. Three repeaters located in the surrounding hills (Avila, el Volcan and Trapa) provides the complete coverage for metropolitan district. This system is the digital system but the communication devices are analog ones.

The existing communication system in the metropolitan area can be summarized as follows.

System	Trunking, APCO 25
Model	Motorola
Total Capacity	48000
Installed Capacity	6155
Repeaters	3
Coverage	Metropolitan Area

The technological implementation and maintenance is supervised by Technological Direction of Metropolitan municipality. A central server located in the hill "El Volcan" which registers and monitors all the communication system.

This communication system provides two basic functions.

- Emergency incident reporting Gateway
- Communication Gateway between different institutions in Metropolitan Municipality

Emergency incident reporting Gateway:

The central operation room located in the Metropolitan Police station in Parque Caobos receives all the daily incidents occurring anywhere in Metropolitan district. Any call received through the unique number 171 is processed by one of the eight operators and forwarded to the competent authority (for example: Fire Fighters, Police, and Protection Civil). The competent authority then proceeds to take the necessary action on the incident. The system can monitor the progress or the action taken over the incident and could make the necessary coordination in communication by allocating one or more channel for the communication among different participating authorities.

The existing communication system was found to be good starting point for DMI system. Beside, if the existing projects to strengthen and modernize the communication system are realized, this would benefit the overall implementation.

Communication Gateway between different institutions in Metropolitan Municipality:

Another function of this central system is to provide the unique communication system among different institutions in the Metropolitan Municipality. Most of the dependencies of the Metropolitan Municipality have been allocated the unique channel and the communication devices. They may remain in their channel to communicate with other personnel or may switch the channel to communicate with other dependencies. This way it will facilitate the officials of metropolitan municipality to communicate each other.

There are two projects presented in the year 2003 (project cost 750 Million Bolivars) and 2004 (project cost 1400 Million Bolivars) to FIDES jointly by Secretary of Infrastructure and Technological Direction to modernize the physical infrastructure and technology of call center 171. Once implemented, these projects will likely to improve and strengthen the existing communication network.

(2) Information management system (based on GIS and database system)

The information management system will act as the heart of the planning and the decision making for DMI system. This system will be based on the GIS and database system. As mentioned before, the GIS and database system developed in this study will be the starting point for the new information management system.

The technological direction of metropolitan municipality host different database system (namely fingerprints database for police, database for secretary of education, secretary of health etc). These database are hosted in the central server in the office of the technological direction and some database like fingerprints database for police is hosted in the hosting place in "El Volcan". This makes the technological direction the natural choice to host the GIS and database system required for the activity of disaster management.

1. 8. 3. Prefeasibility Study of DMI System

The study team reviewed four important aspects for the prefeasibility study for the implementation of DMI system.

1) Legal aspect
2) Institutional/ Organizational aspect
3) Financial aspect
4) Technical aspect

(1) Legal Aspects

Basically there are three main laws which regulate the disaster management activities and related information system. They are:

- The Law of National Organization of Civil Protection and Disaster Administration

- Decree with Legal Force of Firefighters Brigades and Administration of Emergency with Civil Character

- Citizen Security Law

Beside that, a National Cartographic Law regulates the production and representation of cartographic materials.

The relevant portions of each law are cited below.

The Law of National Organization of Civil Protection and Disaster Administration

Article 1: The objective of this law is to regulate the organization, capacity, integration, coordination and functioning of the Organization of Civil Protection and Administration of Disasters at the national, state and municipal levels.

Article 2: The Organization of Civil Protection and Administration of Disasters will form part of the National System of Risk Management and of the National Coordination of Citizen Security.

To prepare inventories of the national, state and municipal resources that could be required in order to fulfill the objectives of the present Law Decree.

Once declared the State/Condition of Warning or the State/Condition of Emergency, and together with the governmental entities, established for that purpose, to coordinate the supply of information on the measures and pertinent recommendations to the non official agencies and to the public opinion in general.

Decree with Legal Force of Firefighters Brigades and Administration of Emergency with Civil Character

Article 2: The Firefighters Brigades and Emergency Administration of Civil Character constitute agencies of citizen security, to the exclusive service of the State interest and will comply, in whatever it regards with their structure, competences, direction and functioning, with the norms of the Law-decree and its regulation, likewise by the other laws that may be applicable to them.

Article 5: The Firefighters Brigades and Administration of Emergencies of civil character have by purpose:

1. As opposed to safeguard the life and the goods of the citizenship situations that represent threat, vulnerability or risk permanently, promoting the application of preventive measures as much as of mitigation, taking care of and administering and the emergencies directly, when the people or communities are affected by any generating event of damages, jointly with other competent organisms.

2. To act like consultants and promoters in the matter of management of risk, associated to the communities.

3. To cooperate with the maintenance and reestablishment of the public order in cases of emergencies.

4. To participate in the formulation and design of policies of administration of emergencies and management of risks, for promoting processes of prevention, mitigation, preparation and response.

5. To develop and to execute activities of prevention, protection, fight and fire extinguishing and other generating events of damages, as well as the investigation of its causes.

6. To develop programs that allows the fulfillment of the service of civil character.

7. To make in coordination with other competent organs, activities of rescue of patients, victims, affected and injured before emergencies and disasters.

8. To exert the activities of organs of penal investigation that attributes the law to him.

9. To watch over the observance of the practical standards and security in accordance with the law.

10. To take care of events generating of damages where they are involved material dangerous.

11. To promote, to design and to execute plans oriented to the prevention, mitigation, preparation, attention, answer and recovery before moderate, greater or serious emergencies.

12. To make the pre-hospital attention to the affected ones by a generating event of damages.

13. To develop and to promote oriented activities to prepare to the citizens and citizens to face situations of emergencies.

14. To before support to the communities, during and after catastrophes, public calamities, imminent dangers or other necessities of analogous nature.

15. To collaborate with the National service operations search and Rescue, as well as with other relatives by marriage to this service, conforms to the national and international norms on the matter.

16. To make its objectives in coordination with the other citizen security elements.

17. The others that the law indicates.

Law of Citizen Security Coordination

Article 2: The agencies of citizen security are:

5. The Firefighters Brigade and the Administration of Emergencies of Civil Character

6. The Organization of Civil Protection and Disasters Administration.

Article 3: It corresponds to the agencies of citizen security, without prejudice of the competences established by the Law that regulates them:

4. To organize and develop systems of information technology, communication, administration and of any other nature that allows optimizing the coordination between different agencies of citizen security.

Title IV

Organization and Interchange of Information between the Agencies of Citizen Security

Chapter I

Object, Organization and Functioning of the National System of Criminal Registry, of Emergencies and Disasters

Article 29: It is created the National System of Criminal Registry, of Emergencies and Disasters with the purpose that the agencies of citizen security have an information system that facilitates the proper planning, formulation and execution of the plans, strategies and actions of citizen security.

Cartographic Law

Chapter I

Of the Territorial Information Surveys by Means of Remote Sensors

Article 7: All the organizations of the State that in the fulfillment of their obligations obtain territorial information by remote sensors, will procure that said surveys be carried out by using the highest existing technology for such purposes and will submit the original of the same ones, for their custody and safeguard, to the Geographic Institute of Venezuela "Simon Bolivar".

Article 8: All the original materials that contain data obtained during the execution of aero-transported surveys, contracted by State agencies, will be submitted to the Geographic Institute of Venezuela "Simon Bolivar" by the person that executes such works, during the term of ten labor days counted from the contract expiration date.

The Institute will issue the correspondent certificate of solvency, in which it is stated the fulfillment of this obligation.

Article 9: The original materials that contain data obtained during the execution of the aero-transported surveys with such purposes as cartographical, geophysical, cadastral, hydrological, hydro-geological and seismological ones, which are product of contracts celebrated between particulars, might be object of expropriation by part of the Geographic Institute of Venezuela "Simon Bolivar" whenever, by reasons of public utility and social interests, it be required; in conformity with the Constitution and the laws.

Article 10: The registry of all original materials that contain data gathered during the execution of territorial information surveys by means of remote sensors, to which the previous Articles refer to, will be at the responsibility of the Geographic Institute of Venezuela “Simon Bolivar”.

Chapter V

Of the Publication of the Cartography

Article 22: Whoever makes or prints maps, planes or cartographic letters, total or partial ones, of the Bolivarian Republic of Venezuela, will be obligated to submit to the Geographic Institute of Venezuela “Simon Bolivar” three sets of the publication for their registry and conservation.

The Institute will issue the correspondent certificate of solvency, in which it is stated the fulfillment of this obligation.

Article 23: All publication and distribution of maps, planes, cartographic letters, total or partial ones, and whichever other forms of representation of the territory of the Bolivarian Republic of Venezuela will respect the veracity of its territorial information.

The Geographic Institute of Venezuela “Simon Bolivar” will verify and certify the veracity of the same ones and their adjustment to the established technical norms.

Article 57: Whoever incurs in the delay of the fulfillment of the obligation of submitting the original materials that contain the data gathered by the execution of aero-transported surveys, to which the Article of this Law refers to, will be penalized with a fine of two hundred Tributary Units (200 T.U.) daily. If the delay would continue once thirty continuous days have elapsed of the expiration date of the contract, it will be understood that no fulfillment exist that will produce the imposition of a fine equivalent to the hundred percent of the cost of the survey, indexed to the day of the imposition of the said fine. Besides the fine, a disqualification from the execution of those works will be imposed for a period of up to three years.

(2) Institutional/ Organizational Aspect

The JICA Study team realized different institutional visits and discussions with different organization to propose the organizational aspect of the DMI system. The database required for disaster related activities should come from different institutions. They are identified as in all level of government (national, regional and local as well as private companies).

