The Study on Comprehensive Disaster Prevention around Mayon Volcano

SUPPORTING REPORT (2)

(Part II: Feasibility Study)

XVII : Land Use Planning

SUPPORTING REPORT (2) - XVII
LAND USE PLANNING

Table of Contents

Page

1. BACKGROUND FOR CONCEPT OF LAND USE PLAN XVII-1
   1.1 Present Land Use XVII-1
   1.2 Problems and Issues over Land Use in Yawa Protected Area XVII-2

2. LAND USE PLAN FOR YAWA RIVER SYSTEM SABO PROJECT XVII-6
   2.1 Concept of Land Use Plan XVII-6
   2.2 Basic Concept of Alternatives for Land Use Plan XVII-6
   2.3 Alternative Study XVII-8
   2.4 Land Use Plan XVII-8
   2.5 Land Acquisition XVII-11

List of Tables

Page

Table XVII 1.1.1 Land Use in the Protected Area of the Yawa River Sabo System XVII-14
Table XVII 1.2.1 Self Sufficiency Level in Province of Albay in 1998 .... XVII-16
Table XVII 2.4.1 Proposed Land Use in the Protected Area of the Yawa River Sabo System XVII-17

List of Figures

Page

Figure XVII 1.1.1 Present Land Use in the Protected Area of the Yawa River Sabo System XVII-19
Figure XVII 2.4.1 Land Use Plan in the Protected Area of the Yawa River Sabo System XVII-20
Figure XVII 2.4.2 Future View of the Protected Area of the Yawa River Sabo System XVII-21

SUPPORTING REPORT (2) - XVII
LAND USE PLANNING

1. BACKGROUND FOR CONCEPT OF LAND USE PLAN

1.1 Present Land Use

The area of the Yawa River System Sabo Project (the Yawa Protected Area, 2,539.03ha) and surroundings show clear classification of land cover along its slope over the skirt of Mayon Volcano. The area from the peak of the Mayon Volcano to the 6km radius line, Permanent Danger Zone (PDZ), is mostly covered by lava, volcanic sand, bush and coconut, where is the upper hedge of the Yawa Protected Area. PDZ has an area of 96.28ha. The area from this PDZ toward 10km area is indebted to the Volcano and enriched and grown fertile for the agricultural activity. The area leads farther down to an urban center, the City of Legazpi. The Protected Area is adjacent to the center of the city over Yawa River.

Existing Land Use in the Yawa Protected Area

Land Use	Area (ha)		(%)	
Agriculture	**2,320.70**		**91.40**	**(100.00)**
Paddy	896.94		(40.39)	
Irrigated		648.73		*27.95*
Non-irrigated		248.21		*10.70*
Coconut	594.54		(34.34)	
Idle & Vacant Land (mostly Land covered by Sand & Gravel)	429.60		(15.90)	
Forestry	67.52		(5.52)	
Bush	9.5		(5.59)	
Rural Area	**200.20**		**7.88**	
Residential	111.87		4.41	
Commercial	25.50		1.00	
Industrial	23.02		0.91	
Others	29.96		1.06	
Road Traffic	**18.14**		**0.78**	
Total		**2,539.03**	**100.00**	

Source : CPDO/MPDO,
Assessors Office in City of Legazpi, Daraga and Camalig

(1) Agriculture

The Yawa Project Area has about 70% of the share of agricultural use. The major crop in this area is coconut and paddy, which showed clear occupation along the slope, upland has 7 to 10 degrees and lowland 3 to 7 degrees. The main barangay road mentioned up above is running between these two major crop area and looks like dividing them as upland and lowland. Upland is mostly occupied by coconut and intercropping. Permanent vegetable area can be seen along the barangay road of Mi-isi. Most other vegetables cultivated in this area are harvested along the barangay road on the paddy area between two paddy harvesting period. Paddy is spreading over the lowland area.

(2) Bush and Forestry

Some bush area show their share in the upper part of the Project Area toward into the PDZ. Forestry, mostly “agoho”, has its share along the gully and among the sand and gravel area.

(3) Residential

Twnety barangays are in this Yawa Project Area. Most of the settlement is along the barangay road and in the paddy field. Not so much settlement can be seen in upland area except Anoling.

(4) Vacant Area – Sand and Gravel Area

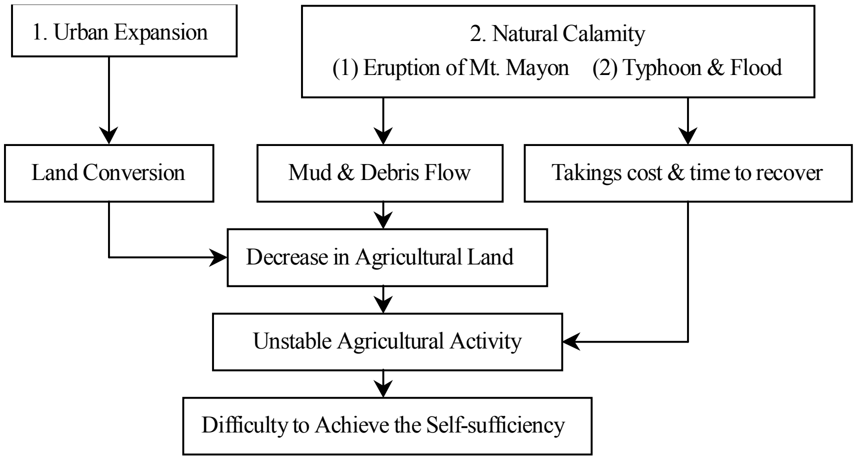
Pyrocrastic materials are deposited at the upper portions due to the eruption of Mayon Volcano. These materials were carried down during flash floods along gullies to tributary rivers like Budiao, Banadero, Mabinit, Matanag and Pawa-Brabod down to the main Yawa River. The quarrying activity can be seen along these gullies.

(5) Road Trafic

The main barangay road running horizontally in the middle of the area between Salvacion, Daraga, and Padang, Legazpi, is the core for residents in this area. Yawa River dividing the Yawa Project Area and the city proper. Also there is the National road running from Salvacion into the center of the city of Legazpi. To commute from the Project Area to the center of Legazpi City there are only two ways, the one from Matanog through Alcara and over Yawa River by the spillway to Binitayan, and another from Bonga through Dirta to Rawis. The new bridge from Pawa to Bogtong over the Yawa River is under construction to be completed in February 2000.

1.2 Problems and Issues over Land Use in Yawa Protected Area

The Yawa Protected Area has two major problems and issues over the land, urban expansion, natural calamity. The figure as follows is the problem structure to explain that these problems and issues lead to a decrease of agricultural land and to the low standard of living.



Problem Structure over the Land in Yawa Project Area

(1) Low Productivity – Low Self Sufficiency in Albay Province

The agricultural sector is a major pillar of economy in Albay. According to the Provincial Food Security Plan 1999-2002, Province of Albay has 158,311.63ha, which is 65.40% of agricultural land in the total area in 1996. However, the sufficiency level of the Province of Albay is 44.60% on average. (Table XVII 1.2.1) Almost 18% or 131,000 people among the total labor force are employed in agricultural endeavor. About 55% of this population live in the rural areas and depend on agriculture as their main source of livelihood. Also, more than 80% of the farm families are classified in the low 30% income group. Therefore, it is the one of the urgent issues for province to achieve a self-sufficiency level at least and improve the living standard of farmers.

One of the factors that makes the increase of productivity difficult is the high cost of the agricultural inputs, fertilizers and pesticides for crops. DA and "Provincial Food Security Plan (1999-2002)", Province of Albay, estimates that the appropriate amount of the fertilizers and pesticides is three to four times more than which are used now. (Refer to Agricultural Development Plan.)

Self Sufficiency Level in Province of Albay in 1998

Commodity	Sufficiency Level (%)
Rice	43.65
White Corn	0.38
Root crop/Tuber	34.92
Vegetables	36.68
Fruit	32.44
Chicken Meat	11.00
Egg(Layers)	41.00
Beef	106.00
Carabeef	67.00
Pork	57.00
Fish	61.50

Source: "Provincial Food Security Plan 1999-2002", Province of Albay

(2) Urban Expansion - Land Conversion

1) Regulations and Rules over the Land Conversion

"Revised Rule and Regulations on the Conversion of Agricultural Lands to Non-Agricultural Uses, 1999", the criteria of the land which can be subject to the land conversion is as follows:

a. Not the irrigated area.
b. Not the Protected Area - NIPAS. (described in Master Plan)
c. Not classified as the Agricultural Land in the LGU's land use plan.

* 500m from the National Rd. can not be classified as Agricultural Land.

2) Present Situation

Land conversion is a typical issue of the agricultural area close to urban area. According to the Provincial Food Security Plan 1999-2002, the latest official data shows that out of the province's total agricultural land of 156,277.00ha, 0.18% or 292.31ha were already converted to other uses such as commercial, residential and industrial areas in a month. Such percentage tends to increase with the growing population.

The Yawa Project Area is adjacent to the center of the City of Legazpi, which is growing rapidly, over the Yawa River. According to the aerial photograph, the center of the city, where used to be about 100ha of the palay area, has been changing into residential in this 20 years and classified as residential area on the land use map of City of Legazpi in 1990. Now the area has changed to be a large sub-division residential area.

3) Irrigation System

According to NIA and “Provincial Food Security Plan (1999-2002)”, Province of Albay, the province had a total potential irrigation area of 50,046ha in 1996. The existing system has a service area of 23,741ha and has a potential area of 26,305ha for development. The province assumed that increasing the irrigation service area and grain recovery, the province will attain self sufficiency and moreover experience the a surplus of 48,797.48 metric tons of milled rice if the existing irrigation system will be increased by 10,926ha.

In the Yawa Project Area, 12 irrigation projects are giving their profits to beneficiaries, 11 private irrigation systems and one irrigation system assisted by other agency.

The Irrigation System in Yawa Project Area (1996)

Name of Irrigation System	Area (ha)
1. Private Irrigation System	
Alcala	119
Bagong Abre	41.5
Banadero	49
Budiao	35
Malobago	22
Matanag	17.30
Quilicao	65
Salvacion	22
Tagas	13.25
Mabinit	15
Matanag	44
Tamayoan	24.40
Sub-total	423.89
2. Other Agency Assisted System	
Pawa CIS*	200
Total	623.89

*CIS : Community Irrigation System

Source : NIA, CENRO

(3) Natural Calamity – Eruption of Mayon Volcano, typhoon and floods

Environmental degradation caused by soil erosion, flash floods and mudflow by the eruption of Mayon Volcano is the major factor to affected agricultural production. (“Provincial Food Security Plan (1999-2002)”, Province of Albay) There are areas, especially the uplands, which are considered prone to erosion under intensive cultivation and floods. In the lowland, according to the aerial photographs in 1999 and 1982, in Yawa Project area, about 17% of the agricultural area, coconut and mostly paddy, had been covered by mudflow by the eruption in 1993 and 1984. (Figure XVII 1.1.1) It has stayed as it is without any rehabilitation over the land covered by mud and sand. Each municipality has a rehabilitation plan over the eroded area especially for coconut and abaca, however they are not progressing so much due to the financial problem.

(4) Land Rehabilitation

According to DENR, municipalities and the aerial photographs (1982, 1999), land, including agricultural area, which has once been covered by mudflow, becomes the sand & gravels area and classified as an idle and vacant land. It stays as it is. Some farmers may start growing vegetables. However, there is no financial or physical assistance or aid for the disaster-stricken land.

2. LAND USE PLAN FOR YAWA RIVER SYSTEM SABO PROJECT

2.1 Concept of Land Use Plan

To solve or improve these problems and issues (Figure XVII 2.1.1), two major concepts are proposed, the improvement of productivity and the prevention of area decrease for agriculture. For each concept, the plan stated below is proposed.

(1) Improvement of the Productivity (Refer to Agricultural Development Plan as a details)

- Agricultural Development Plan
- Livelihood Development Plan

(2) Prevention of Area Decrease for Agriculture

- Sabo Project (Refer to the Sabo Planning as a detail) with Resettlement Plan

For these plans, three concepts, alternatives, of the land use plan had been proposed in the Master Plan. The final plan had been selected by the economic evaluation among these alternatives.

2.2 Basic Concept of Alternatives for Land Use Plan

(1) Alternative

Three alternatives had been proposed as the possible plan. These alternatives can be assessed under the economic evaluation to be chosen as the final plan.

(2) Alternative I : Without Sabo project + Resettlement of all residents.

This is the alternative without the Sabo Facility.

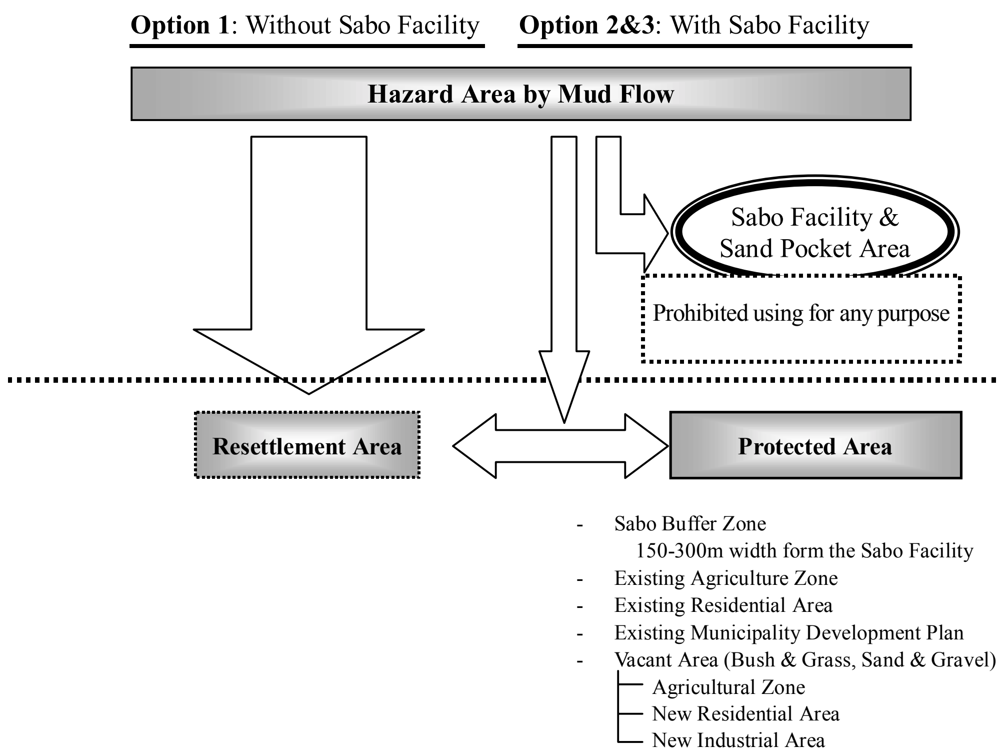
In this option all residents in the hazard area of the mudflow must be resettled and the hazard area will not be utilized for any purpose. The number of residents who should be resettled is the largest among the three alternatives and the new resettlement site must be provided.

