社会開発調査部報告書

No. 52

REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

FEASIBILITY STUDY ON THE RESTORATION OF RURAL ROADS

FINAL REPORT

VOLUME II

MAIN REPORT

JANUARY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

SSF
JR
92-003

REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

FEASIBILITY STUDY
ON
THE RESTORATION OF RURAL ROADS

FINAL REPORT

VOLUME II

MAIN REPORT

JANUARY 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a study on the Feasibility Study on the Restoration of Rural Roads and entrusted the study to the Japan International Cooperation Agency(JICA).

JICA sent to the Philippines a study team headed by Mr. Kunihiko Sawano, Katahira & Engineers International, twice between October 1990 and November 1991.

The team held discussions with the officials concerned of the Government of the Philippines, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

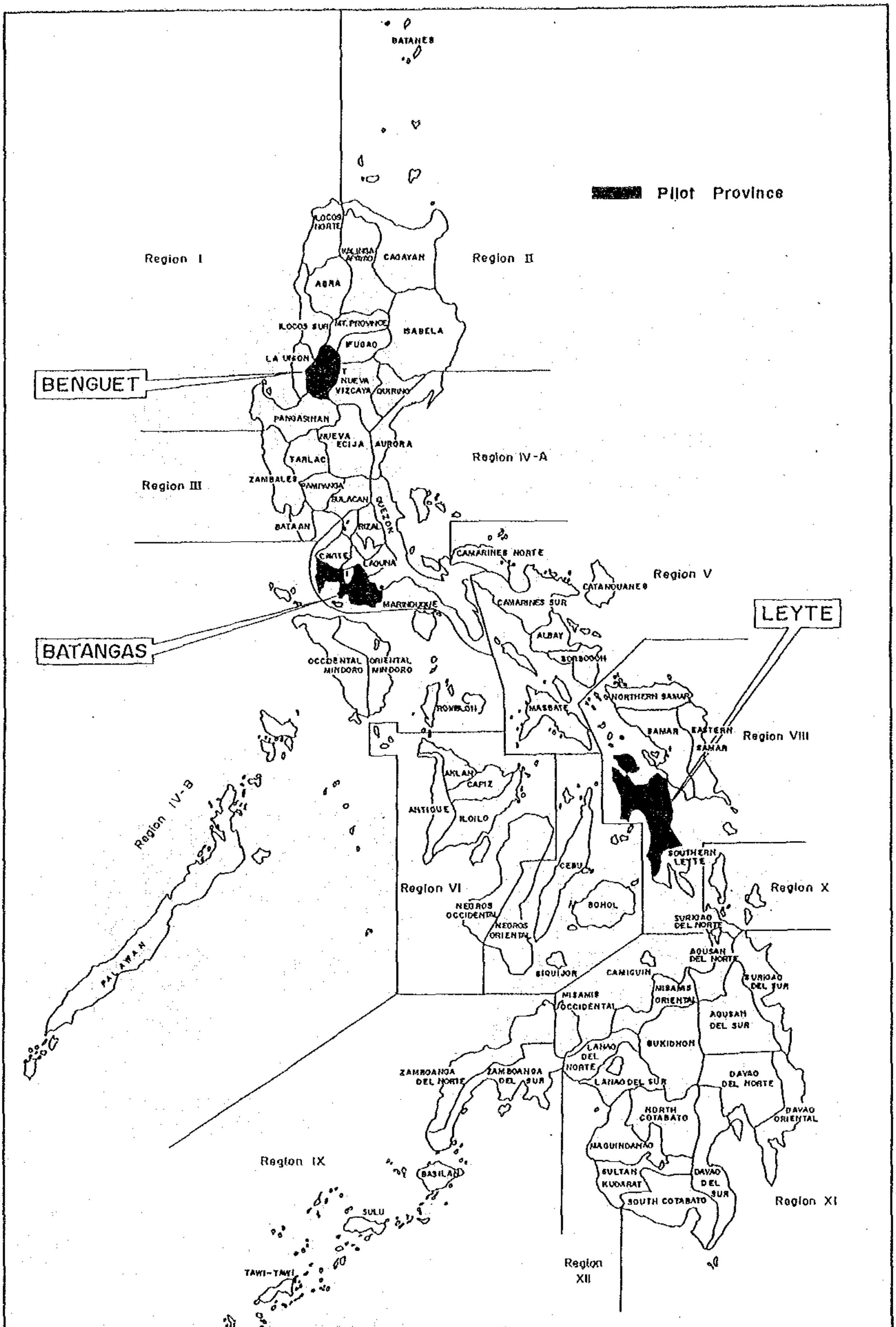
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the the Republic of the Philippines for their close cooperation extended to the team.