Following institutions should take part in the DMI system database construction and maintenance.

Metropolitan Protection Civil

National Protection Civil

IGVSB

Funvisis

Planning Secretary, ADMC

Bomberos ADMC

Protection Civil, Municipio Chacao

HidroCapital

INE

Ingeomin

Protection Civil, Municipio Libertador

Protection Civil, Municipio Sucre

CANTV

CENAMB

Electricity of Caracas

IMF, UCV

PDVSA GAS

Inparques

MARN

Direccion Technolgico, ADMC

Protection Civil, Municipio Baruta

Protection Civil, Municipio El Hatillo

During these discussions, it was agreed that, the metropolitan protection civil is basically the institution responsible for implementation of this system in the metropolitan area of Caracas.

As metropolitan protection civil, at present, lacks specialized tools and knowledge of the GIS based system, the database and GIS part of this system should be placed in technological direction of metropolitan municipality. Some participating institutions (like metropolitan firefighters' office) already have GIS system. The maintenance and update of this system is the responsibility of all the organizations.

(3) Financial Aspect

To sustain the cost of operation, maintenance and future upgrades, there should be some mechanism of funding from national or municipal government. The budget required for the initial development of DMI system should be set aside. It is noteworthy to mention that there are two projects presented in the year 2003 (project cost 750 Million Bolivars) and 2004 (project cost 1400 Million Bolivars) to FIDES, jointly by secretary of infrastructure and technological direction, to modernize the physical infrastructure and technology of call center 171.

Beside the initial development fund, a provision for the maintenance and updating of the system should be separately earmarked. JICA study team identified the following sources as the fund provider.

- General public with insurance fee
- Municipal government
- Metropolitan government
- National government

(4) Technical Aspects

There are three alternatives proposed for the GIS based database system implementation. Alternative 1 is the simple solution but will not fulfill much critical aspect of DMIS (like information processing for response operation).

Alternative 1

This is the simple implementation of interconnected GIS and database System. This system implementation involves the setting up the procedures (protocols) for communication between GIS and database System. The spatial unit of interconnection is parcel, manzana, microzone, parroquia and municipality.

The cost of implementation of the system would be approximately as follows.

System Cost:	US$ 50000
Initial Data Cost:	US$400000
Training Cost:	US$20000
Annual Maintenance cost:	US$100000
Total Cost:	US$600000

This cost does not include the cost of housing of the system and personnel.

Alternative 2

This alternative employs the scheme of the distributed system among national, regional and local government. This scheme may require certain data priviledge among different institutions as the data required by each institute is different.

The schematic representation distributed and interconnected GIS and Database System is given in Figure S19-1.8.1.

The cost of implementation of the system would be approximately as follows.

System Cost	US$500000
Initial Data Cost	US$500000
Training Cost	US$50000
Annual Maintenance cost	US$500000
Total Cost	US$ 1.5Mln

Alternative 3

This alternative employs the scheme of the distributed system among national, regional and local government interconnected with private companies/media and general public. This scheme requires separating the web based access to governmental agencies and general public. The schematic view of distributed and interconnected GIS and database system with participation of private Sector is given in Fig. S19-1.8.2.

The cost of implementation of the system would be approximately as follows.

System Cost:	US$2.5 Mln
Initial Data Cost:	US$500000
Training Cost:	US$500000
Annual Maintenance cost:	US$100000
Total Cost:	US$1 Mln.

1. 8. 4. Prototype System Implementation

The JICA Study Team together with the engineers from technological direction, Alcaldia Mayor (TDAM) has implemented a prototype system for accessing the GIS/database system by different users. This system is based on the virtual private network (VPN) scheme.

Basically, a VPN is a private network that uses a public network (usually the Internet) to connect remote sites or users together. Instead of using a dedicated, real-world connection such as leased line, a VPN uses "virtual" connections routed through the Internet from the company's private network to the remote site or employee.

The GIS/database developed in the project resides on the central server in TDAM. The system can be accessed using existing connection to internet. The minimum required infrastructure would be, a computer with P4 Processor and high speed internet connection (Aba or Other fiber optics connections).

Initially, twenty two institutions are selected to access the system. Additionally, these institutes can acquire the software de ArcView or ArcExplorer to run the application develop or visualize the content of the data. The ArcExplorer software is the free software for visualizing ArcView data.

The connection to the DMIS is configured by followings.

a. Configuring the VPN network of Microsoft

IP 200.44.181.190

Networking PPTP VPN

b. Then the user can reach the central server by http or ftp.

The IP of the HTTP/FTP Server is: 192.9.18.253

The user may switch to directory CARACAS ones the FTP is connected.

Free downloadable software ArcExplorer may be used for the visualizing data. ArcExplorer is the software that can be found in public domain. This software can be downloaded from the web site of ESRI (www.esri.com).

Use the following link for downloading.

http://www.esri.com/software/arcgis/arcreader/index.html

Following institutions were provided the user name and passwords to access the system. The technological direction (who hosts the GIS/database system) will create additional user name and password for the other institutions in future.

Table S19-1.4.1 GIS Layers Created from the Base Map

FILENAME	MAP LAYER
\Base_Map\Contour_Line\elevation_26_06.shp	Contour Lines
\Base_Map\Facilities\airport.shp	Airport
\Base_Map\Facilities\club.shp	Club
\Base_Map\Facilities\Fence.shp	Fence
\Base_Map\Facilities\Golf_Field.shp	Golf Field
\Base_Map\Facilities\Horse Track.shp	Horse Track
\Base_Map\Facilities\Metro Line.shp	Metro Line
\Base_Map\Facilities\School and Sport Buildings.shp	School and Sport Buildings
\Base_Map\Facilities\vegetation.shp	Croplands and Forest
\Base_Map\Hydrologic_Network\Channel.shp	Channel
\Base_Map\Hydrologic_Network\Check_Dam.shp	Check Dam
\Base_Map\Hydrologic_Network\Coast Line.shp	Coast Line
\Base_Map\Hydrologic_Network\Lagoon of Seasonal Regimen.shp	Lagoon
\Base_Map\Hydrologic_Network\Reservoir.shp	Reservoir
\Base_Map\Hydrologic_Network\River of Seasonal Regime.shp	River of Seasonal Regimen
\Base_Map\Hydrologic_Network\River.shp	River
\Base_Map\Life_Line\Gasoline Tank.shp	Tank
\Base_Map\Life_Line\High Tension Electric Line.shp	High Tension Electric Line
\Base_Map\Life_Line\Pipe Line.shp	Pipeline
\Base_Map\Road_Network\Path_Road.shp	Foot Path
\Base_Map\Road_Network\Paved_Road.shp	Highway, Paved Road and Street
\Base_Map\Road_Network\Secondary_Road.shp	Secondary Road
\Base_Map\Road_Network\Tunnel.shp	Tunnel
\Base_Map\Urban_Area\Buildings.shp	Building-polygon
\Base_Map\Urban_Area\buildings_line.shp	Building-line
\Base_Map\Urban_Area\Urban_Areas.shp	Urban Area

Table S19-1.4.2 Administrative Boundaries Source

Administrative Unit	Data Source	Comments
Municipal Limits	Interpretation of official gazette by Study Team	Revised by IGVSB
Parroquia Limits	Interpretation of official gazette by Study Team	Revised by IGVSB
Urbanization Limits	Secretary of Planning, ADMC	Converted to La Canoa System and topology generation by Study Team
Barrio Limits	Secretary of Planning, ADMC	Converted to La Canoa System and topology generation by Study Team
Manzana Limits	Secretary of Planning, ADMC	Converted to La Canoa System and topology generation by Study Team
Individual Houses	Working map 1:5000, Hidrocapital	Converted to La Canoa System and topology generation by Study Team, Additional interpretation was done for barrio houses and rural areas

Table S19-1.4.3 Area of Different Administrative Boundaries

Municipality	Total Area (Has.)	Total Number of Microzone	Barrio		Urban		Rural		Park
			No.	Area (Has.)	No.	Area (Has.)	No.	Area (Has.)	No.
Libertador	47137.7	269	87	2285.95	162	9925.79	19	21316.8	1
Chacao	11906.1	34	9	1.727	24	1113.55	0	0	1
Sucre	32299.6	115	51	1062.38	53	2773.226	10	17368.3	1

Table S19-1.4.4 Current use of GIS, Database and CAD System in Visited Institutions

Institution	GIS Platform	Database Platform	CAD Platform
Risk Map Project, National Cartography	ArcGIS	-	Microstation
Cadastral Office, Municipality of Libertador	AutoCAD Map plan to migrate to ArcGIS	Access, SQL Server	AutoCAD
Cadastral Office, Municipality of Chacao	ArcGIS	Plan to use Oracle	AutoCAD
Cadastral Office, Municipality of Sucre	MapInfo	SICA (based in Access and Visual Basic)	AutoCAD
Ingeomin	ArcGIS	-	AutoCAD
Secretary of Planning and Urban Development, Metropolitan Municipality	MapInfo	-	AutoCAD
Firefighting Department, Metropolitan Municipality	MapInfo	-	-
Funvisis	MapInfo	-	-
National Census Institute	ArcGIS	Oracle	AutoCAD
Hidrocapital	MapInfo plan to migrate to ArcGIS	-	AutoCAD
Inparques	ArcGIS	-	AutoCAD

Table S19-1.4.5 GIS System Platform

GIS Package	Vendor	Operating System
ArcGIS 8.3	ESRI	Windows XP
ArcView 3.2a	ESRI	Windows XP

Table S19-1.4.6 CAD System Platform

CAD Package	Vendor	Operating System
AutoCAD	AutoDesk	Windows XP
AutoDesk Map	AutoDesk	Windows XP