(3) Alternative II : Sabo Project + Intensive Agricultural Plan + Resettlement Plan ; Enhancement of the productivity with maintaining present land use.

In the protected area by the Sabo project the agricultural productivity will be enhanced but the present land use should be maintained. The residents under the Sabo facility and the sedimentation area must be resettled in the resettlement area.

(4) Alternative III ; Sabo Project + Agricultural Plan + Agro-industrial Plan + Resettlement Plan ; Enhancement of the productivity with the intensification of land use.

In this alternative the land use of the Protected Area will be enhanced by agro-industrial usage as well as agricultural. The residents under the Sabo facility and the sedimentation area must be resettled in the resettlement area.



Structure of Land Use Classification

2.3 Alternative Study

Based on the economic evaluation the Alternative III has been selected in the Master Plan.

2.4 Land Use Plan

(1) Zoning I : Sabo Facility Area

In the Yawa Project Area two Sabo Facilities are proposed, Anoling and Pawa-Brabod. The area for the Sabo structures and the circumference area, which is 7m from the structure, and Sand Pocket area are subject to the land acquisition to be under the jurisdiction of LGU.

1) Sabo Structure

The total area for the construction is 27.28ha, Anoling 11.59ha and Pawa-Brabod 15.69ha. The total circumference area is 6.81ha, 2.92ha for Anoling and 3.89ha for Pawa-Brabod, which does not include the sand pocket side due to the land acquisition of sand pocket area.

2) Sand Pocket

The total Sand Pocket Area is 553.13ha. This area will be categorized as two areas, the sand sedimentation area and the other area, the upper portion.

(2) Zoning II : Protected Area

1) Forestry Area

a. Buffer Zone

The Sabo-Buffer Zone is proposed along the Sabo Facility, which area is 50m from the facility. The purpose of this Sabo buffer zone is to prohibit the new dwellings there in the future for further safety. For this Buffer Zone agro-forestry plan is proposed under the Agricultural Development Plan.

b. Forestry in Upland

Reforestation Plan is proposed in upland area, which is from the PDZ toward the Project Area to control the erosion and water, in Agricultural Development Plan.

2) Agricultural Area

Agricultural Development Plan is proposed for the Project Area and surroundings. The purpose is to improve the productivity and to encourage water retention in upland as well.

Considering the productivity and cost for the agricultural land development, the area which slope is less than 4% should be the rice paddy, and more than 4% should be the intercropping of coconut, banana or abaca,. In the area under 4% slope, the paddy field can be developed without the land formation for the terrace paddy and the fee for it. These criteria will support the concept of NPAAD and Food Security. To complete the existing irrigation plan and promote the fertilizer usage is more urgent and significant for the productivity improvement than to take the cost for land formation for the terrace paddy in upland and reduce the coconut area.

a. Upland

In upland, the intercropping of coconut & abaca has been proposed to control the water system to prevent the erosion and for the stable water volume in lowland as well as for reforestation.

b. Lowland

The water control in upland leads to the stable water volume and the good maintenance of irrigation system in lowland. The crop pattern will be rice - corn - vegetable or rice -vegetable -rice.

3) Industrial Area

The small agri-business has been conducted in places as the family business base. For the future development of agribusiness in Banquerohan and as the industrial usage for it, the small industrial area for the first processed goods will be proposed in the protected area to be transferred to Banquerohan to be final goods. Also, Mayon Volcano has given sand and gravel of good quality. In this Project Area three industry are proposed, agro-industry, aroma industry, and sand and gravel industry.

a. Agro-Industry

For these industry, several products from coco tree and abaca, perfume and soap from aroma grass & others are proposed. In terms of convenience of the transfer the products the area for the industry is proposed between barangay of Matanag and Mabinit as 3ha.

b. Sand & Gravel

The area for sand and gravel is proposed at the west side of the dyke of Mabinit.

Criteria

- Lot : 3ha at least per a factory & research center
- Road Traffic: 6m wide road as the traffic circulation and a parking lot, which is 10% of the total area.
- Buffer Zone & Utility Zone: five times of the facility area, traffic circulation and buffer zone & utility area.

4) Residential Area

New settlement area is proposed in Matnog, where is the area around the junction of the barangay roads between Salvasion and Sto. Domingo and Mabinit and Daraga. This area is to be the core of this protected area as the junction area of residential, agro-industrial and reserch and commercial.

Criteria

- Lot : 200m^2 at least per a lot per a household
- Road Traffic : 6m wide road as the community circulation
- Residential Buffer Zone & Utility Zone: the area 10% of the total residential and circulation area.
- Park Amenity Zone

5) Service and Commercial

Due to the new industrial and residential area, the service and commercial area will be proposed. Also this is the main function to connect between areas of residential, industrial and park & amenity.

6) Road Traffic

A new main barangay road is proposed from the junction in Matnog to the Upper Area Development Center which is about 2km long. Other secondary road will be proposed to connect the center and the Pilot Farm, Nursery and Sabo dykes as the evacuation road.

(3) Land Area by Category

Refer to Table XVII 2.4.1.

2.5 Land Acquisition

(1) Land Acquisition

The total area, which needs to be expropriated, is 587.21ha, showed in the table as follows and Figure XVII 2.4.1 and XVII 2.4.2, which are the Sabo facility area and the sand pocket area.

The area to be expropriated for the Sabo facility is 34.09ha. The actual area of the facility is 27.28ha and the circumference area, which is 7m form the facility, is 6.81ha.

The total area to be expropriated for the sand sedimentation is 553.13ha, 318.13ha in Anoling area, 235.00ha in Pawa-Burabod area.

Land Acquisition Area for Sabo Facility

Type of Dike	Length (m)	Width (m)	Total Area to be Expropriated for Facility (ha)	Circum-ferential Area (ha)	Total Area to be Expropriated (ha)
Anoling					
Sabo Dam	650.00	37.00	2.41	0.46	2.86
Spur Dike (Type A)	1,725.00	24.00	4.14	1.21	5.35
Spur Dike (Type B)	1,800.00	28.00	5.04	1.26	6.30
Subtotal	4,175.00	89.00	11.59	2.92	14.51
Sand Sedimentation Area (ha)					318.13
Total					332.64
Pawa-Burabod					
Sabo Dam	450.00	35.00	1.58	0.32	1.89
Spur Dike (Type A)	600.00	24.00	1.44	0.42	1.86
Spur Dike (Type B-1)	3,375.00	28.00	9.45	2.36	11.81
Spur Dike (Type B-2)	750.00	28.00	2.10	0.53	2.63
Spur Dike (Type C)	375.00	30.00	1.13	0.26	1.39
Subtotal Area	5,550.00	145.00	15.69	3.89	19.58
Sand Sedimentation Area (ha)					235.00
Total					254.58
Grand Total (ha)	9,725.00	234.00	27.28	6.81	587.21
Total Sand Pocket Area (ha)					553.13

Note: * The area does not include the sand sedimentation area side.

(2) Compensation

1) Criteria of Compensation

a. Landowner

The compensation for landowners should be the purchase price.

b. Tenant : Disturbance Compensation

The compensation for tenants should be the amount of five times the average gross harvest of the last five years.

(3) Criteria of Resettlers

Resettlers must be decided under the consideration stated below.

a. Both Resident & Livelihood (Farmland) are in the Protected Area. In this case, there is no major concern about the residents and livelihood. Therefore, there is no need to consider about the resettlement.

b. Resident is in the Protected Area, and Livelihood in the Construction Area. In this case, the resident will be protected from the mudflow, but the livelihood will be damaged. For this case, two options will be concerned.

   i) Resettlement

   As far as it is not the option for this Study to leave or resettle the residents without livelihood, it can be the alternative to resettle the all residents who lose the farmland and other livelihood because of the construction of Sabo Facility.

   ii) New livelihood in a community

   It is another alternative to create the new livelihood in a community for the residents who lose the farmland and other livelihood because of the construction of Sabo Facility.

c. Livelihood is in the Protected Area, and Resident in the Construction Area. In this case, the livelihood (farmland) will be protected from the mudflow, but the resident will be damaged. For this case, two options will be concerned also.

   i) Resettlement

   In this case it can be solved this issue just by moving the resident into the part of their own farmland or other property.

ii) New Housing Zone in a community

It is another alternative to create the New Housing Zone in a community for the residents who lose the housing because of the construction of Sabo Facility.

d. Both Resident and Livelihood are in the Construction Area. In this case, there is no option to take other than the resettlement with a new livelihood.

Table XVII 1.1.1 Land Use in The Protected Areas Of The Yawa River Sabo System (1/2)

LOCATION	TOTAL PROTECTED AREA IN HECTARES	AGRICULTURAL LANDS (AREAS IN HECTARES) PALAY N I R L	PALAY I R L	COCO LAND	CORN & LEGUMES	BANANA & FRUITS	VEGETABLES ROOT CROPS	HORT OR MIX CROPS	INDUSTRIAL CROPS ABACA	INDUSTRIAL CROPS PILI	OTHERS BUSH	OTHERS FOREST	IDLE LAND (mostly Sand & Gravel)	TOTAL AREA AGRI. LAND	%
CITY OF LEGAZPI															
1 **ARIMBAY**	**75.00**	2.50	33.00	22.41		2.75	4.37	6.37					6.43	64.33	85.77
2 **BAGONG ABRE**	**135.24**	4.84	94.40	28.12			6.99						6.76	134.12	99.17
3 **BONGA**	**228.00**	1.00	25.09	13.09	8.25	8.35	1.63		5.00		61.00	85.53	31.59	217.30	95.31
4 **BUYUAN**	**17.00**	0.29	3.98	2.05				0.29					10.69	17.00	100.00
5 **DITA**	**51.09**	21.37	13.50	13.50	4.50		6.00							48.37	94.68
6 **MABINIT**	**41.50**	0.48	8.05	8.31			0.50				4.50	2.02	17.75	41.11	99.05
7 **MATANAG**	**67.00**	6.56	7.44	18.11	7.75	3.00	0.50					9.50	23.58	65.19	97.29
8 **PAWA**	**184.76**		44.04	36.99	12.00	1.76	1.20	9.99				11.50	88.94	181.47	98.22
9 **SAN JOAQUIN**	**54.67**	32.61	16.60	3.50		1.00								52.71	96.41
10 **TAMAOYAN**	**28.00**	25.72	1.50	0.50										27.72	99.00
SUBTOTAL	**882.26**	95.36	247.60	146.57	32.50	16.86	21.19	16.65	5.00		65.50	108.55	185.73	**849.31**	96.26
MUN. OF DARAGA															
1 **ALCALA**	**169.26**	39.19	*80.50*	*2.00*	*1.00*		*1.00*						1.33	123.02	72.68
2 **BANADERO**	**224.34**	55.98	*50.00*	*100.50*			*0.50*						11.78	218.26	97.29
3 **BUDIAO**	**183.30**	0.44	*78.43*	*59.00*			*1.00*					9.00	32.26	179.13	97.73
4 **BUSAY**	**103.94**	30.00	*37.00*	*4.50*			*0.50*						29.78	101.28	97.44
5 **KILICAO**	**160.49**	10.00	*95.33*	*7.25*	*0.25*		*1.00*						4.35	116.93	72.86
6 **MALABOG**	**54.11**	16.43	*16.57*	*13.60*	*7.10*		*0.50*						6.23	52.83	97.63
7 **MATNOG**	**141.32**		*17.30*	*109.70*	*0.75*		*1.00*				5.00		6.24	138.24	97.82
8 **MI-ISI**	**334.50**			*231.67*			*0.90*				59.23	10.50	31.85	333.25	99.63
9 **SALVACION**	**130.00**		*18.00*	*16.00*			*1.00*						59.03	93.03	71.56
SUBTOTAL	**1,501.27**	152.04	393.13	544.22	9.10		7.40				64.23	19.50	182.85	**1,355.96**	90.32
MUN. OF CAMALIG															
1 **CABANGAN**	**89.98**	0.80	0.53	54.29		0.37		0.78					0.50	56.12	62.37
2 **SUMLANG**	**65.52**		7.48	51.83		2.38			10.38					59.31	90.52
SUBTOTAL	**155.50**	0.80	8.01	106.12		2.75		0.78	10.38				0.50	115.43	74.23
T O T A L	**2,539.03**	248.21	648.73	796.91	41.60	19.61	28.59	17.43	15.38		129.73	128.05	369.07	**2,320.70**	91.40
(%)*		10.70	27.95	34.34	1.79	0.84	1.23	0.75	0.66		5.59	5.52	15.90	**100.00**	

Source: CPDO/MPDO, Assessors Office in City of Legazpi, Daraga and Camalig, JICA Study Team

(%)* : Agricultural Crops / Total Area of Agricultural Land. Rural Land Area / Total Area

(shaded) : Includded in Coco Land and Paddy as the intercropping.