January, 1992

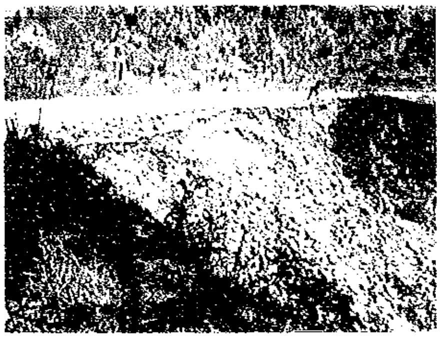
Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency



LOCATION MAP

1. Cut Slope Failure (C-F)
   Spot Bt - 43 (Benguet)



2. Embankment Slope Failure (E-F)
   Spot Bt - 20 (Benguet)

3. Rock Fall/Debris Fall (FALL)
   Spot Bs - 12 (Batangas)

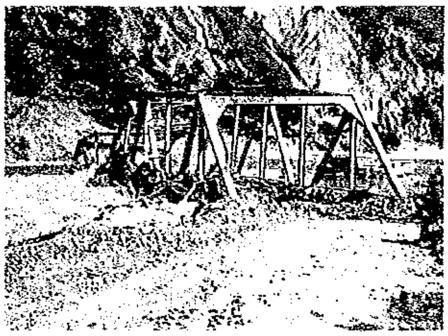
4. Landslide (L-SL)
   Spot L - 50 (Leyte)

TYPICAL DISASTER SPOTS (1)

5. Debris Flow (D - FL)
Spot Bt - 39 (Benguet)

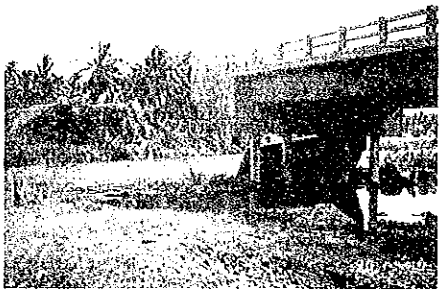
6. Scour/Washout of Roadbed (Rd - D)
Spot Bs - 45 (Batangas)

7. Flooded/Muddy Road Surface (FM-Rd)
Spot L - 23 (Leyte)

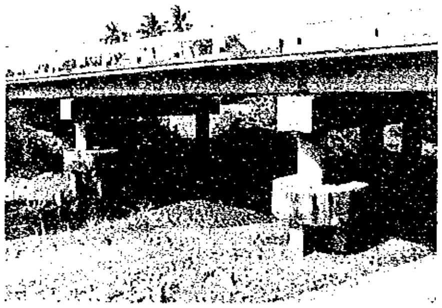


8. Permanent Bridge Washout (PBr-W)
Spot Bt - 27 (Benguet)

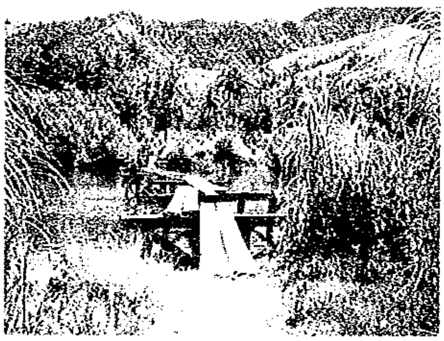
TYPICAL DISASTER SPOTS (2)



9. Permanent Bridge Approach Washout
(PBr - A)
Spot L - 76 (Leyte)



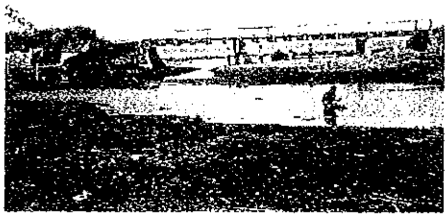
10. Permanent Bridge Other Damage
(PBr - D)
Spot Bs - 6 (Batangas)