Table S19-1.4.7 Image Analysis System Platform

Image Analysis Package	Vendor	Operating System
Envi	Research System Inc.	Windows XP
Ilwis 3.1	PCI Geomatics	Windows XP

Table S19-1.4.8 DBMS System Platform

DBMS Package	Vendor	Operating System
Oracle 8i	Oracle	Windows XP
Access XP	Microsoft	Windows XP

Table S19-1.4.9 Measurement Units

Quantity	Unit Name	Unit Symbol
Length	Meter	m
Mass	Kilogram	Kg
Time	Second	s
Plane Angle	Radian	rad
Plane Angle	Degree	deg
Plane Angle	Percentage	perc
Volume	Liter	l
Area	Sq. meter	m^2
Area	Sq. kilometer	km^2
Area	Hectare	ha

Table S19-1.4.10 Positional Accuracy

Intended Map Scale	Positional Accuracy [m]
1:25000 DEM	±7.5 horizontal ±6.6 vertical
1:25000	±7.5 horizontal

Table S19-1.4.11 Proposed Institutional Participation in DMIS

Institution	Responsible Person	Phone	Email	User Name	Password
Metropolitan Protection Civil				PC_ADMC	123
National Protection Civil				PC_NATIONAL	pcnational
IGVSB				IGVSB	igvsb
FUNVISIS				FUNVISIS	funvisis
Planning Secretary, ADMC				SP_ADMC	spadmc
Bomberos ADMC				BOMBERO_ADMC	bombero
Protection Civil, Municipio Chacao				PC_CHACAO	pcchacao
HidroCapital				HIDROCAPITAL	hidrocapital
INE				INE	ine
Ingeomin				INGEOMIN	ingeomin
Protection Civil, Municipio Libertador				PC_ LIBERTADOR	pclibertador
Protection Civil, Municipio Sucre				PC_SUCRE	pcsucre
CANTV				CANTV	cantv
CENAMB				CENAMB	cenamb
Electricity of Caracas				ELECTRICITY	electricity
IMF, UCV				IMF	imf
PDVSA GAS				PDVSA_GAS	pdvsagas
Inparques				INPARQUES	inparques
MARN				MARN	marn
Direccion Technolgico, ADMC				TECH_ADMC	techadmc
Protection Civil, Municipio Baruta				PC_BARUTA	pcbaruta
Protection Civil, Municipio El Hatillo				PC_HATILLO	pchatilllo

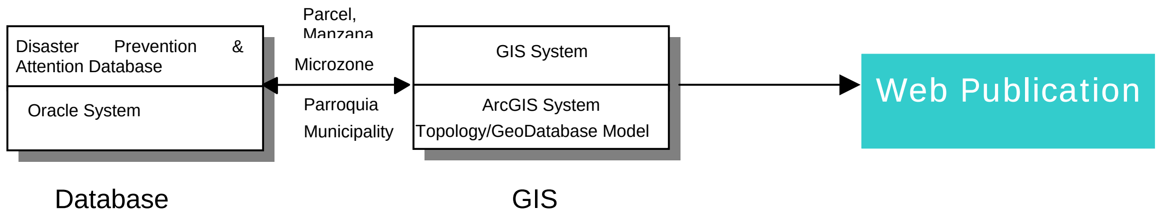


Figure S19-1.8.1 (1) Simple Implementation of Interconnected GIS and Database System (Alternative 1)

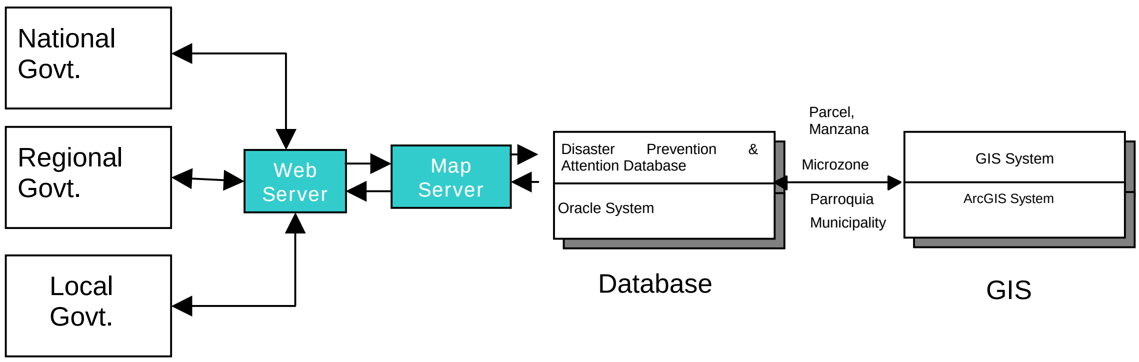


Figure S19-1.8.1 (2) Distributed and Interconnected GIS System and Database System (Alternative 2)

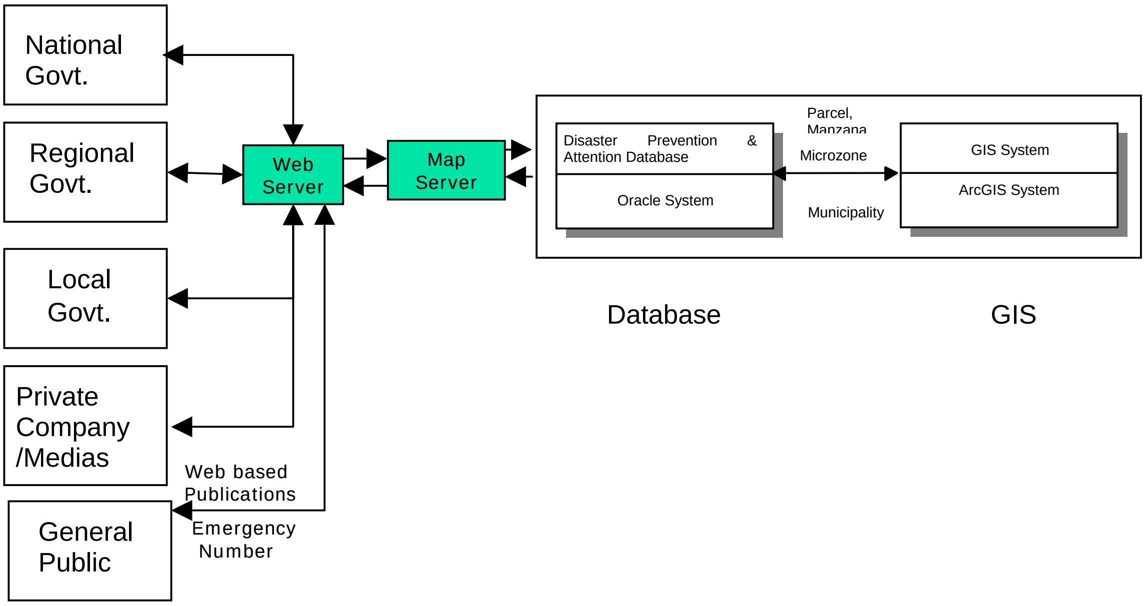


Figure S19-1.8.2 Distributed and Interconnected GIS System and Database System with Participation of Private Sector (Alternative 3)