Table XVII 1.1.1 Land Use in The Protected Areas Of The Yawa River Sabo System (2/2)

LOCATION	RURAL (BUILT-UP AREA) LAND (AREAS IN HECTARES)												TOTAL AREA	%	NATIONAL ROAD		BARANGAY ROAD		RAILROAD		TOTAL AREA	%
	ESIDENTIAL		COMMERCIAL		INDUSTRIAL		EDUCATIONAL		RELIGIOUS		INSTITUTIONAL				LENGTH	AREA	LENGTH	AREA	LENGTH	AREA	ROADWAYS	
	No.	AREA	No.	AREA	No.	AREA	No.	AREA	No.	AREA	No.	AREA	RURAL LAND		IN Km.	IN Ha.	IN Km.	IN Ha.	IN Km.	IN Ha.	IN Ha.	
CITY OF LEGAZPI																						
1 ARIMBAY	*435*	2.18	*5*	*6.27*			*4*	*1.02*	*1*	*0.50*			9.97	13.29	1.20	0.70					0.70	0.93
2 BAGONG ABRE	*192*	0.96	*4*				*4*	*0.16*					1.12	0.83								0.00
3 BONGA	*162*	9.90		*0.16*					*1*	*0.04*			10.10	4.43			1.00	0.60			0.60	0.26
4 BUYUAN													0.00	0.00								0.00
5 DITA	*202*	1.01					*3*	*1.32*	*1*	*0.03*			2.36	4.62			0.65	0.36			0.36	0.70
6 MABINIT	*25*	0.13											0.13	0.30			0.45	0.27			0.27	0.65
7 MATANAG	*245*	1.23					*3*	*0.12*	*1*	*0.05*			1.40	2.08			0.70	0.42			0.42	0.63
8 PAWA	*77*	0.94					*3*	*1.02*	*1*	*0.02*			1.98	1.07			3.10	1.32			1.32	0.71
9 SAN JOAQUIN	*317*	1.59					*1*	*0.01*	*1*	*0.04*			1.64	2.99			0.55	0.33			0.33	0.60
10 TAMAOYAN	*26*	0.04											0.04	0.14			0.40	0.24			0.24	0.86
SUBTOTAL	*1681*	17.96	*9*	*6.43*			*18*	*3.65*	*6*	*0.68*			**28.72**	3.25	1.20	0.70	6.85	3.54			**4.24**	0.48
MUN. OF DARAGA																						
1 ALCALA	201	43.41		1.66			6	0.33			1	0.01	45.40	26.82			1.40	0.84			0.84	0.50
2 BANADERO	159	4.32	1	0.05			5	0.02	1	0.01	1	0.04	5.42	2.42			1.10	0.66			0.66	0.29
3 BUDIAO	36	0.11		1.25			1	0.64	2	1.01	1	0.02	3.03	1.65			1,9	1.14			1.14	0.62
4 BUSAY	28	0.66		1.04	1	0.19	1	0.02				0.75	2.66	2.56								0.00
5 KILICAO	167	12.86	1	3.41	15	22.83		0.97	2	0.01	3	0.08	41.16	25.65			4.00	2.40			2.40	1.50
6 MALABOG	37	0.11		0.09									0.20	0.38	0.50	0.30	0.80	0.48	0.40	0.24	1.08	2.00
7 MATNOG	97	0.68		0.89			1	0.01			3	0.01	1.59	1.12			2.50	1.50			1.50	1.06
8 MI-ISI	23	0.75					1	0.50					1.25	0.37								0.00
9 SALVACION	107	4.88	3	10.67			1	0.00			78	15.73	34.27	26.36	1.50	0.90	3.00	1.80			2.70	2.08
SUBTOTAL	855	67.76	5	19.07	16	23.02	16	2.48	5	1.03	87	16.63	**134.99**	8.99	2.00	1.20	12.80	8.82	0.40	0.24	**10.32**	0.69
MUN. OF CAMALIG																						
1 CABANGAN	71	20.55									17	10.33	30.88	34.32	1.70	1.00	2.20	1.32	1.10	0.66	2.98	3.31
2 SUMLANG	14	5.61											5.61	8.57					1.00	0.60	0.60	0.92
SUBTOTAL	85	26.16									17	10.33	**36.49**	23.47		1.00	2.20	1.32	2.10	1.26	**3.58**	2.30
TOTAL	2621	111.87	14	25.50	16	23.02	34	6.13	11	1.71	104	26.96	**200.20**	7.88		2.90	21.85	13.68	2.50	1.50	**18.14**	0.71
(%)*		4.41		1.00		0.91		0.24		0.07		1.06										

Source: CPDO/MPDO, Assessors Office in City of Legazpi, Daraga and Camalig, JICA Study Team

(%)* : Agricultural Crops / Total Area of Agricultural Land. Rural Land Area / Total Area

: Includded in Coco Land and Paddy as the intercropping.

TableXVII 1.2.1 Sufficiency Level in the Province of Albay (1998)

Commodity (1)	Area/Units/ No. of Heads	Production (MT)	Available Supply(MT) (2)	Consumption (MT) (3)	Sufficiency Level (2)/(3)=(4)
Rice	30,062.62	118,042.31	55,583.76	127,344.44	43.65
White Corn	39.00	39.00	33.15	8,836.10	0.38
Yellow Corn	9,980.00	20,277.32	17,235.72	-	-
Rootcrop / Tuber	1,352.47	10,679.00	9,611.10	27,522.11	34.92
Vegetable (specify)	2,103.64	16,630.06	15,266.70	41,619.32	36.68
Leafy	740.20	4,750.22	4,270.20		
Fruit	853.44	7,854.12	6,676.00		
Root	510.00	4,689.44	220.50		
Fruit	3,524.11	21,410.66	9,709.39	29,880.54	32.44
Papaya	101.61	609.66	548.90		
Pinapple	38.00	494.00	222.30		
Banana	3,384.50	20,307.00	9,138.15		
Chicken Meat	610,490.00	885.21	470.08	4,289.99	11.00
Egg(Layers)	305,245.00	1,162.84	1,162.84	2,806.64	41.00
Beef	26,051.00	6,773.26	1,354.65	1,280.59	106.00
Carabeef	37,803.00	1,512.12	279.74	416.19	67.00
Pork	105,133.00	89,363.00	5,004.33	8,740.05	57.00
Fish			23,626.37	38,417.83	61.50
Inland**	787.49	968.08	628.93		
Marine***	6,122 gear units /18CFVs	32839.2	22987.44		

* : Used as animal feed
** : Includes production of freshwater, brackish water, fishcage and communal bodies of water, computed at 66% coefficient.
***: Includs production of 6,122 municipal bancas and 18 registerd CFV; computed at 70% coefficient.
Source : "PROVINCIAL FOOD SECURITY PLAN (1999-2002)" by Province of Albay

Table XVII 2.4.1 Proposed Land Use in The Protected Areas Of The Yawa River Sabo System (1/2)

LOCATION	TOTAL PROTECTED AREA IN HECTARES	Sand Pocket	AGRICULTURAL LANDS (AREAS IN HECTARES) PALAY		COCO LAND	CORN & LEGUMES	BANANA & FRUITS	VEGETABLES ROOT CROPS	HORT OR MIX CROPS	INDUSTRIAL CROPS		OTHERS		IDLE LAND (mostly Sand & Gravel)	TOTAL AREA AGRI. LAND	%
			NIRL	IRL						ABACA	PILI	BUSH	FOREST			
CITY OF LEGAZPI																
1 ARIMBAY	75.00		2.50	33.00	22.41		2.75	4.37	6.37					0.00	57.91	77.21
2 BAGONG ABRE	135.24		4.84	101.16	28.12			6.99						0.00	134.12	99.17
3 BONGA	228.00	80.00	1.00	25.09	53.09	8.25	8.35	1.63		5.00		21.00	37.12	0.00	137.30	60.22
4 BUYUAN	17.00		0.29	3.98	2.05				0.29					10.69	17.00	100.02
5 DITA	51.09		21.37	13.50	13.50	4.50		6.00							48.37	94.68
6 MABINIT	41.50	35.00	0.48	0.33	2.31			0.50				0.00	0.00	0.00	3.11	7.50
7 MATANAG	67.00		6.56	7.44	41.69	7.75	3.00	0.50					9.50	0.00	65.19	97.29
8 PAWA	184.76	120.00		4.48	56.99	12.00	1.76	1.20	9.99				0.00	0.00	61.47	33.27
9 SAN JOAQUIN	54.67		32.61	16.60	3.50		1.00								52.71	96.41
10 TAMAOYAN	28.00		25.72	1.50	0.50										27.72	99.00
SUBTOTAL	882.26	235.00	95.36	207.08	224.15	32.50	16.86	21.19	16.65	5.00		21.00	46.62	10.69	604.90	68.56
MUN. OF DARAGA																
1 ALCALA	169.26		39.19	*81.83*	*2.00*	*1.00*		*1.00*						0.00	123.02	72.68
2 BANADERO	224.34		55.98	*50.00*	*65.50*			*0.50*						11.78	218.26	97.29
3 BUDIAO	183.30	60.00	0.44	*78.43*	*40.26*			*1.00*					0.00	0.00	119.13	64.99
4 BUSAY	103.94		30.00	*66.78*	*4.50*			*0.50*						0.00	101.28	97.44
5 KILICAO	160.49		10.00	*75.33*	*27.25*	*0.25*		*1.00*						4.35	116.93	72.86
6 MALABOG	54.11		16.43	*10.34*	*13.60*	*7.10*		*0.50*						0.00	40.37	74.61
7 MATNOG	141.32	40.00		*17.30*	*40.94*	*0.75*		*1.00*				0.00		0.00	58.24	41.21
8 MI-ISI	334.50	215.13			*27.04*			*0.90*				59.23	0.00	31.85	118.12	35.31
9 SALVACION	130.00	3.00		*18.00*	*72.03*			*1.00*						0.00	90.03	69.25
SUBTOTAL	1,501.27	318.13	152.04	398.01	293.12	9.10		7.40				59.23	0.00	47.98	985.38	65.64
MUN. OF CAMALIG																
1 CABANGAN	89.98		0.80	0.53	54.29		0.37		0.78					0.50	56.12	62.37
2 SUMLANG	65.52			7.48	51.83		2.38			10.38					59.31	90.52
SUBTOTAL	155.50	0.00	0.80	8.01	106.12		2.75		0.78	10.38				0.50	115.43	74.23
TOTAL	2,539.03	553.13	248.21	613.09	623.39	41.60	19.61	28.59	17.43	15.38		80.23	46.62	59.16	1,705.70	67.18
(%)*		32.43	14.55	35.94	36.55	2.44	1.15	1.68	1.02	0.90		4.70	2.73	3.47	97.95	

Source: CPDO/MPDO, Assessors Office in City of Legazpi, Daraga and Camalig, JICA Study Team

(%)* : Agricultural Crops / Total Area of Agricultural Land. Rural Land Area / Total Area

(shaded) : Includded in Coco Land and Paddy as the intercropping.

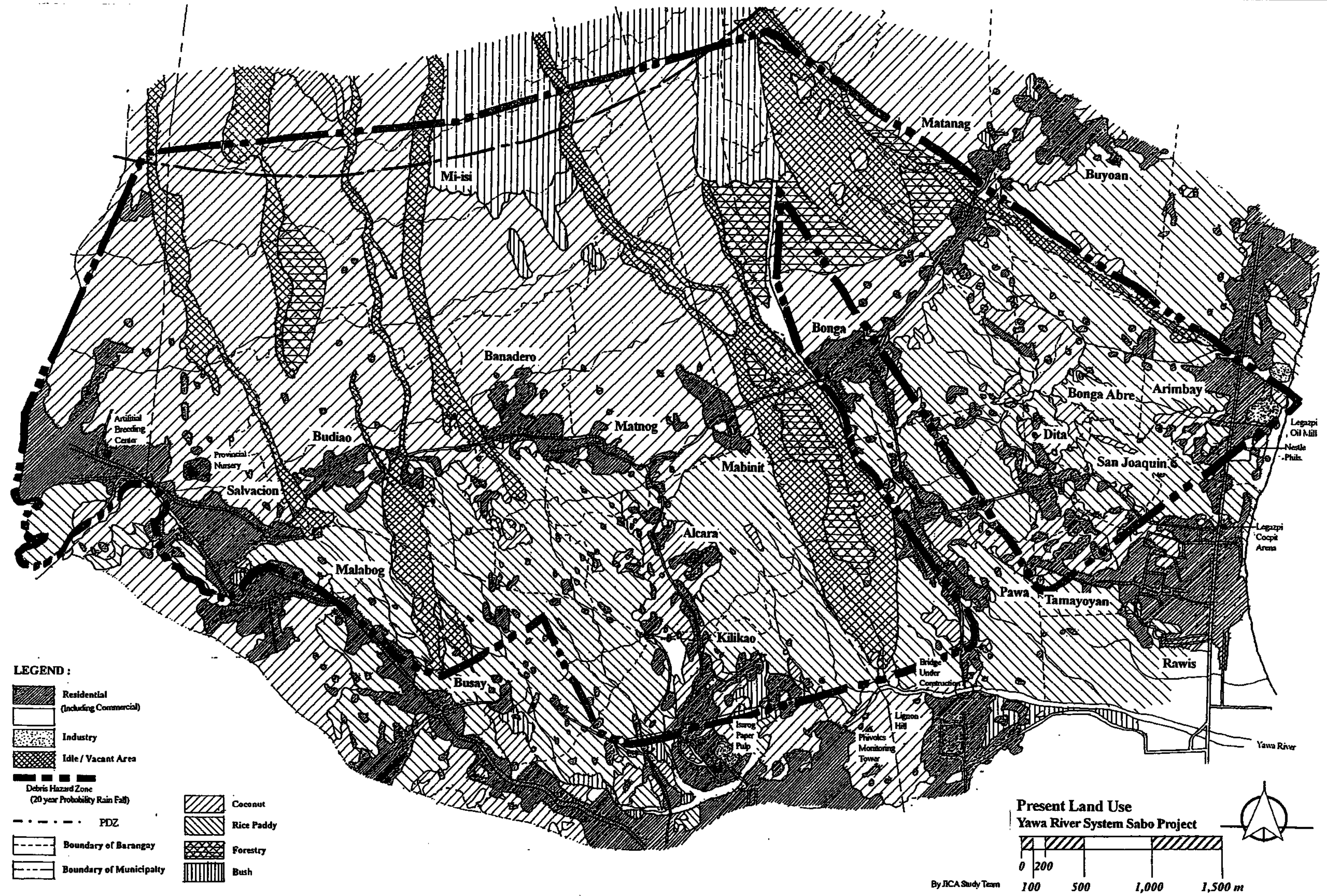
Table XVII 2.4.1 Proposed Land Use in The Protected Areas Of The Yawa River Sabo System (2/2)