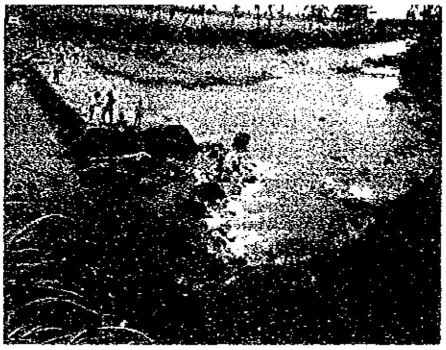
11. Temporary Bridge Washout (TBr - W)
Spot L - 6 (Leyte)

12. Temporary Bridge Approach Washout
(TBr - A)
Spot L - 38 (Leyte)

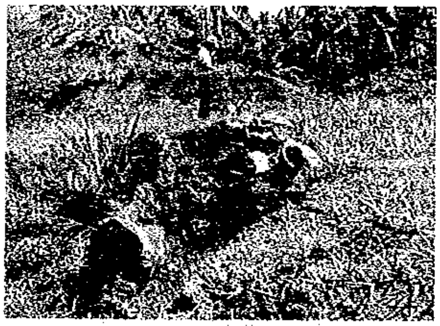
TYPICAL DISASTER SPOTS (3)



13. Temporary Bridge Other Damage (TBr - D)
Spot Bs - 50 (Batangas)



14. Spillway Damage (SPW-D)
Spot L - 90 (Leyte)



15. Culvert Damage (CLV - D)
Spot L - 81 (Leyte)

16. Seawall Damage (SW - D)
Spot Bs - 51 (Batangas)

TYPICAL DISASTER SPOTS (4)

TABLE OF CONTENTS

PAGE

PAGE

FINDINGS AND RECOMMENDATIONS

FINDINGS AND RECOMMENDATIONS

1. FINDINGS

1) Classification of Province

According to disaster potential and topography, provinces were classified as follows:

		Disaster Potential		
		L (Low)	M (Medium)	H (High)
Topography	M (Mountainous)			(CAR) Benguet (CAR) Ifugao (CAR) Abra (CAR) Mountain Province (2) Nueva Vizcaya (4) Aurora (5) Catanduanes (CAR) Kalinga-Apayao (2) Quirino
Topography	MF (Mountainous and Flat)	(11) Davao del Sur (11) South Cotabato (11) Davao Oriental (11) Davao del Norte (12) Sultan Kudarat (10) Misamis Occidental (9) Zamboanga del Norte (12) Lanao del Sur	(6) Antique (10) Agusan del Norte (10) Misamis Oriental (7) Cebu (10) Bukidnon (7) Negros Oriental (4) Romblon (6) Aklan (10) Agusan del Sur	(3) Zambales (8) Southern Leyte (8) Samar (1) Ilocos Sur (1) Ilocos Norte (4) Rizal (5) Albay (4) Marinduque (4) Oriental Mindoro (2) Cagayan (2) Isabela (8) Northern Samar (8) Eastern Samar (4) Batangas
Topography	F (Flat)	(12) Lanao del Norte (12) North Cotabato (9) Zamboanga del Sur (12) Maguindanao (9) Basilan (9) Tawi-Tawi (9) Sulu	(10) Surigao del Norte (4) Palawan (6) Negros Occidental (7) Bohol (6) Capiz (6) Iloilo (10) Camiguin (7) Siquijor (5) Masbate	(5) Camarines Norte (4) Occ. Mindoro (4) Quezon (5) Camarines Sur (8) Leyte (1) La Union (3) Bulacan (11) Surigao del Sur (4) Laguna (3) Bataan (3) Nueva Ecija (4) Cavite (3) Tarlac (5) Sorsogon (1) Pangasinan (2) Batanes (3) Pampanga

Three (3) provinces: Benguet, Batangas and Leyte were selected as pilot provinces.