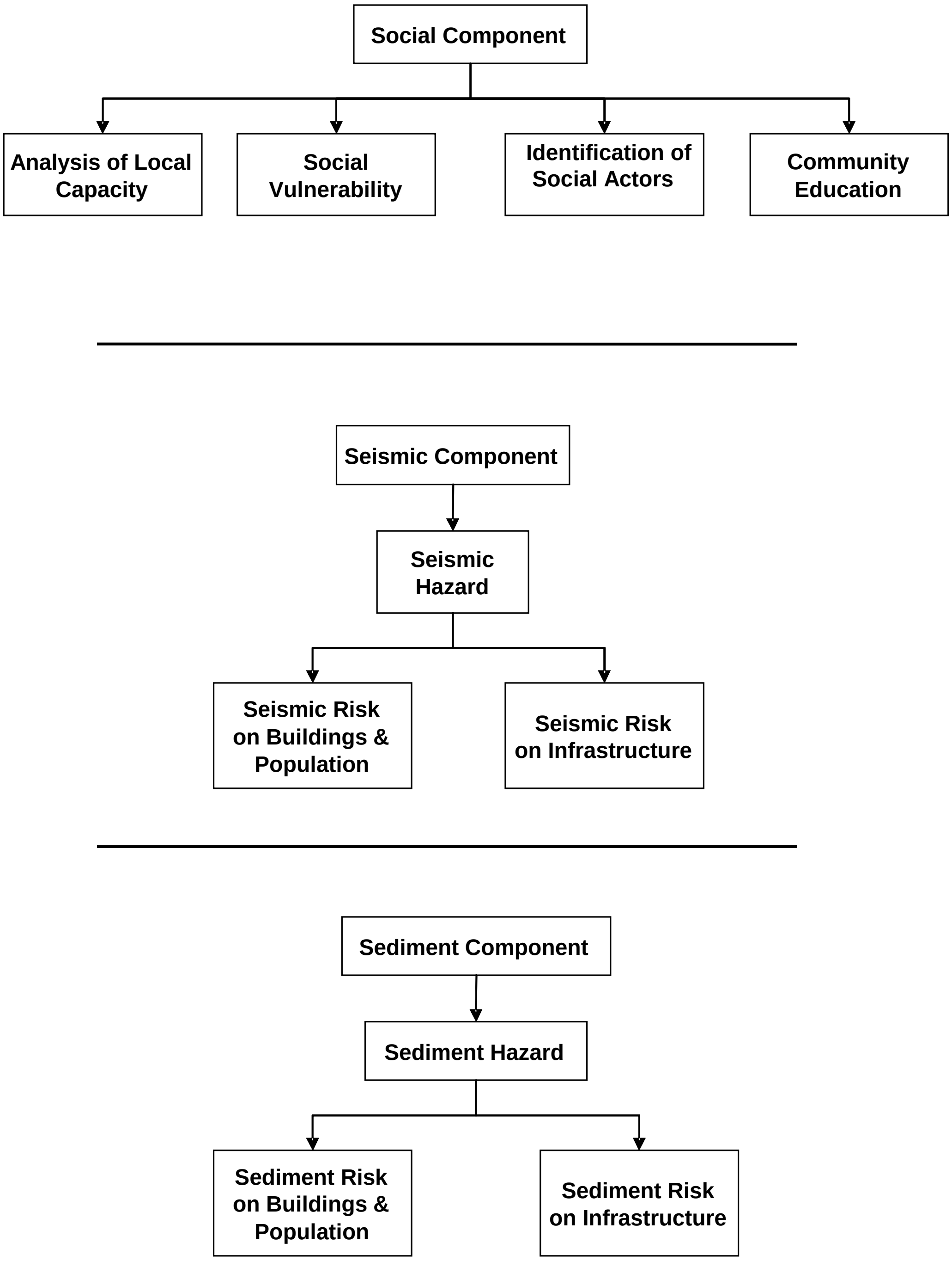


Figure S19-1.8.3 General Conceptual Model of Study Components

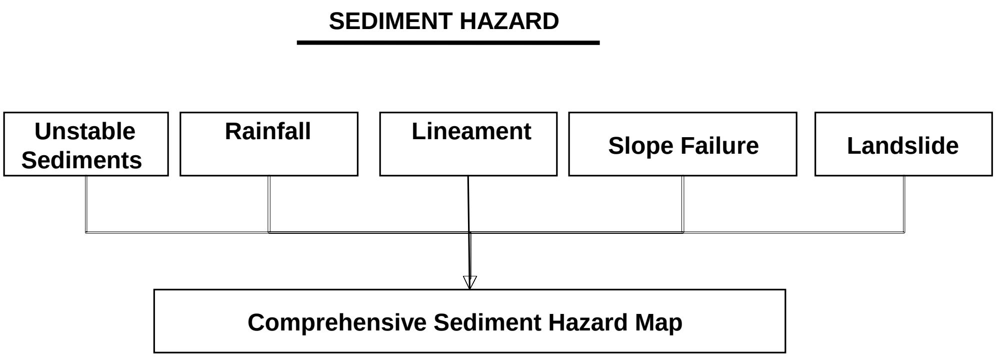


Figure S19-1.8.4 Comprehensive Sediment Hazard

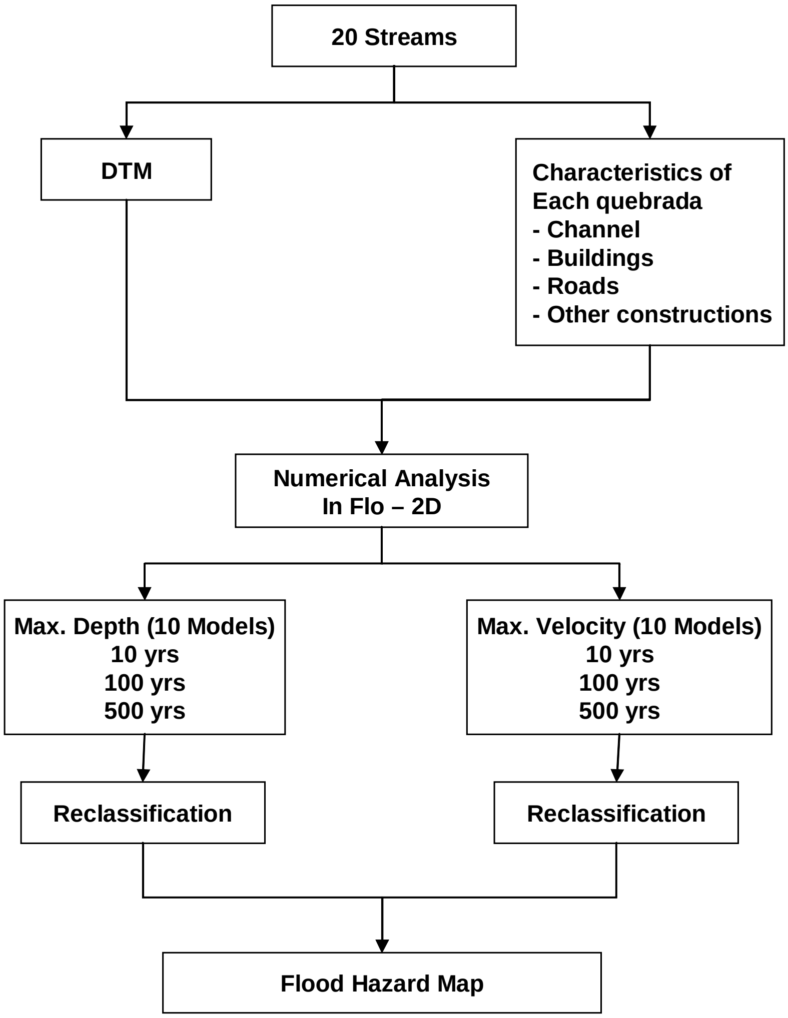


Figure S19-1.8.5 Flood Hazard

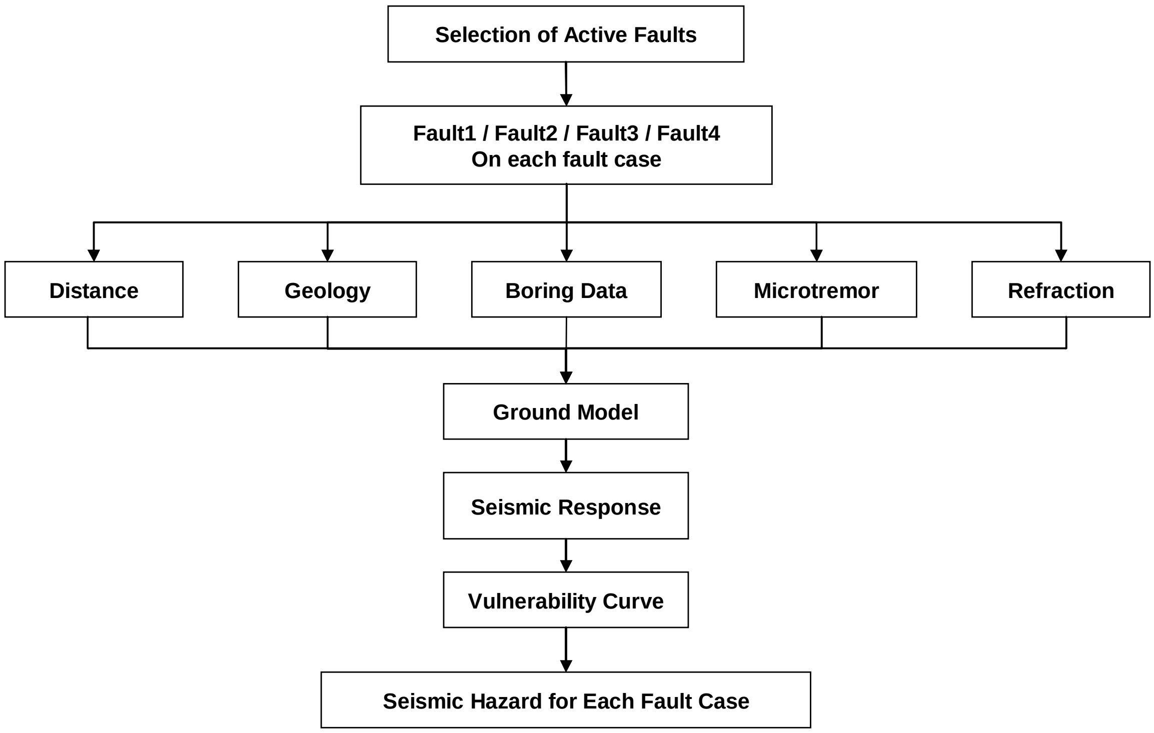


Figure S19-1.8.6 Seismic Hazard for Each Fault Case