LOCATION	RESIDENTIAL AREA	COMMERCIAL AREA	INDUSTRIAL AREA	EDUCATIONAL AREA	RELIGIOUS AREA	INSTITUTIONAL AREA	TOTAL AREA RURAL LAND	%	NATIONAL ROAD LENGTH IN Km.	NATIONAL ROAD AREA IN Ha.	BARANGAY ROAD LENGTH IN Km.	BARANGAY ROAD AREA IN Ha.	RAILROAD LENGTH IN Km.	RAILROAD AREA IN Ha.	TOTAL AREA ROADWAYS IN Ha.	%
CITY OF LEGAZPI																
1 ARIMBAY	2.18	*6.27*	*6.43*	*1.02*	*0.50*		9.97	13.29	1.20	0.70					0.70	0.93
2 BAGONG ABRE	0.96			*0.16*			1.12	0.83								0.00
3 BONGA	9.90	*0.16*			*0.04*		10.10	4.43			1.00	0.60			0.60	0.26
4 BUYUAN							0.00	0.00								0.00
5 DITA	1.01			*1.32*	*0.03*		2.36	4.62			0.65	0.36			0.36	0.70
6 MABINIT	0.13		*3.00*				0.13	0.30			0.45	0.27			0.27	0.65
7 MATANAG	1.23			*0.12*	*0.05*		1.40	2.08			0.70	0.42			0.42	0.63
8 PAWA	0.94			*1.02*	*0.02*		1.98	1.07			3.10	1.32			1.32	0.71
9 SAN JOAQUIN	1.59			*0.01*	*0.04*		1.64	2.99			0.55	0.33			0.33	0.60
10 TAMAOYAN	0.04						0.04	0.14			0.40	0.24			0.24	0.86
SUBTOTAL	17.96	*6.43*		*3.65*	*0.68*		**28.72**	3.25	1.20	0.70	6.85	3.54			**4.24**	0.48
MUN. OF DARAGA																
1 ALCALA	43.41	1.66		0.33		0.01	45.40	26.82			1.40	0.84			0.84	0.50
2 BANADERO	34.32	5.05		0.02	0.01	0.04	39.42	17.57			1.10	0.66			0.66	0.29
3 BUDIAO	0.11	1.25		0.64	1.01	0.02	3.03	1.65			1,9	1.14			1.14	0.62
4 BUSAY	0.66	1.04	0.19	0.02		0.75	2.66	2.56								0.00
5 KILICAO	12.86	3.41	22.83	0.97	0.01	0.08	40.16	25.02			4.00	2.40			2.40	1.50
6 MALABOG	0.11	0.09					0.20	0.38	0.50	0.30	0.80	0.48	0.40	0.24	1.08	2.00
7 MATNOG	20.68	5.89	5.00	0.01		18.01	49.59	35.09			2.50	1.50			1.50	1.06
8 MI-ISI	0.75			0.50			1.25	0.37								0.00
9 SALVACION	4.88	10.67		0.00		15.73	31.27	24.06	1.50	0.90	3.00	1.80			2.70	2.08
SUBTOTAL	117.76	29.07	28.02	2.48	1.03	34.63	212.99	14.19	2.00	1.20	12.80	8.82	0.40	0.24	**10.32**	0.69
MUN. OF CAMALIG																
1 CABANGAN	20.55					10.33	30.88	34.32	1.70	1.00	2.20	1.32	1.10	0.66	2.98	3.31
2 SUMLANG	5.61						5.61	8.57					1.00	0.60	0.60	0.92
SUBTOTAL	26.16					10.33	**36.49**	23.47		1.00	2.20	1.32	2.10	1.26	**3.58**	2.30
TOTAL	161.87	35.50	28.02	6.13	1.71	44.96	**278.20**	10.96		2.90	21.85	13.68	2.50	1.50	**18.14**	0.71
(%)*	6.38	1.40	1.10	0.24	0.07	1.77										

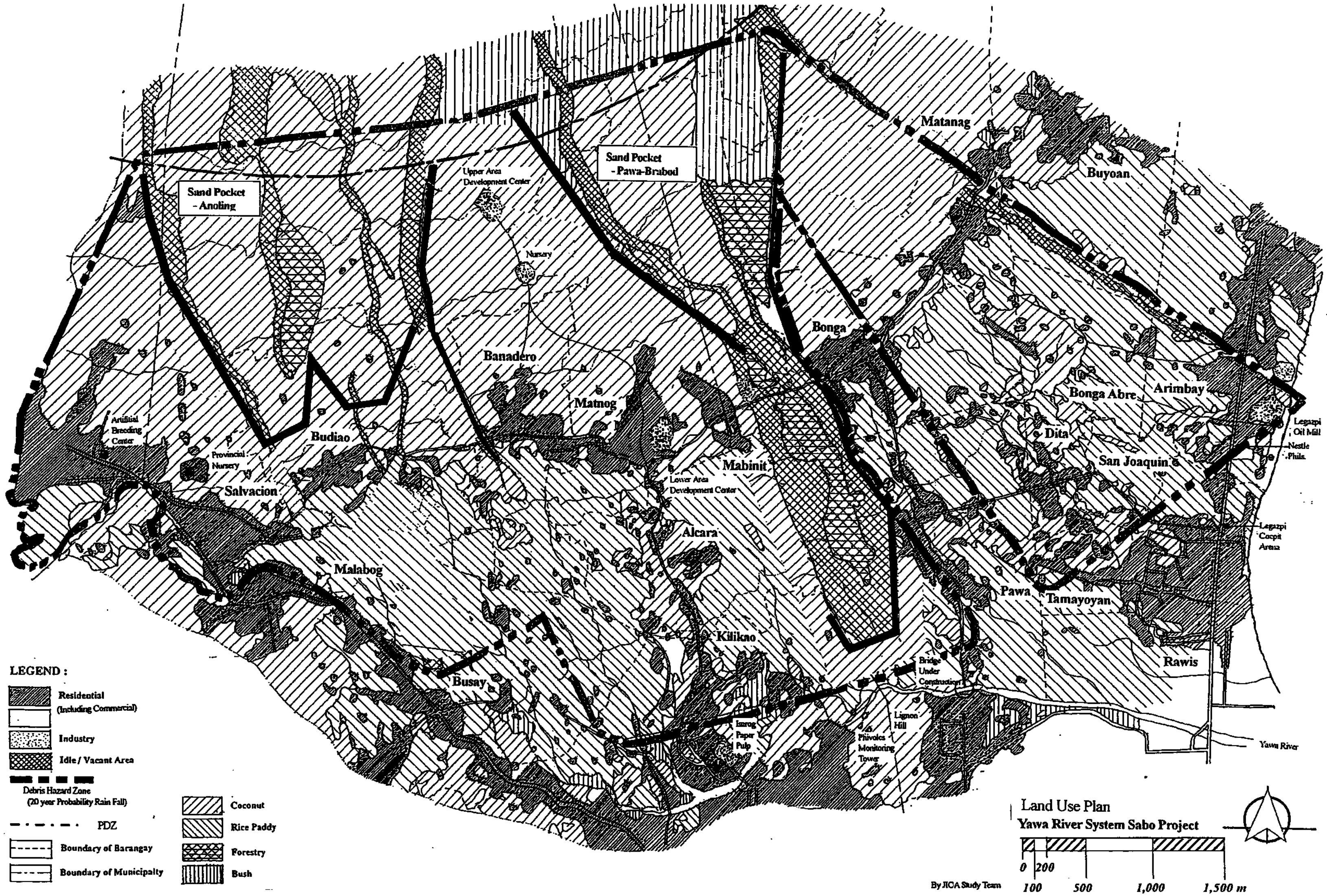
Source: CPDO/MPDO, Assessors Office in City of Legazpi, Daraga and Camalig, JICA Study Team

(%)* : Agricultural Crops / Total Area of Agricultural Land. Rural Land Area / Total Area

(dotted shading) : Includded in Coco Land and Paddy as the intercropping.



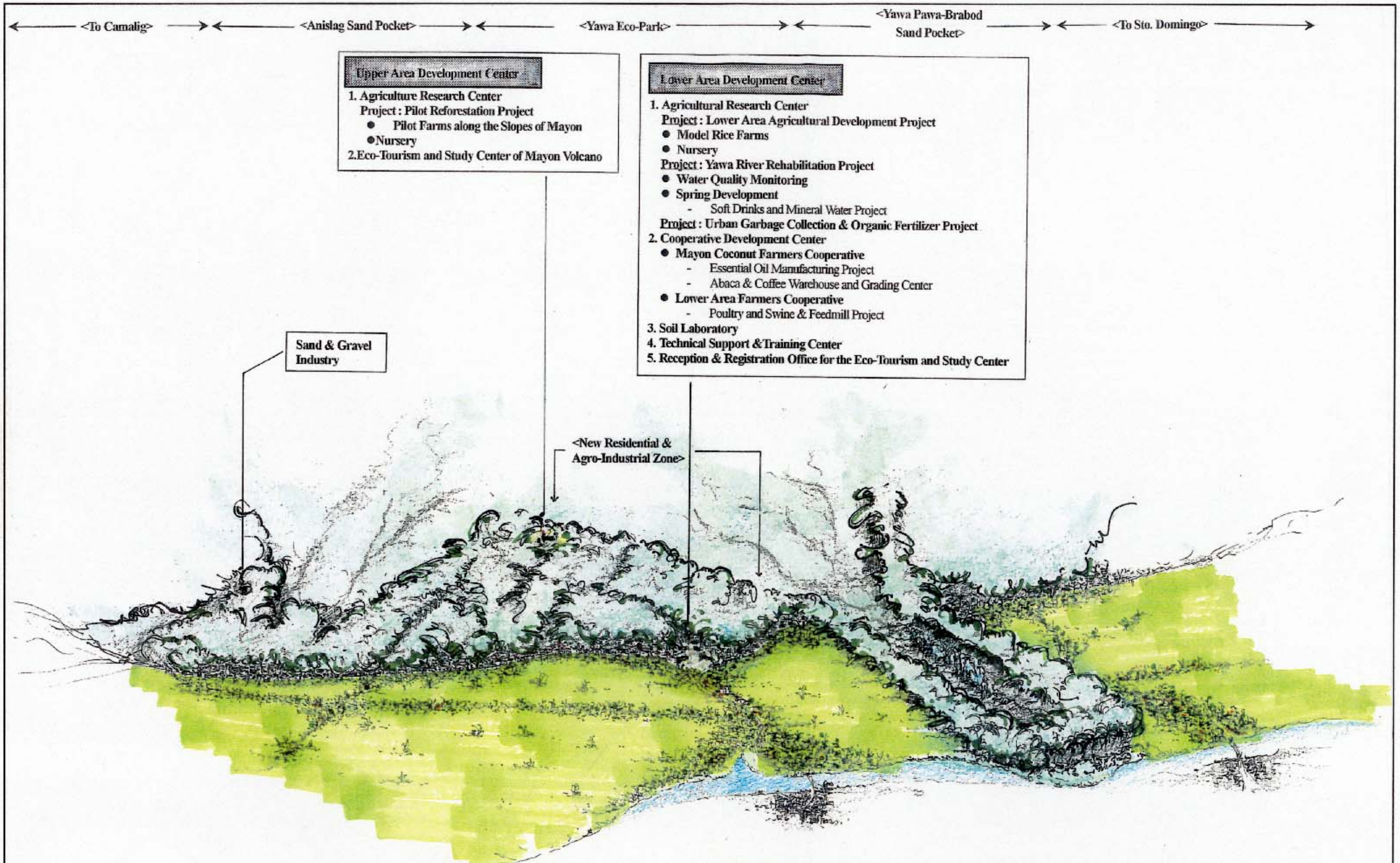
COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure XVII 1.1.1 Present Land Use Yawa River System Sabo Project
JAPAN INTERNATIONAL COOPERATION AGENCY	



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure XVII 2.4.1
Land Use Plan
Yawa River System Sabo Project



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure XVII 2.4.2 Future View of Yawa River System Sabo Project Area
JAPAN INTERNATIONAL COOPERATION AGENCY	

The Study on Comprehensive Disaster Prevention around Mayon Volcano

SUPPORTING REPORT (2)

(Part II: Feasibility Study)

XVIII : Forecasting and Warning System

SUPPORTING REPORT (1) - XVIII
FORECASTING AND WARNING SYSTEM

Table of Contents

Page

1. PRESENT CONDITION OF FORECASTING AND WARNING ....XVIII - 1

2. BASIC CONCEPT OF DESIGN ....XVIII - 2
   2.1 Forecasting and warning for volcanic eruption...XVIII - 3
   2.2 Forecasting and warning for flood, inundation and mud and debris flow XVIII - 3
   2.3 Forecasting and warning for typhoon ....XVIII - 4
   2.4 Warning dissemination..XVIII - 5
   2.5 Inter- agency disaster information system ....XVIII - 5

3. DESIGN OF TELEMETER...XVIII - 5
   3.1 Objective of preliminary design..XVIII - 5
   3.2 Sensor..XVIII - 5
   3.3 Design of communication net work ....XVIII - 7
   3.4 Design of data processing system ....XVIII - 12

List of Tables

Page

Table XVIII 3.1 Losses of Free Space, Topography and Fading ....XVIII - 20
Table XVIII 3.2 Minimum X and Necessary Power...XVIII - 21
Table XVIII 3.3 Allocation of Wave ....XVIII - 22

List of Figures

Page

Figure XVIII 3.1 Communication Network for Rainfall Gauging Stations ....XVIII - 23
Figure XVIII 3.2 Communication Network for Water Level Gauging Stations ....XVIII - 24
Figure XVIII 3.3 Chart to Estimate Loss for Shade ....XVIII - 25
Figure XVIII 3.4 Communication Network for Seismograph...............................XVIII - 26
Figure XVIII 3.5 Critical Lies of Mud and Debris Flow.......................................XVIII - 27
Figure XVIII 3.6 Critical and Warning Lines...XVIII - 28

SUPPORTING REPORT (2) - XVIII
FORECASTING AND WARNING SYSTEM

1. PRESENT CONDITION OF FORECASTING AND WARNING

The identified hazards in the Study area are:

- Typhoon,
- Eruption of volcano,
- Flood and inundation, and
- Mud and debris flow.