2) Classification of Road Disaster

Road disasters were broadly classified into six (6) categories based on the portion of roadway damaged, then further classified into 16 categories by type of damage as follows:

Classification by Portion of Roadway Damaged	Classification by Type of Damage	Abbreviation
I. Slope Damage	1. Cut Slope Failure 2. Embankment Slope Failure 3. Rock Fall/Debris Fall 4. Landslide	C-F E-F FALL L-SL
II. Debris Flow	5. Debris Flow	D-FL
III. Road Damage	6. Scour/Washout of Roadbed 7. Flooded/Muddy Road Surface	Rd-D FM-Rd
IV. Bridge Damage	8. Permanent Bridge Washout 9. Permanent Bridge Approach Washout 10. Permanent Bridge Other Damage 11. Temporary Bridge Washout 12. Temporary Bridge Approach Washout 13. Temporary Bridge Other Damage 14. Spillway Damage	PBr-W PBr-A PBr-D TBr-W TBr-A TBr-D SPW-D
V. Culvert Damage	15. Culvert Damage	CLV-D
VI. Seawall Damage	16. Seawall Damage	SW-D

Other damages than listed above, for example, defects in bridge members like crack/spalling of beam/slab/substructure and deterioration of pavement and road accessories, are not covered by this Study.

3) Preliminary Design for the Selected Spots

Major restoration measures applied to the selected 62 disaster spots are as follows:

Type of Disaster	Urgent Measures	Permanent Measures
C-F (Cut Slope Failure)	U1-1: Removal of Deposit Material	P1-1: Recutting P4 : Slope Protection by Vegetation P6-2: Grouted Riprap
E-F (Embankment Slope Failure)	U1-4: Refilling/Embankment U3-1: Sheet Covering, or U3-2: Sand Bag Covering U4-3: Wooden Fence	P1-3: Refilling/Embankment P6-2: Grouted Riprap
FALL (Rock Fall/Debris Fall)	U1-1: Removal of Deposit Material U1-2: Removal of Unstable Material	P1-1: Recutting P6-2: Grouted Riprap, or P8-2: Catch Gabion Wall
L-SL (Landslide)	U1-1: Removal of Deposit Material	P3-2: Horizontal Drain Hole P16-2: Gabion Foot Protection
D-FL (Debris Flow)	U1-1: Removal of Deposit Material	P8-2: Catch Gabion Wall, or P15-1: Concrete Bridge
Rd-D (Scour/Washout of Roadbed)	U1-4: Refilling/Embankment U3-2: Sand Bag Covering	P6-2: Grouted Riprap
FM-Rd (Flooded/Muddy Road Surface)	U2-2: Temporary Side Ditch U7-1: Gravel Surfacing	P2 : Surface Drainage P19-1: Gravel Surfacing
PBr-W/TBr-W (Permanent/Temporary Bridge Washout)	U6-2: H-Pile Bent U6-3: Bailey Bridge	P15-1: Concrete Bridge, or None
PBr-A/TBr-A (Permanent/Temporary Bridge Approach Washout)	U6-3: Bailey Bridge	P6-2: Grouted Riprap P15-1: Concrete Bridge
PBr-D/TBr-D (Permanent/Temporary Bridge Other Damage)	None	P16-1: Concrete Foot Protection
SPW-D (Spillway Damage)	U1-5: Selected Material Fill U4-2: Gabion Wall	P6-6: Supported Type Concrete Wall P19-3: Concrete Pavement
CLV-D (Culvert Damage)	U1-4: Refilling/Embankment U3-1: Sheet Covering U3-2: Sand Bag Covering U4-1: Sand Bag Wall	P2 : Surface Drainage P6-2: Grouted Riprap
SW-D (Seawall Damage)	U4-3: Wooden Fence	U6-4: Gravity Type Stone Masonry, or U6-5: Gravity Type Concrete Wall

4) Project Evaluation

Technical Evaluation

The restoration measures proposed for the selected 62 disaster spots were examined on their technical feasibilities in terms of constructability, stability, durability, maintainability and environmental aspect.

From all technical points of view, the proposed restoration measures were judged to be feasible, with the following comments:

- Gabions, H-piles, bailey panels and seeds for vegetation may not always easily be procured. Proper steps for improving such situation are expected.

- Unconventional type of work such as gabion work and horizontal drain hole must be well understood on their construction requirements.

- Maintenance works especially for drainage system, vegetation and catch work need to be done in proper timing.

Economic Evaluation

The economic evaluation was made for permanent restoration measures against the condition where only urgent restoration measures are taken or do-nothing condition as the case may be, except for temporary bridge washout for which the following two cases were examined:

- Evaluation of bailey bridge construction against do-nothing condition; and

- Evaluation of concrete bridge construction against the condition of being restored by bailey bridge.