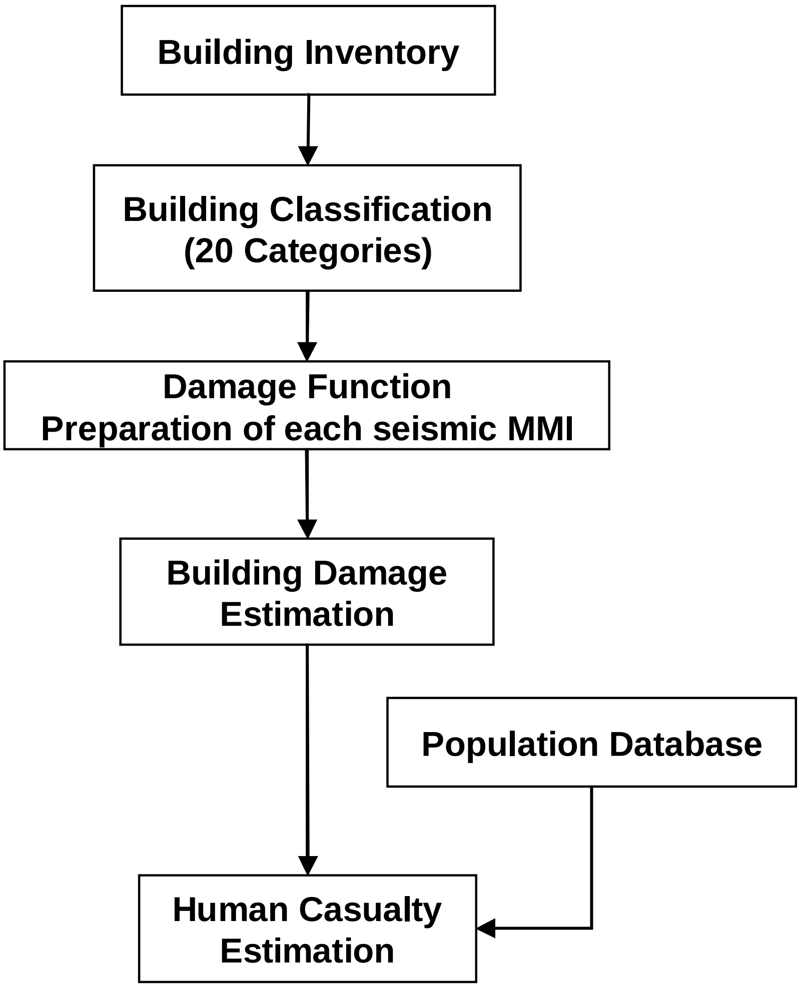


Figure S19-1.8.7 Building Damage and Human Casualties

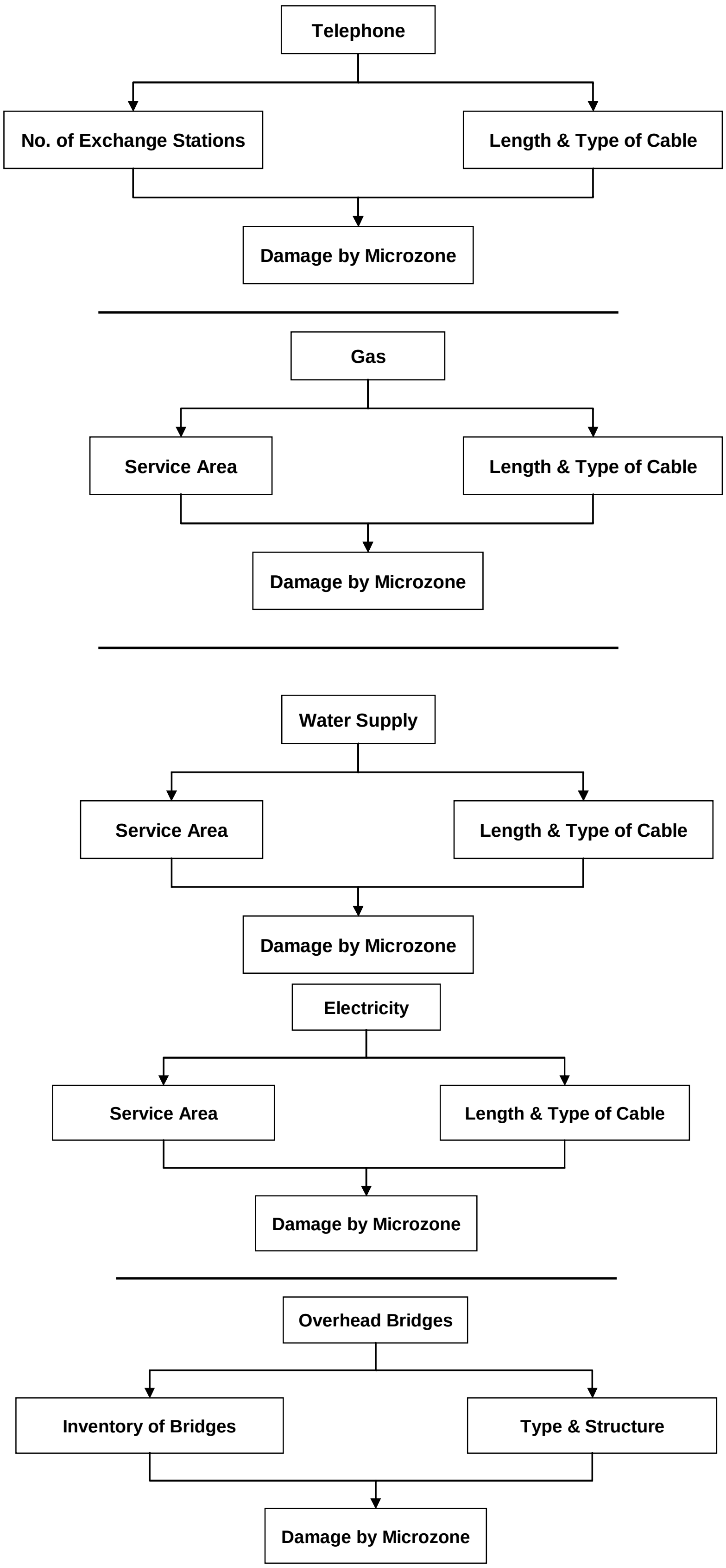


Figure S19-1.8.8 Damage to Infrastructure

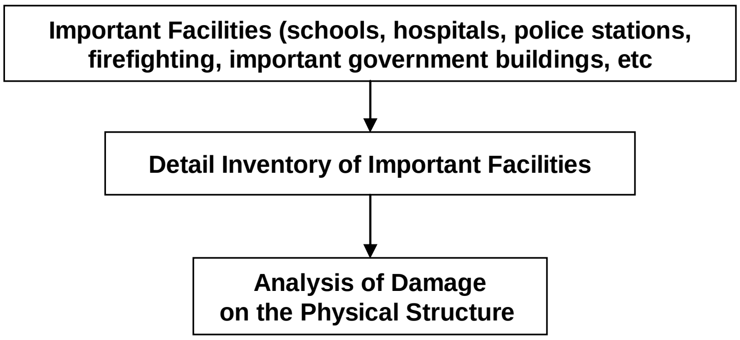


Figure S19-1.8.9 Damage to Important Facilities

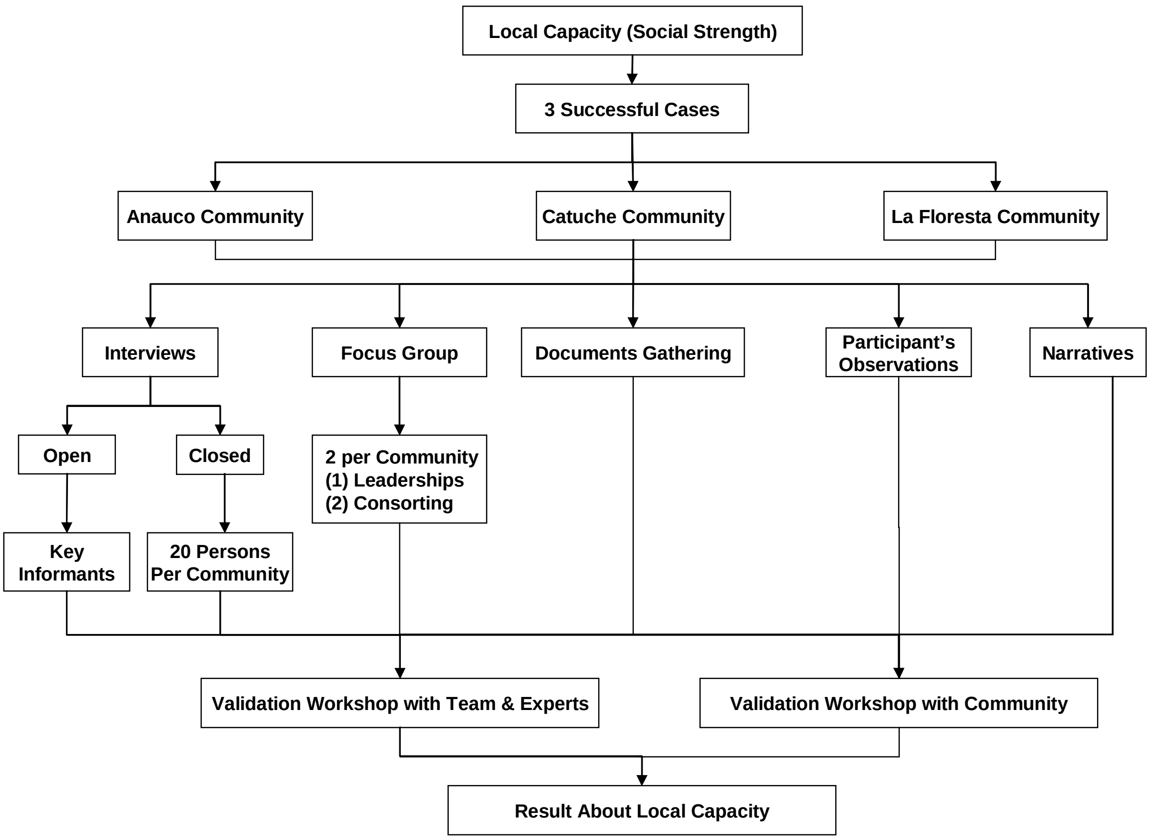


Figure S19-1.8.10 Social Component (Local Capacity)