Typhoon is monitored by the PAGASA availing global meteorological information to be provided by the international meteorological networks together with domestic weather data observed mainly by themselves. The data and information applied and forecasting method adopted in the forecasting are one of the most updated ones. The strengthening thereof might not be so effective unless global strengthening is attained.

The PHIVOLCS is responsible to monitor and issue warning to the local government if the volcano indicate any sign of eruption. The methods adopted to monitor the volcano are as follows:

Seismograph at 4 sites
Analysis of SO_2 concentration
Deformation of mountain slope by EDM

The identified problems with regard to the installed seismograph are:

- Only one element is observed
- The maximum period to be detected is 1 second
- The observation is concentrated to south to east
- The observed seismic wave is recorded by pen plotter

Meanwhile the existing SO_2 gas analyzing method has problems as follows:

- Sampling site is not fixed

Estimation of deformation on the basis of the EDM data takes a considerable time and recursive estimation with short interval might not be afforded.

Rainfall and river water level data are fundamental to forecast flood and inundation. The PAGASA established climatologic observatories in each municipality to observe meteoro-hydrologic conditions in the Study Area. The problems of the observation are as follows:

- Observation of rainfall is manual with 3 hours interval at shortest.
- The locations of the observatories are low lying urbanized area
- No regular water level observation is conducted in the Study Area

Regional OCD has managed mud and debris flow monitoring system. The system comprises 5 telemetered rainfall gauges and 4 wire sensor systems. The problems thereof are as follows:

- The lead time to be afforded by wire sensor system is only a few minutes
- The observed site is limited to south slope
- Forecasting model does not adapt to the site conditions

2. BASIC CONCEPT OF DESIGN

The selected candidate systems constitute the forecasting, warning and evacuation system of the proposed feasibility plan. The criteria adopted to assess the candidate system to select into the feasibility plan are as follows:

Technical reliability	(accuracy in forecasting and reliability in warning) Accuracy and reliability should be sufficient for evacuation and disaster fighting activity
Compliance to needs	(lead time and quick response) Since the system is to furnish a reliable information for evacuation and disaster fighting activity, the system should afford sufficient lead time quick judgement for those activities.
Availability	(existing infra-structure and system) The proposed system should adapt to the existing local conditions, the existing infra-structure and system should be availed as much as possible.
OMR	(OMR cost and manpower) In order to secure sustainability, OMR cost and manpower input should be considered
Durability	(natural circumstance) The proposed system should be available in a critical circumstance.
Economic aspect	(cost and space) Disaster prevention reduce damage value but does not produce any positive economic value and lesser cost and space are preferable.

In the light of the criteria, following systems were selected as the priority project:

2.1 Forecasting and warning for volcanic eruption

(1) Monitoring

1)	Telemetered seismograph	;	7 stations. 4 existing (Mayon Resthouse, Upper S.Misericordia, B.Anoling, Lignon Hill) and 3 additional (B.Canaway, Upper B. Muladbucad Grandei and U. Banadero)
2)	EDM and GPS	;	Existiong EDM and additional GPS (4 directions at about El. 800m)
3)	Gas analysis	;	Existing : Collector and analyzer

(2) Judgement

1)	Analysis of seismic wave	;	Amplitude and frequency Time of travelling
2)	Analysis of SO_2	;	Concentration of SO_2 in air
3)	Assessment of internal pressure	;	The FEM analysis on slope deformation

(3) Warning

1)	Judgement and decision making	;	PHIVOLCS head office in Manila
2)	Transmission of warning	;	PHIVOLCS observatory in Lignon hill transmits the decision made by the head office to PDCC and MDCC through VHF and the public telephone line

2.2 Forecasting and warning for flood, inundation and mud and debris flow

(1) Monitoring

1)	Telemetered rainfall gauge	;	Existing: 5 (B.Maninila, B.Mabinit, B.Buyuan, B.San Antonio and Mayon Rest House)
		;	Additional: 9 telemetered gauging stations tallying 14 stations to observe the rainfall in the area within the circle defined by 8km radius from the crater of the volcano
2)	Telemetered water level gauge	;	New: 6 (Yawa, Quinali B, San Vicente, Nassissi, Oguson, Quinali A)
3)	Tidal level gauge	;	Legaspi port

(2) Judgement

<u>Flood</u>

1)	Analysis of water level	;	Water level at strategic site and down stream reach
2)	Runoff analysis	;	Measured rainfall

<u>Mud and debris flow</u>

1)	Analysis of measured rainfall	;	Accumulated rainfall and intensity of rainfall
2)	Standard for judgement	;	for watch and evacuaiton

(3) Warning

1)	Judgement and decision making	;	DPWH region V
2)	Transmission of warning	:	DPWH region V transmit warning to PDCC and MDCC

2.3 Forecasting and warning for typhoon

(1) Monitoring(ongoing method)

1)	Satellite	;	GTS and GMS
2)	International information	;	RSM and TYM

(2) Judgement (ongoing method)

1)	Map	;	Meteorological map
2)	Chart	;	Weather chart, atmospheric pressure chart and typhoon track forecasting chart

(3) Warning

1)	Judgement and decision making	;	PAGASA head office in Manila
2)	Transmission of warning	;	From PAGASA Manila to Legazpi observatory by SSB From the observatory to PDCC and MDCC by VHF

2.4 Warning dissemination

(1) Main route	;	PDCC to M/CDCC by VHF radio M/CDCC to BDCC by cellular phone BDCC to each family by house to house Visit
(2) Other route	;	PDCC to mass media

2.5 Inter- agency disaster information system

WEBB server system in PDCC, DPWH, PHIVOLCS, PAGASA, MDCC, CDCC, and ROCD

3. DESIGN OF TELEMETER

3.1 Objective of preliminary design

A preliminary design is to confirm the technical feasibility of the proposed forecasting and warning system. The systems, the technical feasibility to be confirmed are seismographic telemetering system, rainfall gauging telemetering system and water level telemetering system because the local conditions affect these proposed systems and the confirmation of the applicability of these core system are necessary. The feasibility of other systems such as VHF radio communication system are already confirmed in the site or any other sites and the effects of local conditions are deemed not significant.

The main subjects discussed are sensor, communication facility, data processing system.

3.2 Sensor

(1) Seismograph system

The priority project proposes the strengthening of seismograph system to monitor the activity of the volcano. As discussed in the previous chapter, strengthening and improvement of the existing sensor are necessary. The main improvements are:

- detect the wave with longer period (10 sec. or more)
- detect the horizontal wave in addition to vertical one
- detect at the west and north slopes
- detect at the site with a high altitude

The proposed plan is to install seismographs at:

- S5 Upper Canaway (north)El.400
- S6 Upper Mabinit (south) El.1500
- S7 Upper Muladbucad Grandai (west)El.400

The specifications of the proposed seismograph are:

- velocity measurement
- frequency of wave; 0.05 to 100
- maximum period of wave; 20 second
- 3 element per site

(2) Rainfall telemetering system

The strengthening of rainfall telemetering system contribute the improvement of the flood and inundation forecasting and mud and debris flow forecasting. As mentioned in the previous chapter, some improvements in the existing system are necessary. They are:

- Installation of rainfall gauge is concentrated in the southern area and the installations in other area are necessary to cover substantial drainage areas
- Installation does not reflect the spatial distribution of rainfall. A rainfall gauge may represent the rainfall in the surrounding area within a radius of 2.67Km with an error of less than 10%

The proposed sites for installation are:

- P6 upper Santa Misericordia
- P7 DPWH region V
- P8 Matnog
- P Bahag （water level/rainfall）
- P10 Upper Muradbucad Grandei
- P11 Nassissi（water level/rainfall）
- P12 Buang
- P13 San Vicente（water level/rainfall）
- P14 Upper Canaway

The locations thereof are indicated in Figure XVIII 3.1 together with radio circuit plan for telemetering.

The specifications of the proposed rainfall telemetering system are:

- tipping bucket
- event reporting type
- event; 1mm
- maximum intensity 200mm/hour

(3) Water level telemetering system

For the time being, no river water level is observed in the regular basis. The measurement of river watyer level is indispensable to forecast flood and inundation. The hydrologic and river engineering study identified rivers liable to flood. The study identified that Legaspi city is an inundation prone area due to poor drainage system that is affected by the tide.

The identified rivers are the Yawa, Nassissi, Ogson, San Francisco Quinali(B) and SanVicente rivers. The Study identified a strategic key point for each river to monitor the fluctuation of the water level. The proposed water level gauges are planned to be installed at the key points. They are:

- W1 Yawa   Bahag
- W2 Nassissi   Nassissi
- W3 Ogson   Paulog
- W4 S. Francisco   Cavasi
- W5 Quinali(B)   Ogob
- W6 S.Vicente   San Vicente
- T1 Port   Legaspi port (tidal gauge)

The locations thereof are indicated in Figure XVIII 3.2 together with radio circuit plan for telemetering.

The proposed specifications are:

- floating type durable for sand and glavel flow
- minimum scale 1.0mm
- poling type telemeter
- minimum poling interval; 10 minutes

3.3 Design of communication net work

The existing telemetering systems for seismograph and rainfall are using UHF radio with a frequency of 400MHz band. The strengthening system should adapt to the existing ones. The proposed additional gauging sites are 24 which are distributed in the surrounding area of the volcano. Accordingly, some waves allocated to gauging stations might be availed to ones on the other side of the volcano. The consequent numbers of waves might be around 15 waves which is considered to be allowable number of wave allocation. Along this line the feasibility plan constitute the communication net works with UHF with a frequency band of 400MHz.

The proposed networks comprises 2 sub-systems, the seismograph system and rainfall and water level system. The supervisory control unit of the former system is located in the PHIVOLCS observatory at Lignon hill. Mean while DPWH region Voffice is the site for the supervisory control units for rainfall system and water level system. The existing repeater stations in Ligao and Mayon rest house are available for both subsystems .

In order to carry the data collected at northern slope of the volcano within 2 spans, a new repeater station is provided on the east slope of the volcano. The repeater site is Santa Misericordia. The data of U. Canaway seismograph is to be sent to Lignon hill via the repeater station. The data of U.Canaway rainfall gauge is to be sent to DPWH region V via the repeater station.

The existing system proved that S/N ratio of 30dB or more under the condition of fading provide sufficient data transmission quality. And the margin against confidence limit of 10dB or more is necessary according to the experiences.

The necessary antenna output for each station and the required number of circuit wave were studied under the following assumptions and procedure:

(1) Assumptions

The existing system attested the availability of Yagi antenna with 5 elements for transmission and Brown for receiver.

The frequency of the circuit wave is 400MHz.

The existing system attested the availability of antenna pole with an antenna height of 10m.

The S/N ratio of the proposed circuit must be 30dB or more under the condition of fading.

The margin against confidence limit of the proposed circuit must be 10dB or more.

(2) Modeling

Model for S/N ratio

The S/N ratio under fading is given by the following formula:

S/N = x + G1 – L1 .... (1)

Where	x	;	antenna output
	G1	;	antenna gain(Ag), Circuit improvement(Ig), Gain by noize(Ng)
	L1	;	free space loss(Sl),topographical loss (Tl), antenna loss(Al), fading loss(Fl)

Model for margin

Margin against the confidence limit is given by the following formula:

M = x + G2 – L2 .... (2)

Where	x	;	antenna output
	G2	;	Ag, confidence limit (Cg)
	L2	=	L1; S1, T1, A1, F1

(3) Gain and loss

Antenna gain (Ag)

Ag = AG(t) + Ag(r)

Where	Ag(t)	=	11.0dB (5 element Yagi)
	Ag(r)	=	2.1dB (Brown)

Accordingly Ag = 13.1dB .... (3)

S/N improving factor (Ig)

Assuming 70% modulation, Ig = 1.3dB... (4)

Receiving noise gain (Ng)

Comprises internal and external noise, Ng = 120.0dB...................... (5)

Free space loss (Sl)

Sl is given by the following formula:

S1 = 20logf + 20logD + 32.4 .... (6)

Where	f	;	frequency in MHz
	D	;	span length in km

Topographic loss (Tl)

In case topographic profile has sufficient clearance against the 1st Fresnel zone, loss is nil. If the clearance is not sufficient, the loss due to knife edge and loss due to shading are accounted for

Where the depth of the Fresnel radius is given by

$$R = \{ 0.72d1*d2 /(d1+d2) \}^{0.5}$$

Antenna loss (Al)

Transmitter and receiver power line losses, coaxial cable loss and other loss. Power line loss is estimated by the ratio of 0.11dB per meter.

Coaxial cable loss = 0.4
Other loss = 3.0

Assuming the cable length to be 20m, the loss is estimated to be

A ; 7.8dB .... (7)

Fading loss (Fl)

Fading loss is obtained by the following formula:

F1 = 0.2D + 3 .... (8)
Where D ; span length in km

Confidence limit (Cg)

Confidence limit is given by the following formula:

Cg = Ng + Ig – 30
= 91.3 .... (9)

(4) Criteria for circuit design

The formula and figures obtained in the previous paragraph, G1,G2,L1 and L2 are simplified as follows:

G1 = 134.4dB
G2 = 104.4dB
L1 = S1 + T1 + F1 + 7.8
= L2

The design criteria are,

$S/N \geq 30dB$ and
$M \geq 10dB$

Accordingly,

$X \geq Sl + Tl + Fl - 86.6$ (dB)............................. (10)

Where Sl, Tl, and Fl are specific to each span. The antenna output (x) should be so designated to satisfy the equation (10).

(5) Antenna output and necessary power

Terrain profiles were developed for each span on the basis of the topographic map in a scale of 1:33,000 as shown in the group of profiles Figure XVIII 3.2. Sl and Fl can be obtained by formula (6) and (8). The Fresnel zones depicted indicate that losses due to shading should be accounted in the spans of S5-R3, P14-R3, R1-Lignon hill and R1- DPWH region V. The estimated losses are 8.5dB, 8.5dB, 4.5dB, and 5.2dB, respectively on the basis of the chart shown in Figure XVIII 3.3. The total of Sl, Tl, and Fl are summarized in Table XVIII 3.1.

The obtained max. mini of X was 36.1dB for the span R1-DPWH region V. Next to the span, X for the span R1- Lignon hill is 33.7dB, the second largest. Xs of other spans are less than 30dB.