The former case is considered as restoration to the original condition, while the latter case as its upgrading.

The results of economic analysis show that implementation of the proposed restoration measures are all economically feasible, except that the feasibility of upgrading scheme of washed-out temporary bridge restoration depends on traffic demand.

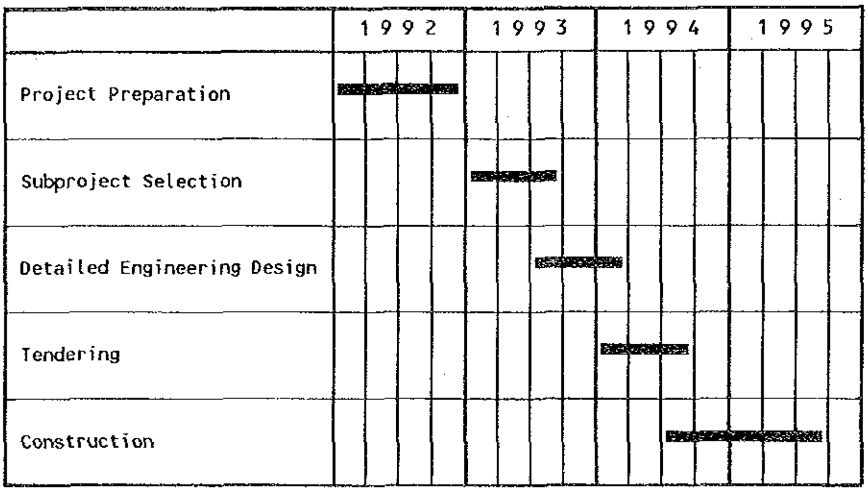
5) Implementation Program for Rural Road Restoration Project

The rural road restoration project is proposed as a foreign- assisted project with the object of restoring the damaged facilities that are left behind without having been covered by maintenance fund/calamity fund.

The project covers restoration of damaged facilities on national secondary roads, provincial roads and barangay roads in the 40 provinces which are ranked high disaster potential in the classification of province shown in 1) above. Road disasters in the following states are eligible to subproject:

- Damage left unrestored, keeping the road section closed to traffic;
- Progressive defect suspected to cause a serious damage in future even though presently no interference to traffic; and
- Damage for which only stopgap measure is taken, needing permanent measure for preventing its recurrence.

Implementation Schedule



Fund Requirement

Construction cost	510.6 million pesos
Cost for consulting services	66.4 million pesos
Total	577.0 million pesos

2. RECOMMENDATIONS

1) In line with the government policy on highway sector giving priority to the rehabilitation and restoration of existing facilities, the rural road restoration project is proposed as a foreign-assisted project.

   Since the project is composed of many small-scale subprojects, introduction of program type of loan is recommended.

2) Gabions, due to their advantages of being flexible, permeable, easily and quickly constructable, and economical, are widely applicable to restoration works as main material for retaining wall, foot protection, catch work, slope breasting, sabo dam, consolidation, spurdike, etc. However, the gabion supplying capacity in the Philippines is presently very low.

   Political measures to promote the spread of gabions are recommend to be taken. Establishment of gabion factories at seven (7) locations is proposed in this Study.

3) Many bridges and/or their approaches have been or will be damaged or destroyed causing traffic interruption.

   For these portions to be opened to traffic urgently, recommended is a stockpile of such bridges as are disintegrated into pieces, transported and assembled at site. Establishment of 13 depots possessed of 10 sets of 19-m span bridge and equipped with a complete set of equipment and tools necessary for construction of the bridge is proposed in this Study.

PART I

INTRODUCTION

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The development of the highway network in the Philippines is one of the major programs being implemented by the Government in support of the overall socio-economic development goals of the country. Road improvement and construction activities began in early 1970's and have been pursued continuously since then. At present, the road system would seem adequate in terms of location and extent, except those in some remote areas where improvement is now actively implemented.

Despite the fact, however, that a quantitative expansion of road system has been realized, the qualitative improvement of roads is still far from adequate. There is in fact an increase in road disasters such as slope failure, debris flow, landslide, and the like caused by typhoons and heavy rains, resulting in interruption of traffic. These problems in existing facilities have started to affect the overall efficiency of the road network, which if not corrected, will impede the momentum of the socio-economic development currently being pursued for the country.