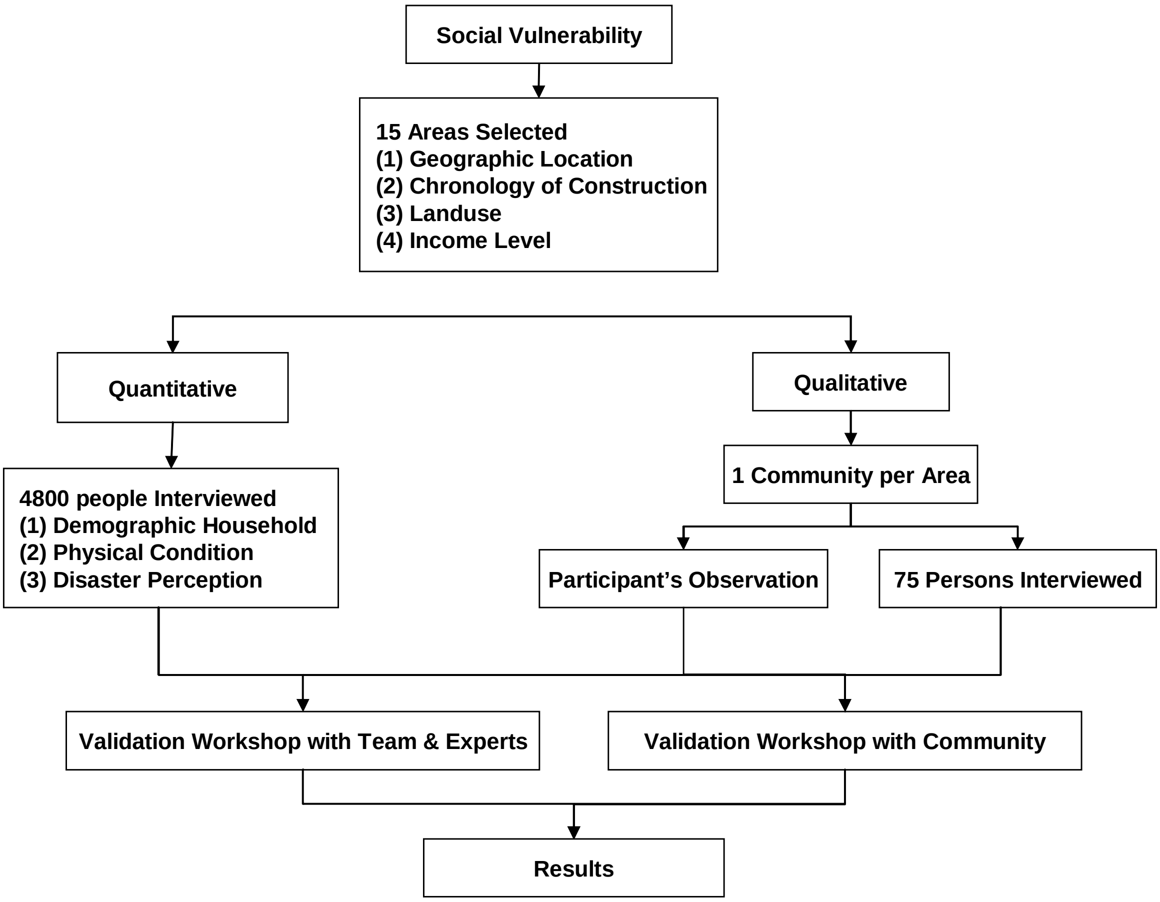


Figure S19-1.8.11 Social Component (Vulnerability)

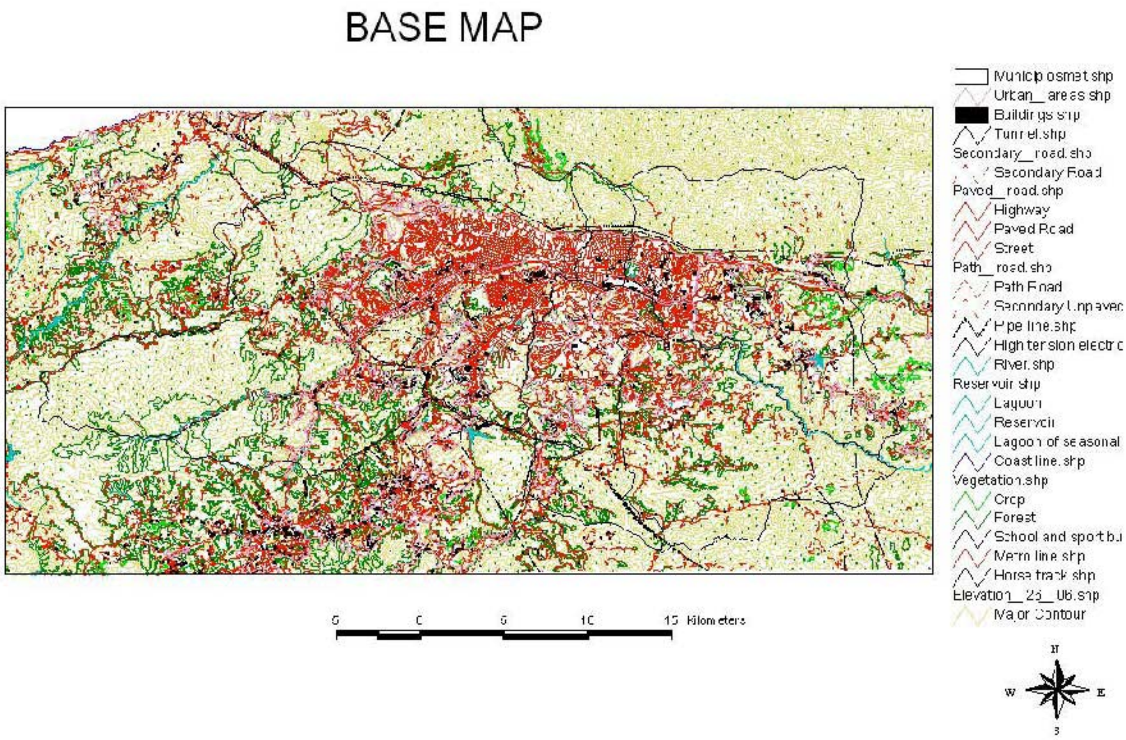


Figure S19-1.8.12 View of Base Map (1:25000)

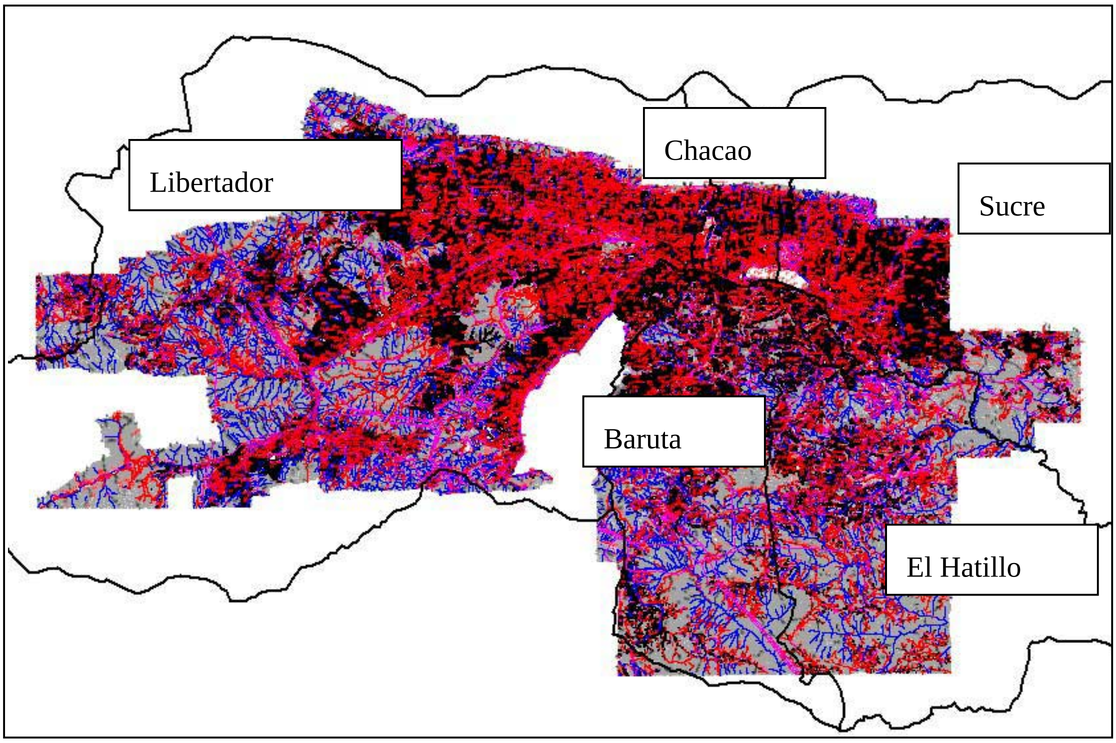


Figure S19-1.8.13 A View of Working Map (1:5000)