Antenna output X is given by the following formula:

$$X = 20 \text{ Log } w + 30$$

Where w ; power in watt

The necessary transmission power for each station was estimated on the basis of minimum antenna output estimated. The results of the estimation are as follows:

R1 to Lignon hill	;	3 watt
R1 to DPWH	;	5 watt
Others	;	1 watt

Since R1 is the existing Ligao repeater station, public electricity is available. Other stations may be located in the remote area but the necessary power is 1 watt and solar system can be availed for power source. The estimated necessary powers are summarized in Table XVIII 3.2.

The proposed radio circuits for telemetering systems of seismograph, rainfall gauging and water level gauging are shown in Figures XVIII 3.1, 3.2 and 3.4, respectively.

(6) Necessary number of wave

As of now, 10 waves are utilized in the Study Area. They are mostly allocated to the stations located in the southern slope. They are consequently available for the stations located on the northern slope again. The allocation of wave were examined span by span. According to the result of the wave allocation study, 15 more waves are necessary as shown in Table XVIII 3.3.

3.4 Design of data processing system

(1) Volcanic eruption forecasting

PHIVOLCS Manila has carried out the forecasting on the basis of the data obtained at the Lignon hill observatory and other environmental information. At the observatory, the main work is to detect the abnormal activity of the volcano on the basis of the observed seismographic data. Other data processing at the observatory is preliminary data arrangement to send the data to Manila.

Accordingly the data processing system required to the observatory should have functions of supervisory control of telemetering system, graphic display of the obtained seismic wave to monitor and to compilation of a digital data file to attach E-mail. The proposed processing system comprises a control unit, a processing unit, a graphic terminal, a printer and external storage like a DAT.

(2) Mud and debris flow forecasting

The data processing unit should have functions to control telemetering system, forecasting the occurrence of mud and debris flow, issuing warning and data recording. The main component of the data processing system are the supervisory control unit of telemetering system, data processing unit, graphic terminal, printer and external memories.

The highlight of the job of the data processing is the forecasting of the occurrence of mud and debris flow. The forecasting is carried out on the basis of the measured rainfall data and possible future rainfall.

Critical Line

In order to judge the occurrence the critical line of rainfall was developed on the basis of the rainfall records which triggered mud and debris flow in the Pawa-Burabod river and the Padan river as follows:

$Y = -0.03x + 11.3$ .... (1)

Where Y ; mean rainfall intensity in mm/hour

X ; cumulative rainfall depth in mm

The developed model (1) indicate that a rainfall with the mean intensity larger than Y for the measured certain cumulative rainfall X has a high possibility to cause mud and debris flow. The proposed critical line and the plotting positions of the recorded rainfalls are depicted on Figure XVIII 3.5.

Warning and Lead Time

As mentioned in the previous paragraph, a rainfall to be plotted in the upper zone from the developed critical line in the chart has a high possibility of causing mud and debris flow. The issuance of warning should be prior to such situation by means of forecasting to afford the time for disaster preparedness to the people at risk. The necessary lead-time for warning depends on the required time for preparedness.

The system for the preparedness such as organization, communication, transportation, and the physical conditions of the site might be imperative to define the required time against disaster. The system should be so designed as to require the shortest time for preparedness with the highest reliability because the accuracy of forecast become higher if the lead time is shorter. The activities for the preparedness were staged in accordance with roles, responsibilities, and lapse time is shorter.

Stage I : Staff of OCD and DPWH in charge should be stationed at the weather monitoring offices to watch and wait further development for 24 hours by 3 shifts.

Stage II : Warning should be issued addressed to officials and residents at risk for their preparation works. Warning should be released to mass media. MDCC/CDCC and BDCC should commence the preparatory works to execute the disaster management plans. Residents at risk should prepare for evacuation. DPWH should prepare to execute SOP and dispatch inspection teams to the strategic site to monitor the situations of infrastructures.

Stage III : Warning should be issued to all the concerned people, through official routes and mass media because the occurrence of disaster is highly possible. MDCC/CDCC and BDCC should execute their disaster management plan.
Residents at risk should evacuate to the evacuation center DPWH should execute SOP.

Stage IV : Release should be issued to all the concerned people. All the people and officials may resume the normal activities.

The preliminary study on the required time for the activity of each stage tentatively concluded as follows:

Stage I	:	Warning level 1 (WL-1), 1 hour
Stage II	:	Warning level 2 (WL-2), 1 hour
Stage III	:	Warning level 3 (WL-3), 1 hour
Stage IV	:	Warning level 0 (WL-0), 1 hour

The subsequent tentative necessary lead times for warning are as follows:

WL-1	:	4 hours
WL-2	:	3 hours
WL-3	:	2 hours
WL-0	:	after no occurrence of disaster is confirmed (after one shortest dead time of 12 hours)

The assumed lead times indicate that each level of warning should be issued how many hours in advance the occurrence of disaster. For instance warning of level-2 (WL-2) should be issued 3 hours before the occurrence of disaster.

Warning Line

As discussed before, a mud and debris flow occurs when the plotting position of a rainfall reached to the critical line in the chart presented in Figure XVIII 3.5. Accordingly, the locations of the plotting position obtained from the critical line less the forecasted 3 hours rainfall defines the line for warning level 2. The developed formula to define the warning line is as follows:

$$Y = \frac{aX^2+(b+ax_{mt}-ax_1)\,X-(b+ax_{mt})x_1}{(1-a.t1)X-x_1+x_{mt}-(b+ax_{mt}).tl} \quad \text{..} \quad (2)$$

Where

Y	;	y value of warning line with a lead time of tl.
X	;	x value of warning line with a lead time of tl.
a	;	slope of critical line given by equation (1) -0.03
b	;	y- intercept of critical line given by equation (1) 11.3
tl	;	lead time in hour 4, 3 and 2 for WL-1, WL-2 and WL-3 respectively
x_1	;	initial rainfall to start accumulation in mm
x_{mt}	;	assumed maximum rainfall for 1,2 and 3 hours; 156, 141 and 107mm for WL-1, WL-2 and WL-3 respectively

The tl for each warning level might be fixed as assumed until new required lead time is obtained. Meanwhile x_I will vary from event to event. The assumed X_{MT}s are the recorded maximum rainfall depth occurred on January 5 to 7, 1994.

Those maxima were recorded at the same event. In order to secure the safety of disaster preparedness, the adoption of the recorded maxima is recommendable because recurrences of the maxima are provable.

The level zero warning can be issued 12 hours after the subsidence of rainfall because the dead time is set at 12 hours. However, a deliberation on PAGASAs weather forecast is necessary prior to the decision making on the issuance of the release. It is possible that weather threaten the area again after 12 hours dead time.

The warning line was developed applying the recorded maximum rainfall and the consequent warning lines become low, which tends to put alarm with small rainfall. Further, the warning lines start from zero total effective rainfall with negative y value which mean any effective rainfall cross over the warning line. Y value become positive when total effective rainfall become around 15mm.

Meanwhile the recorded maximum rainfall reached that high intensity 6 to 7 hours after the commencement of the event. The accumulated effective rainfall at 5 hours before the occurrence of the recorded maximum 4 hours rainfall is 20mm on Jan. 6, 1994 at 8 o'clock in the morning. Further the minimum accumulated effective rainfall at 5 hours before the occurrence of mud and debris flow is 35.5mm in the case of March 3, 1996. In this accord, it is tentatively concluded that the warning lines are to be applied after the accumulated effective rainfall reached to 20mm.

The example of the warning lines are shown in Figure XVIII 3.6.

(3) Flood forecasting

The data processing system for flood forecasting will be installed in the DPWH Region V to issue warning to the local government. The substantial functions of the system is to control the telemetering system of water level, forecasting of the occurrence of flood, issuance of warning and recording of the collected data. Accordingly the proposed data processing system comprises a control unit, a processing unit, a graphic terminal, a printer, and external storage like a DAT.

The highlight of the job of the data processing is the forecasting of the occurrence of flood. The forecasting is carried out on the basis of the measured rainfall data and water level at the strategic points.

Lead Time for Forecasting and Warning

A timely warning affords time to residents and agencies to prepare against the impeding flood. Residents might evacuate carrying their valuables. Agency might respond in line with their disaster preparedness plans. Measurement of the necessary times for those activities are yet to be done in the occasion of actual disaster. So far the necessary times are assumed on the basis of hearing surveys as follows:

Residents	Preparation for evacuation	:	1 hour
	Evacuation	:	2 hours
Agency	Preparatory works for preparation	:	1 hour
	Mobilization	:	1 hour
	Stationing of monitoring team	:	1 hour

Along this line, 3 levels of warning might be necessary for the disaster prevention activities as summarized in the following table:

Lead Time and Activity by Warning Level

Warning Level	Lead time in hour	Activities Resident and CDCC	Agency (DPWH)
1	4	-	Station by 3 shifts at the monitoring office. Watch and wait further development. Preparatory works to issue second level warning.
2	3	Preparation of evacuation	Issue second level warning to PDCC, MDCC/CDCC and media. Dispatch inspection team to the strategic point of structures. Preparation of emergency response Preparatory works to issue third level warning.
3	2	Execution of Evacuation . Management of Evacuation center	Issue 3rd level warning to PDCC, MDCC/CDCC and media. Execution of emergency response.
0	-	Resume normal Activities	Issue zero level warning to PDCC, MDCC/CDCC and media. Withdraw the emergency response facilities and resources and resume normal activities.

<u>Critical Line</u>

Phase – I study have selected strategic sites for water level measuring for hazardous 6 rivers in the Study Area. The sites are the most vulnerable or representing point of each river. The river water levels at the selected points might be possible to indicate the occurrence of the flood.

Dikes are provided at the banks of the selected site. The height of wave due to winds and hydraulic dynamics during flooding is assumed to be 70cm. In this consequence, the adopted critical water level turned to be 70cm below the top of the river bank. A water level of the stream higher than the critical water level has high possibility to overtop the bank and to cause flooding. Warning is to be issued when the river water level is predicted to exceed the adopted critical water level.

Forecasting algorithm for future water level

a) Most likelihood forecast

As mentioned in the previous sentences, the proposed system measures real time rainfall and water level. The measuring interval of rainfall is deemed to be zero because event report type telemetering system is proposed. The interval of water level is 60 minutes for ordinary case but could be shorten to 15 minutes at critical case because poling type telemetering system is proposed. Consequently the most likelihood estimation for the forecast of discharge at t-hour later is given by the following formula:

$$q(T, t) = Q(T) + EN(T, t) + er \qquad (3)$$

Where	T	;	The time when the forecast is done
	t	;	Lead time of forecast
	Q(T, t)	;	Forecasted discharge for time T + t
	Q(T)	;	Measured discharge at time T
	EN(T, t)	;	External noize affects the system during the period...between the times T and T + t.
	er	;	Error distribute in accordance with the standard normal distribution N (0,1)

The proposed water level telemetering system furnish real time Q (T) through working out the relevant water stage – discharge curve to be established. Er might be assumed zero because the expectation thereof is zero.

Meanwhile, the substantial element of EN (T, t) is runoff corresponding to the rainfall received before T. Or more in accurate, the difference between the runoff at time T and time T + t.

b) Estimation of runoff

There are several method to estimate runoff on the basis of the received rainfall. Most of the methods require calibration using the recorded rainfall and runoff. The runoff record is not available in the Study Area and a hypothetical linear response function (Nakayasu Method) is applied. The method is expressed by the following formula:

$$t_g = 0.26\ L_m^{0.7}$$

$$T_1 = t_g + 0.8\ t_r$$

$$T_{0.3} = 3.0\ t_g$$

$$Q_{max} = AR/\{3\ (0.3\ T_1 + T_{0.3})\} \quad \text{.................................} \quad (4)$$

$$Q_a = (t_t/T_1)^{2.4}\ Q_{max} \quad \text{...} \quad (5)$$

$$Q_d = 0.3^{(t-T_1)/T_{0.3}}\ Q_{max} \quad \text{..} \quad (6)$$

Where

- t_g : Time of concentration (hour)
- L_m : Average distance in km from watershed area to channel (km)
- T_1 : Time of peak runoff (CMS)
- T_r : Duration of rainfall accumulation (10 minutes)
- $T_{0.3}$: Time when the runoff become 30% of the peak (hour)
- A : Catchment area (km^2)
- R : Accumulated rainfall (mm)
- Q_{max} : Peak runoff (CMS)
- Q_a : Runoff in the ascending period (CMS)
- Q_d : Runoff in the descending period (CMS)
- t_t : Lapse of time

In this Study, all the L_ms are less than 10km and t_gs are to be assumed between 0.5 ~ 1.5 hour. Consequently the following constants might be adopted:

$$T_g = 60 \text{ (minutes)}$$

$$T_1 = 70 \text{ (minutes)}$$

$$T_{0.3} = 180 \text{ (minutes)}$$

Working out formula (4), (5) and (6), runoff of each 10 minutes is obtained applying linear interpolation.

c) Filtering

The formula (3) indicate that q(T-1,1) is the most likelihood estimation of Q(T). The difference between the measured Q(T) and estimated Q(T) represent the adaptability of the adopted forecasting moded, formula (3). In order to enhance the accuracy of the forecast, the adjustment factor C is introduced by the means of the filtering as follows:

$$C = \frac{Q(T) - q(T-1,\ 1)}{Q(T)} \quad \text{..} \quad (7)$$

Where C : Adjustment factor of forecast

The consequent forecasting model is presented as follow;

$$q(T, t) = \{ Q(T) + EN(T, t) \} (1 + C) \quad (8)$$

(4) Issuance of warning

Disaster preparedness requires a certain time as mentioned in the former paragraph. The lead time necessary for warning levels of 1, 2 and 3 are 4, 3, hours. Accordingly, warning of each level should be issued as follows:

Warning level 1	:	When the estimated water level corresponding to q(T,4) exceed the critical water level
Warning level 2	:	When the estimated water level corresponding to q(T,3) exceed the critical water level
Warning level 3	:	When the estimated water level corresponding to q(T,2) exceed the critical water level
Warning level 0	:	When the estimated water level corresponding to q(T,6) do not exceed the critical water level