In recognition of the problems attached to these road disasters, the Government of the Republic of the Philippines (hereinafter referred to as "GRP") has planned the formulation of a long term program on disaster prevention and conducted the following two (2) studies with technical assistance provided by the Japan International Cooperation Agency (hereinafter referred to as "JICA"), which is the official agency responsible for the implementation of technical cooperation programs set up by the Government of Japan (hereinafter referred to as "GOJ"):

The Feasibility Study of Philippine Road Disaster Prevention Project, June 1984; and

The Feasibility Study of Philippine Road Disaster Prevention Project, Stage II, July 1985.

The studies covered the Pan-Philippine Highway (Luzon and Samar - Leyte Section only) and the three (3) roads leading to Baguio. Based on the findings through the studies, disaster prevention projects along major trunk roads are now being implemented.

Moreover, road disasters have occurred along rural roads more frequently, where the permanent and full-scale prevention measures are not taken. These include slope failure, debris flow, washout of roads and the like. These disasters have obstructed the linkages from the rural areas resulting in hampering efficient distribution of agricultural and industrial commodities form surplus production areas to deficit areas, as well as efficient movement of people and services among growth centers and between these centers and hinterlands.

Thus, restoration of these rural roads damaged by disasters is an urgent issue in the highway sector to provide essential transportation facilities and improve agricultural productivities in rural areas.

With this view, GRP through the Department of Public Works and Highways (hereinafter referred to as "DPWH") sought a technical assistance from GOJ for the conduct of the Feasibility Study on the Restoration of Rural Roads (hereinafter referred to as "the Study").

In response to the request of GRP, GOJ decided to conduct the Study. JICA organized a study team to be engaged in the Study. The JICA Study Team, in close collaboration with the DPWH Counterpart Team, commenced work in September 1990 and completed its tasks in January, 1992.

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are:

1) To identify disaster spots along rural roads in the pilot provinces and recommend restoration measures.

2) To prepare a program for implementation of the recommended restoration measures.

3) To develop techniques of restoring rural roads damaged by disasters.

4) To pursue technology transfer to the Philippine counterpart personnel in the course of the Study.

1.3 SCOPE OF THE STUDY

In order to achieve the objectives mentioned above, the Study was carried out in four (4) stages. The scope of work is as follows:

Stage I: Selection of Pilot Provinces and Identification of Disaster Spots in the Pilot Provinces

Three (3) provinces covering all types of disaster commonly found in the Philippines shall be selected as the pilot provinces.

Disaster spots along rural roads in the pilot provinces shall be identified and about 60 spots shall be selected for feasibility study.

Stage II: Feasibility Study on Typical Disaster Restoration Measures

Feasibility Study shall be carried out for the disaster spots selected under Stage I, including traffic study, engineering surveys, preliminary design, cost estimate and project evaluation.

Stage III: Preparation of Implementation Program for the Selected Disaster Spots

Practical implementation program for restoration of the selected disaster spots shall be prepared based on the preliminary design conducted under Stage II.

Stage IV: Preparation of Rural Road Restoration Manual

Rural Road Restoration Manual shall be prepared based on the findings from the whole study. The manual shall cover procedure for identification of road disaster, design of restoration measure, and construction methods of restoration works.

The study flow diagram is presented in Figure 1.3-1.