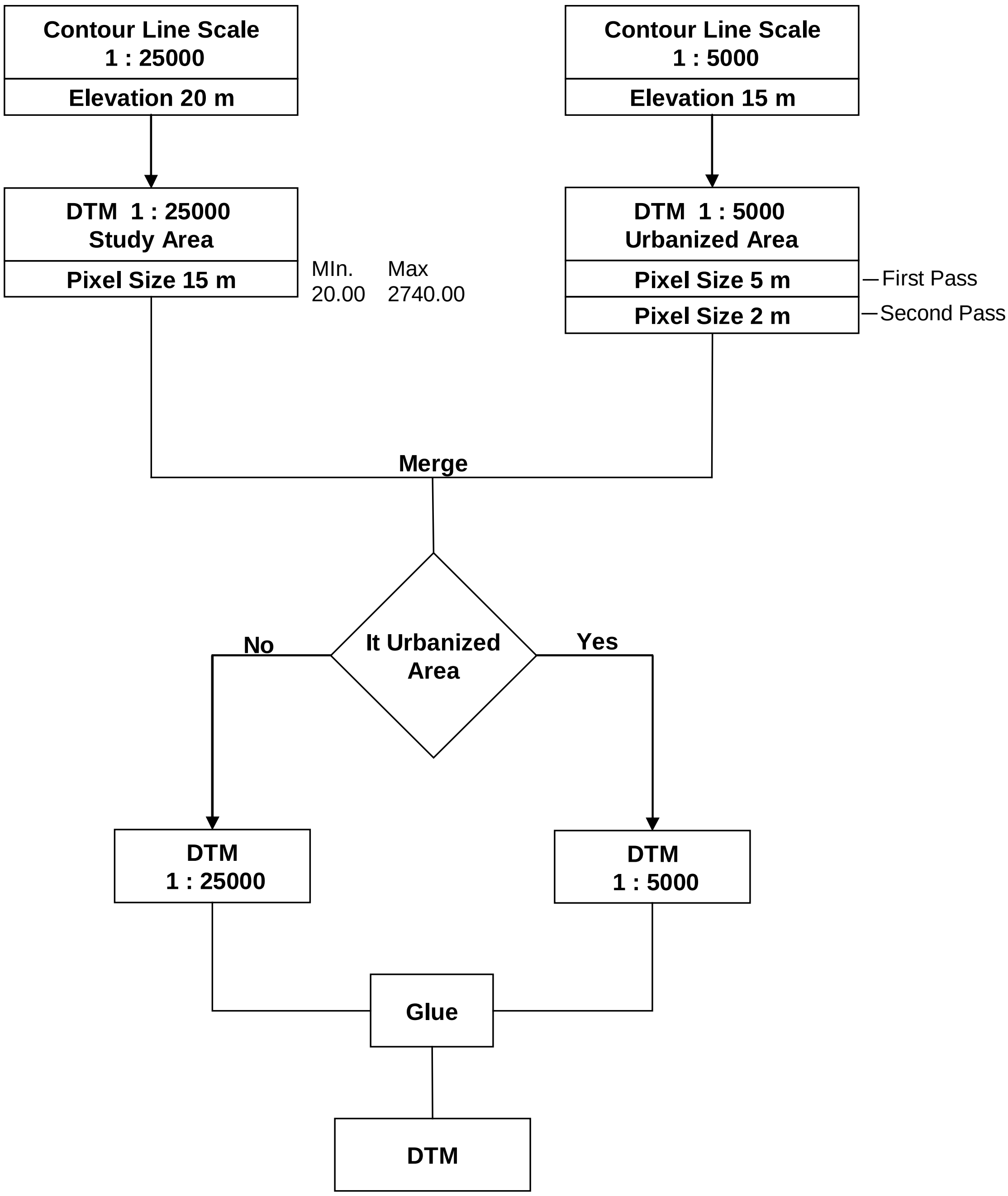


Figure S19-1.8.14 DTM Preparation

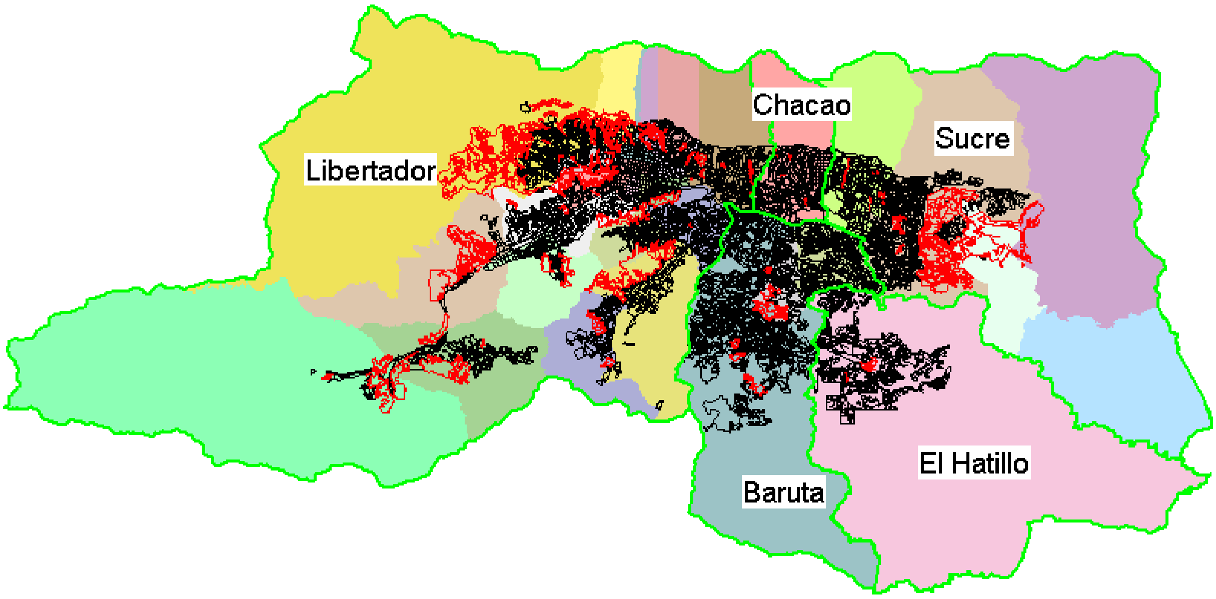


Figure S19-1.8.15 Administrative Boundaries (upto Manzana)

Figure S19-1.8.16 Administrative Boundary (upto Individual Houses)