Table XVIII 3.1 Losses of Free Space, Topography and Fading

Span	D (km)	Sl (dB)	Tl (dB)	Fl (dB)	Total (dB)
S5 — R3	6.8	101.1	8.5	4.4	114.0
P14 — R3	6.8	101.1	8.5	4.4	114.0
R3 — LH	11.3	105.5	0.0	5.3	110.8
S6 — LH	10.1	104.5	0.0	5.0	109.5
S7 — R1	7.0	101.3	0.0	4.4	105.7
R1 — LH	17.5	109.3	4.5	6.5	120.3
P6 — DP	10.9	105.1	0.0	5.2	110.3
P8 — DP	4.8	98.0	0.0	4.0	102.0
P9 — DP	4.4	97.3	0.0	3.9	101.2
W1 — DP	4.4	97.3	0.0	3.9	101.2
P10 — R1	7.0	101.3	0.0	4.4	105.7
R1 — DP	20.3	110.4	5.2	7.1	122.7
P11 — R1	3.0	93.9	0.0	3.6	97.5
W2 — R1	3.0	93.9	0.0	3.6	97.5
P12 — R1	9.6	104.0	0.0	4.9	108.9
P13 — R2	8.1	102.6	0.0	4.6	107.2
W6 — R2	8.1	102.6	0.0	4.6	107.2
R2 — R1	11.4	105.5	0.0	5.3	110.8
R3 — DP	10.2	104.6	0.0	5.0	109.6
W3 — R1	1.8	89.5	0.0	3.4	92.9
W4 — R1	5.8	99.7	0.0	4.2	103.9
W5 — R2	9.4	103.9	0.0	4.9	108.8
T1 — DP	1.5	87.9	0.0	3.3	91.2

Note:

D : Span length (km)

$Sl = 20 \log f + 20 \log D + 32.4$

Tl = Chart

$Fl = 0.2 D + 3.0$

Table XVIII 3.2 Minimum X and Necessary Power

Span	Total Loss (dB)	Min. X	Necessary Power (W)
S5 ー R3	114.0	27.4	1
S6 ー LH	109.5	22.9	1
S7 ー R1	105.7	19.1	1
P6 ー DP	110.3	23.7	1
P8 ー DP	102.0	15.4	1
P9 ー DP	101.2	14.6	1
P10 ー R1	105.7	19.1	1
P11 ー R1	97.5	10.9	1
P12 ー R1	108.9	22.3	1
P13 ー R2	107.2	20.6	1
P14 ー R3	114.0	27.4	1
W1 ー DP	101.2	14.6	1
W2 ー R1	97.5	10.9	1
W3 ー R1	92.9	6.3	1
W4 ー R1	103.9	17.3	1
W5 ー R2	108.8	22.2	1
W6 ー R2	107.2	20.6	1
T1 ー DP	91.2	4.6	1
R1 ー LH	120.3	33.7	3
R3 ー LH	110.8	24.2	1
R1 ー DP	122.7	36.1	5
R2 ー R1	110.8	24.2	1
R3 ー DP	109.6	23.0	1

Note

X ≧ Total Loss – 86.6

Output = 10 log W + 30 (dB)

W = 1 : 30.0 W = 4 : 36.0

2 : 33.0 5 : 37.0

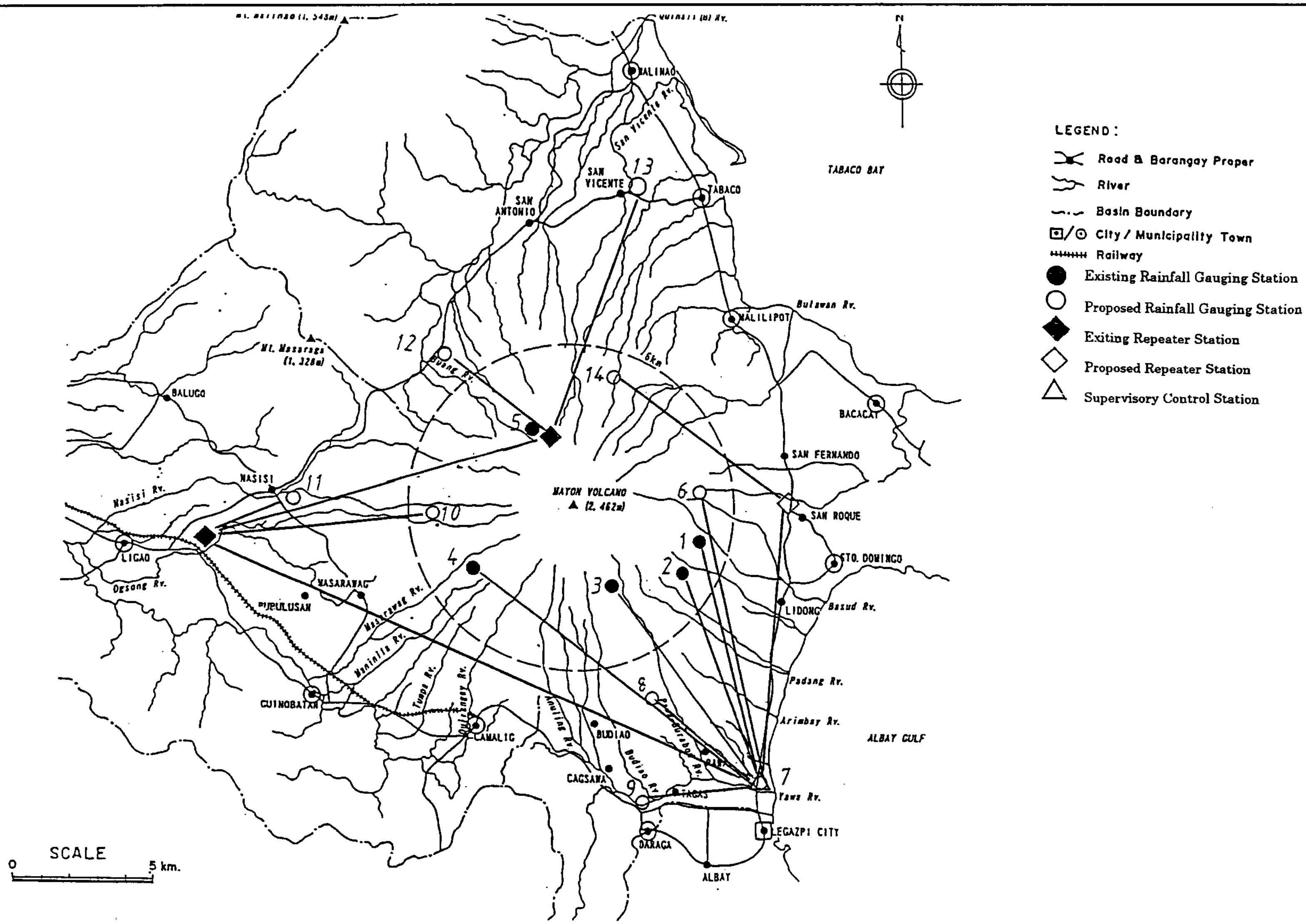
3 : 34.8

Table XVIII 3.3 Allocation of Wave

Span 1	Wave	Span 2	Wave	Span 3	Wave	Existing
S1－LHill	a	－	－	－	－	*
S2－LHill	Cable	－	－	－	－	*
S3－LHill	b	－	－	－	－	*
S4－R1	c	R1－LHill	d	－	－	*
S5－R3	(o)	R3－LHill	e	－	－	－
S6－LHill	(c)	－	－	－	－	－
S7－R1	(e)	R1－LHill	f	－	－	－
P1－DPWH	g	－	－	－	－	*
P2－DPWH	h	－	－	－	－	*
P3－DPWH	i	－	－	－	－	*
P4－DPWH	j	－	－	－	－	*
P5－R1	k	R1－DPWH	l	－	－	*
P6－DPWH	(w)	－	－	－	－	－
P7－DPWH	Cable	－	－	－	－	－
P8－DPWH	m	－	－	－	－	－
P9－DPWH	n	－	－	－	－	－
P10－R1	(a)	R1－DPWH	o	－	－	－
P11－R1	(b)	R1－DPWH	p	－	－	－
P12－R1	(h)	R1－DPWH	q	－	－	－
P13－R2	(p)	R2－R1	(j)	R1－DPWH	S	－
P14－R3	(s)	R3－DPWH	(k)	－	－	－
W1－DPWH	r	－	－	－	－	－
W2－R1	(g)	R1－DPWH	t	－	－	－
W3－R1	(e)	R1－DPWH	u	－	－	－
W4－R1	(a)	R1－DPWH	v	R1－DPWH	X	－
W5－R2	(a)	R2－R1	(n)	R1－DPWH	Y	－
W6－R2	(p)	R2－R1	(r)	－	－	－
T1－DPWH	w	－	－	－	－	－

Note

*：Existing



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES

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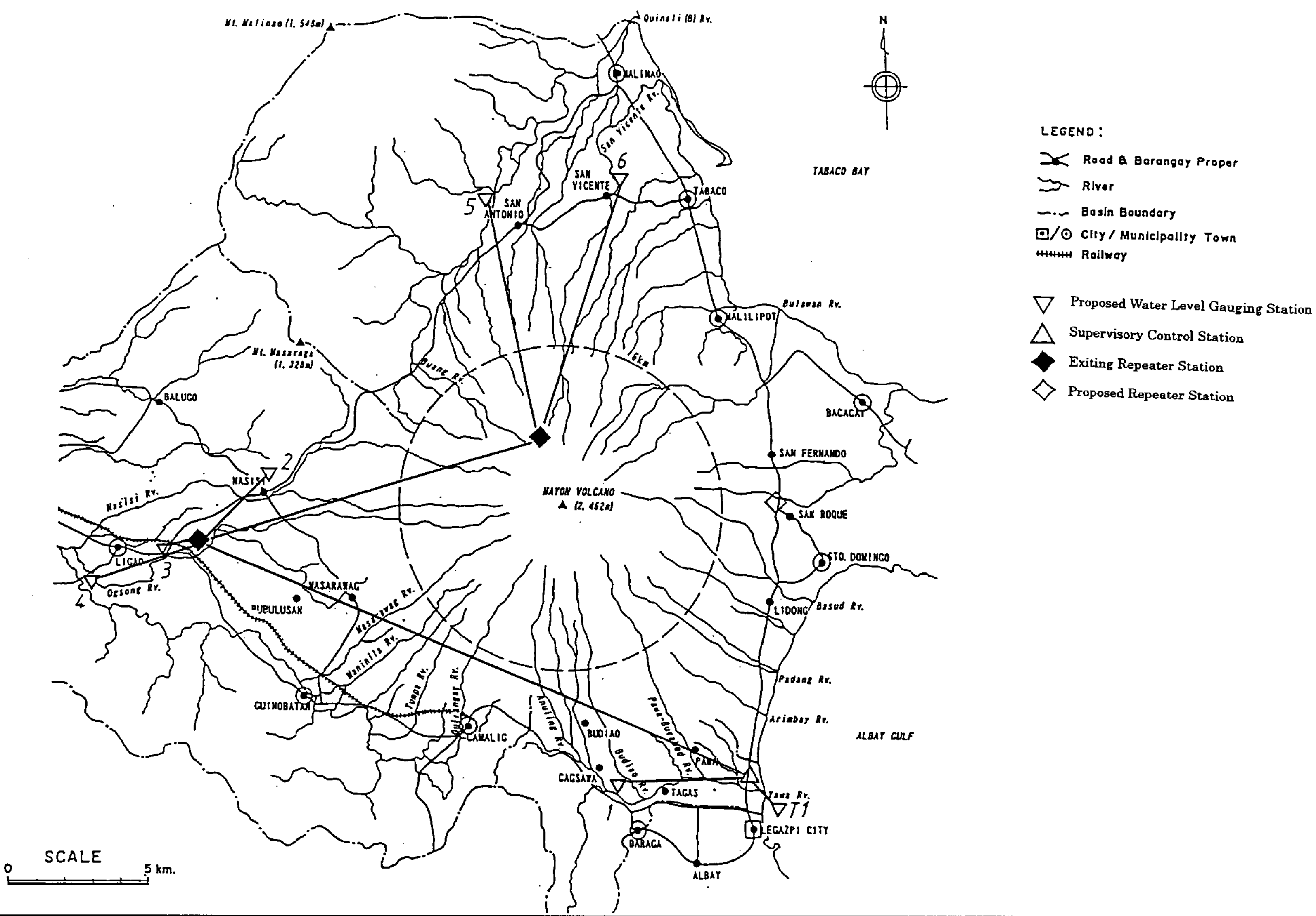
Figure XVIII 3.1
Communication Network For Rainfall Gauging Stations



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES

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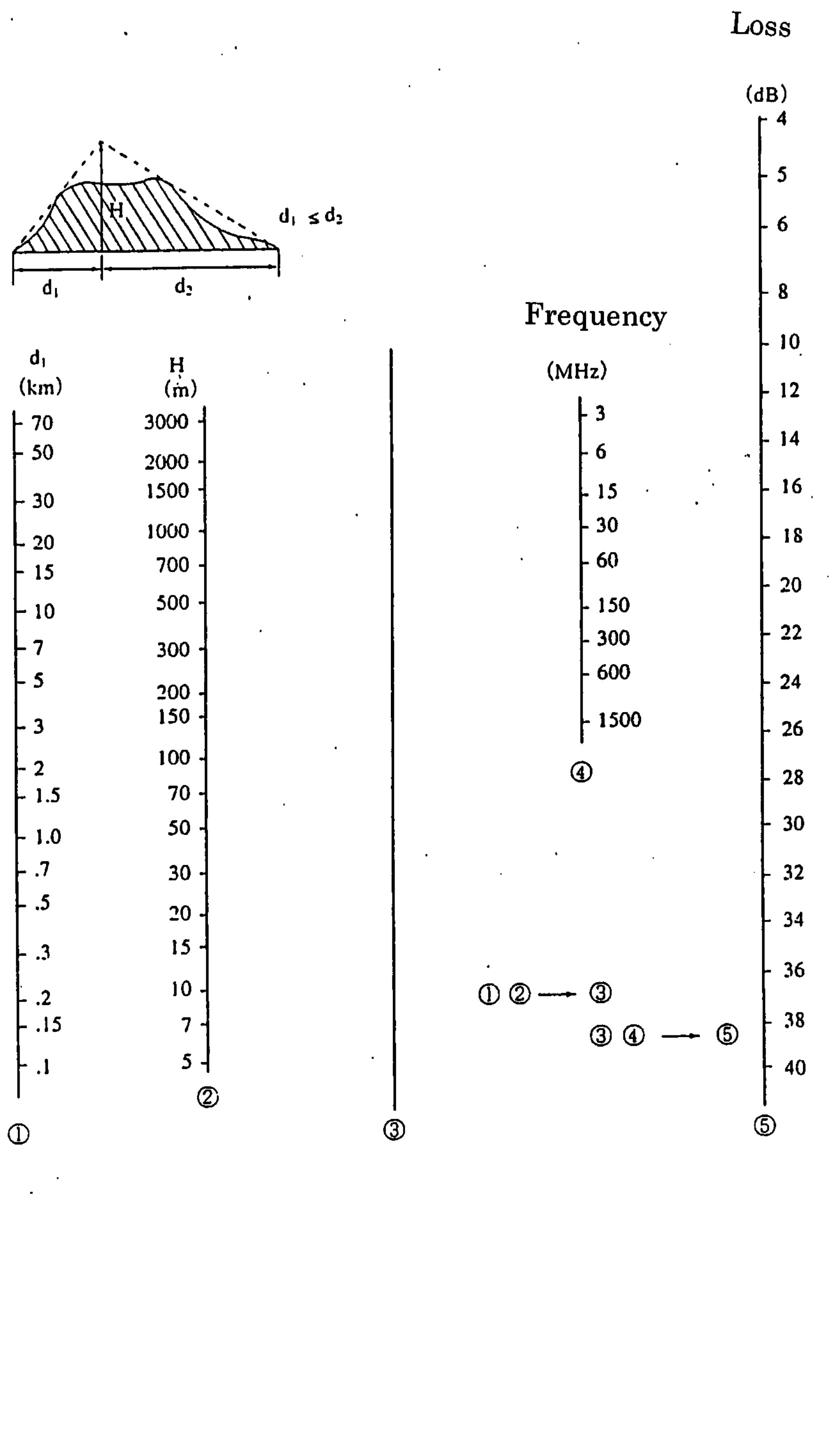
Figure XVIII 3.2
Communication Network For Water Level Gauging Stations



COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure XVIII 3.3** **Chart to Estimate Loss for Shade**
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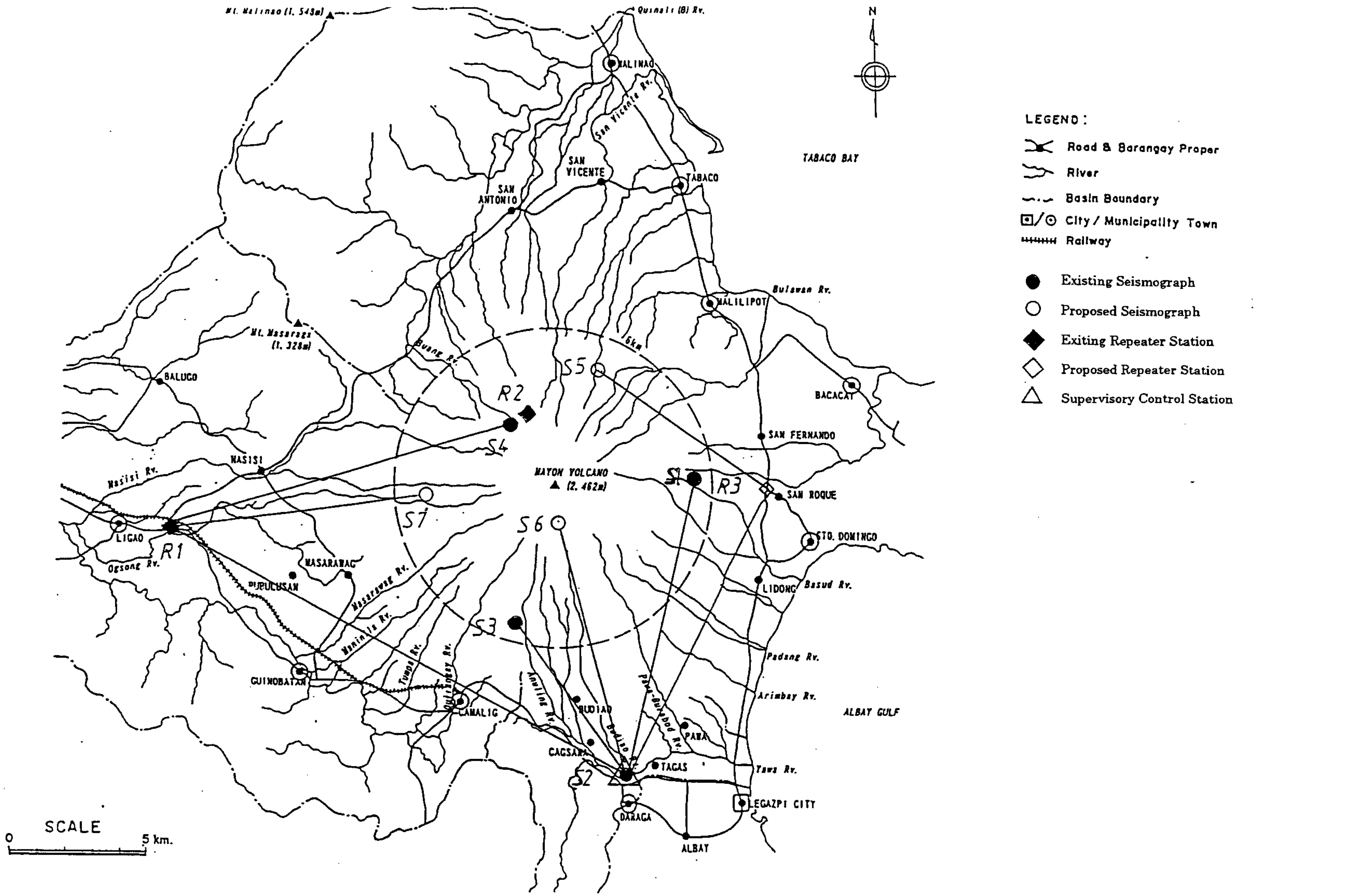

COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	Figure XVIII 3.4 Communication Network For Seismograph
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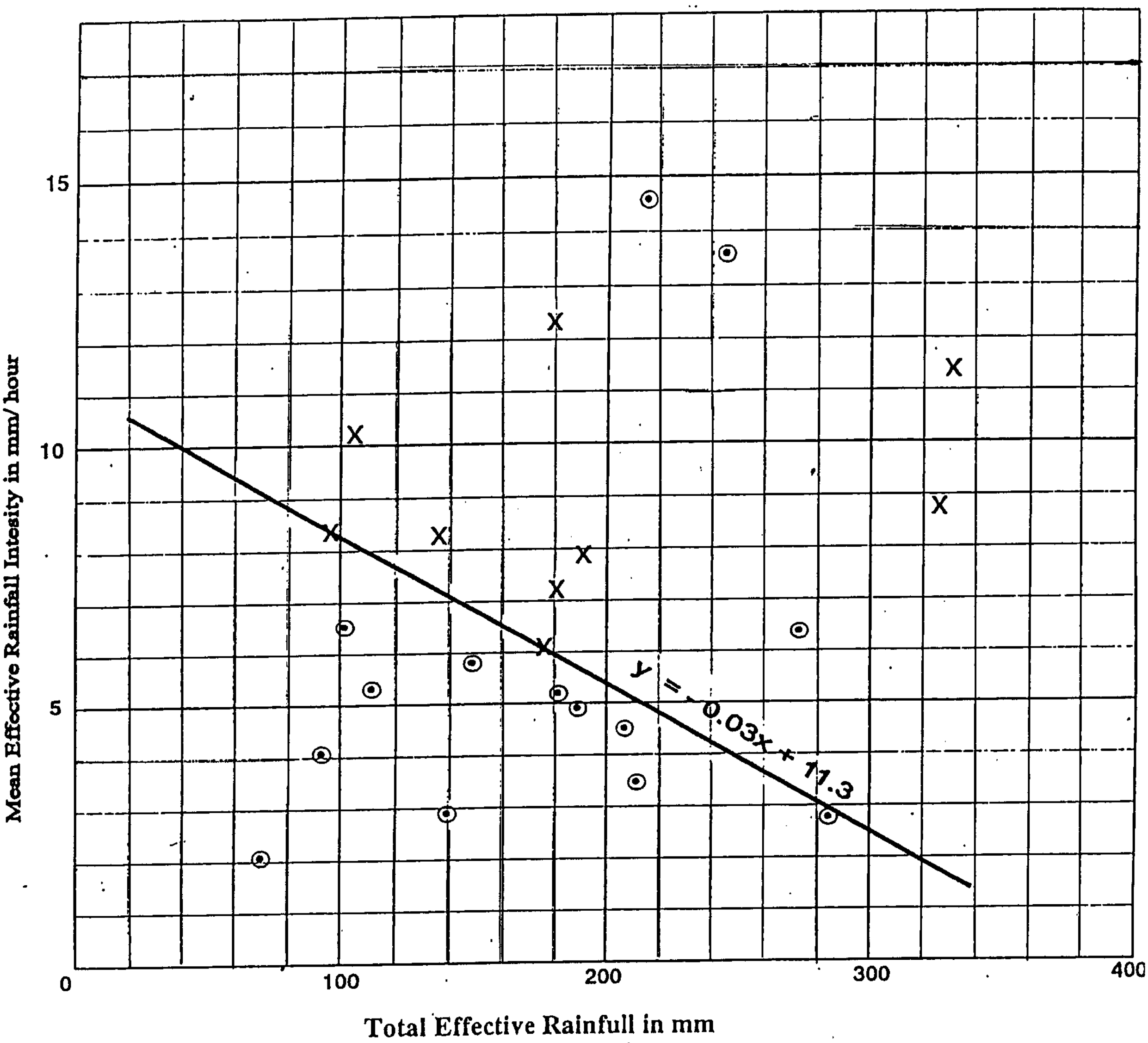

Legend:

⊙ : Plotting position for a heavy rainfall which did not record the occurrence of mud and debris flow.

X : Plotting position for a rainfall which is supposed to be the trigger of the occurred mud and debris flow

COMPREHENSIVE DISASTER PREVENTION AROUND MAYON VOLCANO IN THE REPUBLIC OF THE PHILIPPINES	**Figure XVIII 3.5** **Critical Line of Mud and Debris Flow**
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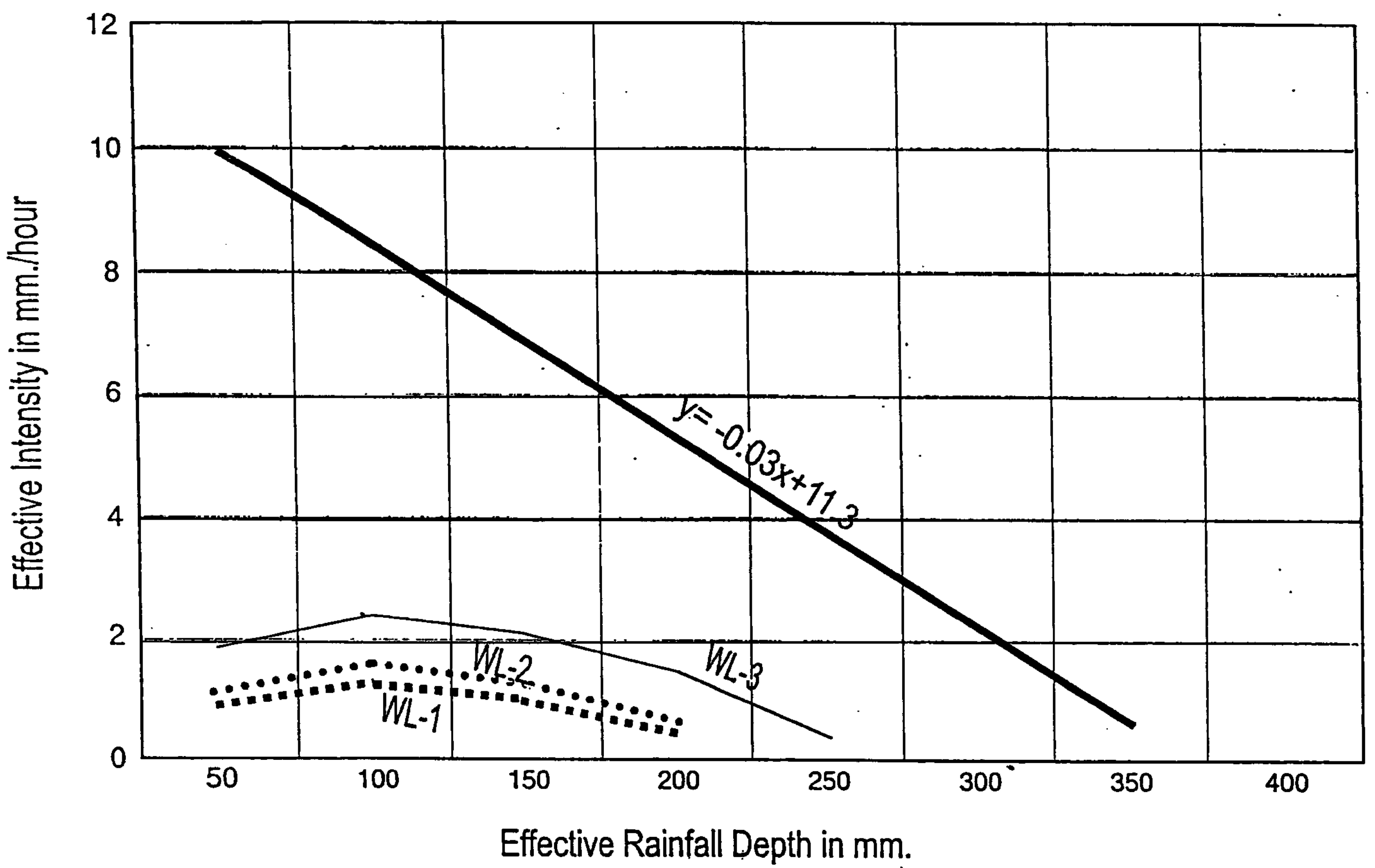

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Figure XVIII 3.6
Critical and Warning Lines