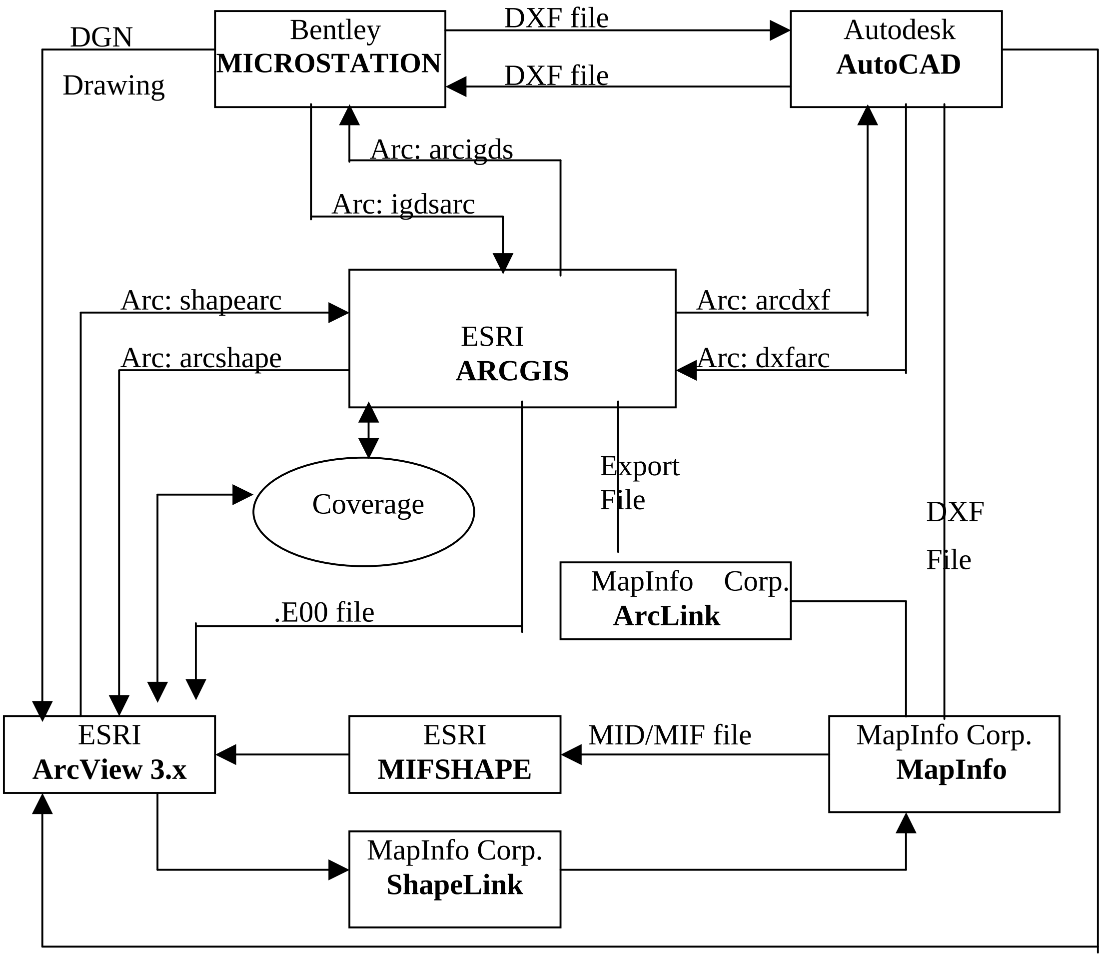


Figure S19-1.8.17 Cross-Platform Conversion Processes

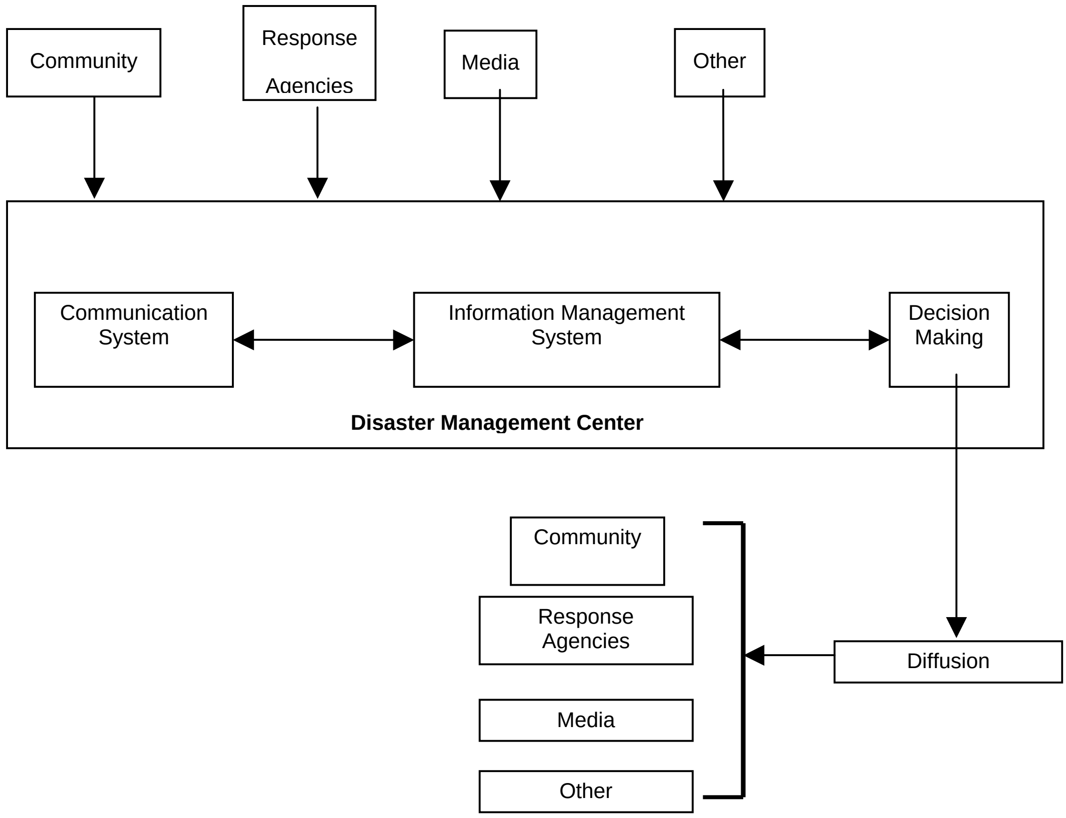


Figure S19-1.8.18 Schematic View of DMI System

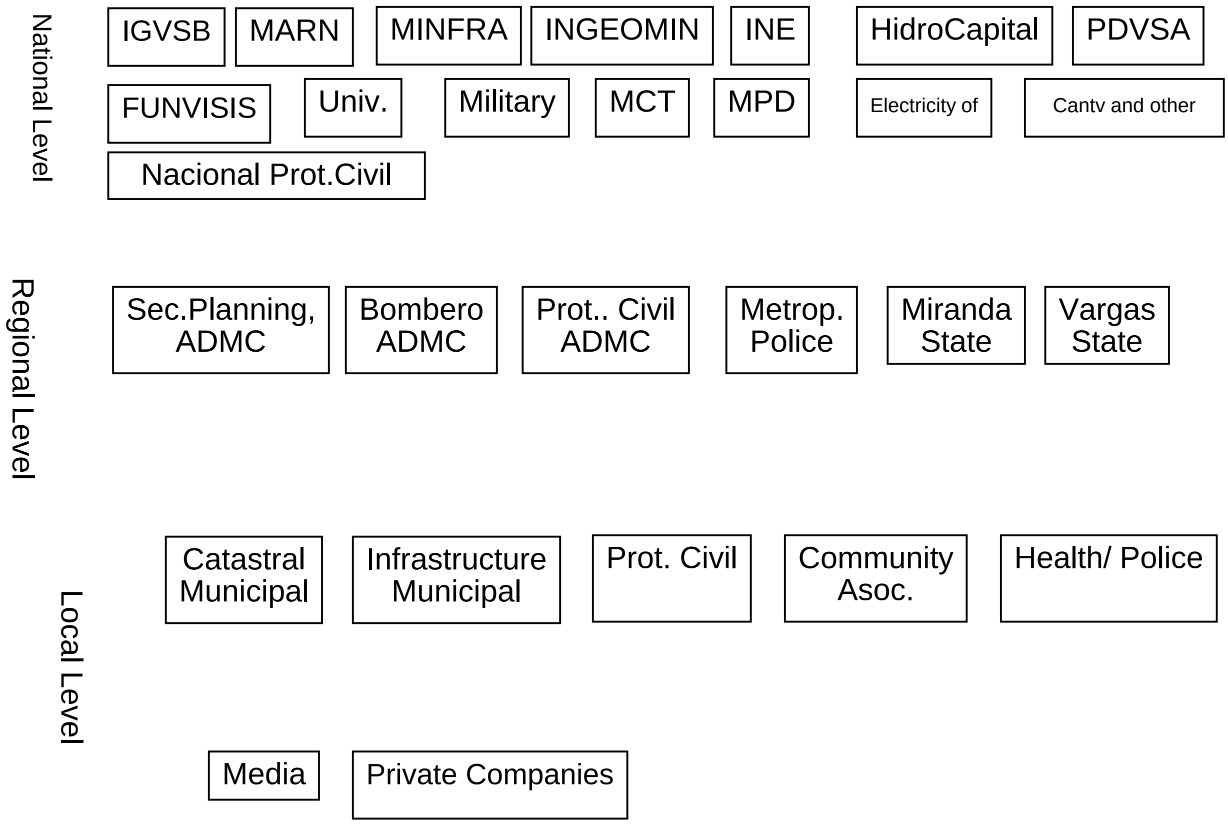


Figure S19-1.8.19 Proposed Institutional Participations

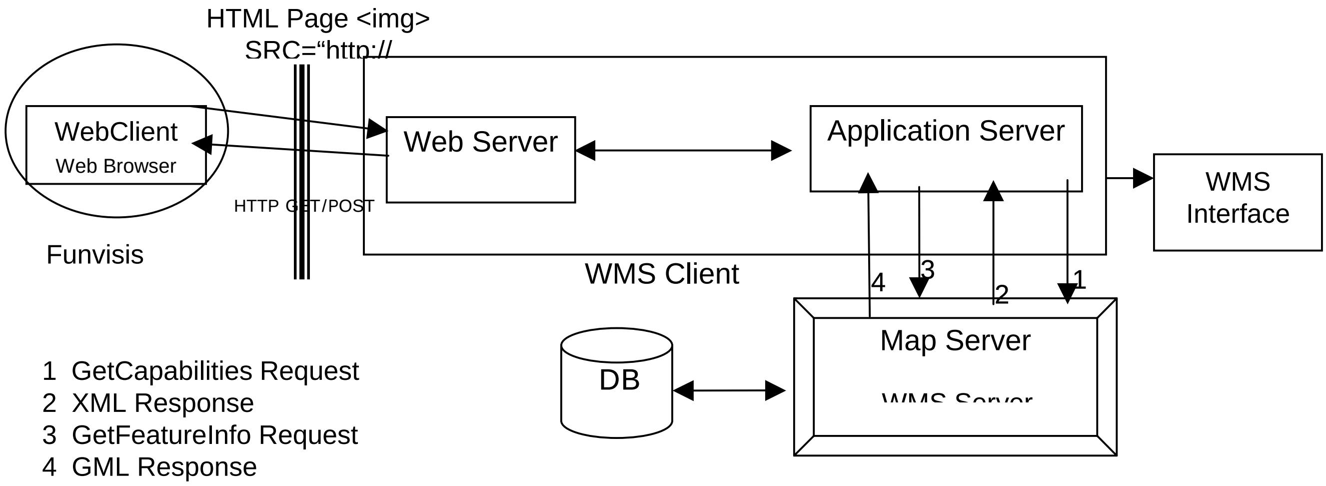
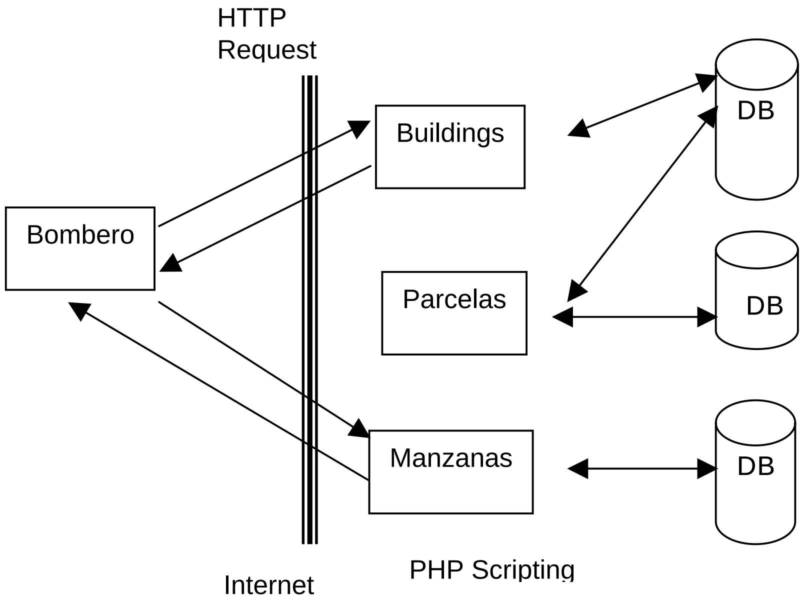


Figure S19-1.8.20 An Example of FUNVISIS Accessing the System

(Web Mapping System, WMS)



Events that will be triggered:

- Map with Attribute data is supplied (stories /structure /fire exit /year of construction /number of person etc.)
- Bombero responds the emergency and register the event
- This event is automatically uploaded via PHP Active scripting

Figure S19-1.8.21 An Example of Firefighters Requesting Detail Building Distribution Map with Attribute Data