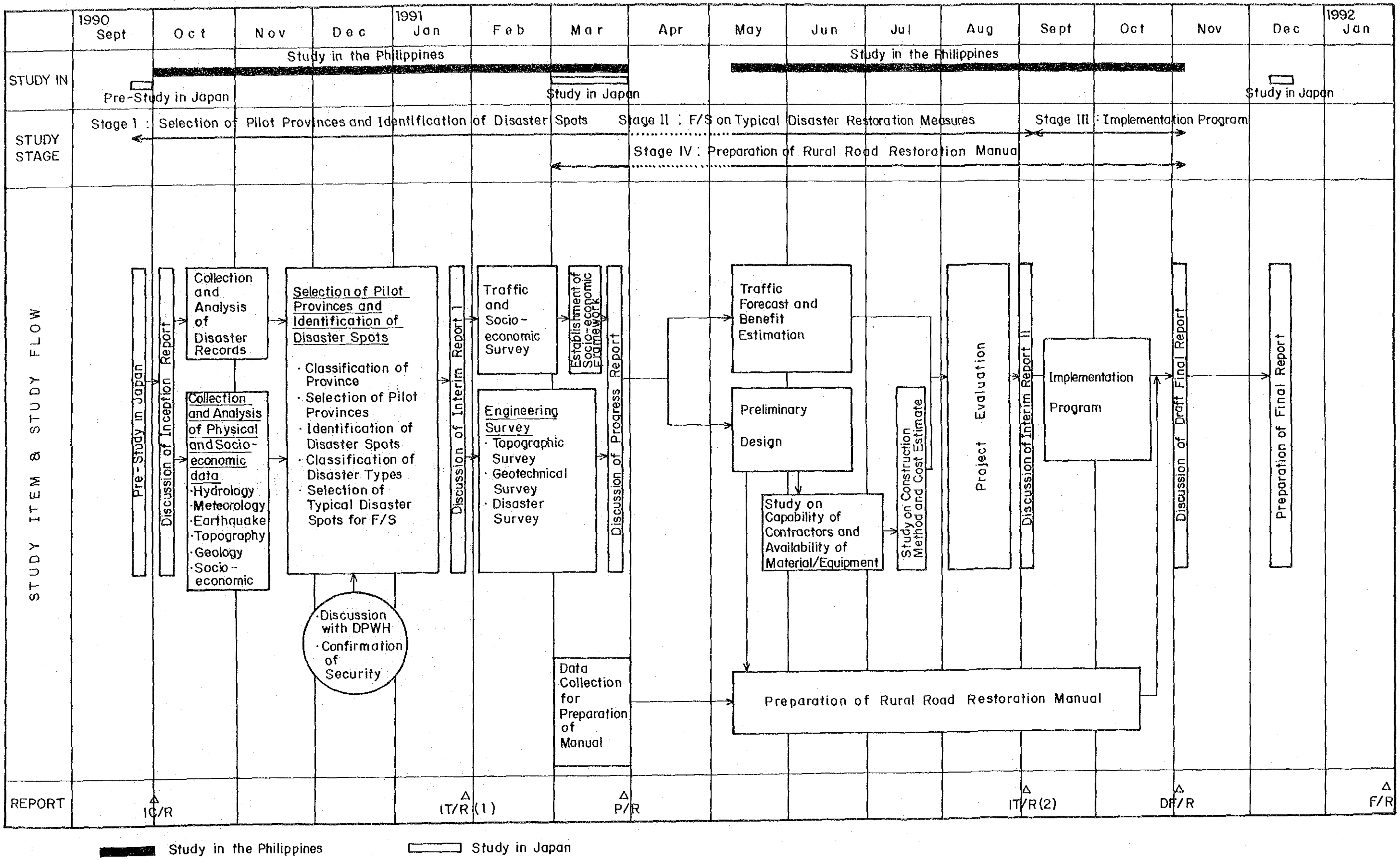


FIGURE 1.3-1 STUDY FLOW DIAGRAM

1.4 ORGANIZATION FOR EXECUTING THE STUDY

The Study was undertaken jointly by the JICA Study Team and the DPWH Counterpart Team under the guidance of the DPWH Steering Committee and the JICA Advisory Committee.

The organization chart is shown in Figure 1.4-1.

The members participating in the Study are listed below.

DPWH Steering Committee

Chairman	TEODORO T. ENCARNACION
Member	MANUEL M. BONOAN
Member	FRANCISCO N. PASCUAL (Sept. 1990 - Jun. 1991)
	BIENVENIDO C. LEUTERIO (Jul. 1991 - Jan. 1992)
Member	LEONARDO A. NUNEZ
Member	JOSE H. ESPIRITU
Member	MANUEL V. MAPA
Member	JOSE P. GLORIA
Member	RYOJI HAGIWARA
Member	KUNIAKI NAKAMURA

DPWH Counterpart Team

Team Leader	JOSE P. GLORIA
Proj. Coordinator/Highway Planner	GERONIMO S. ALONZO
Highway Engineer, Benguet Group	GENEROSO S. ALCONIS
	JOSE TEODERICO REAL
Structural Engineer, Benguet Group	FILOMENA VALES
Highway Engineer, Batangas Group	MARIETTA T. VELASCO
	MAGDALENA B. EUSTE
Structural Engineer, Batangas Group	BERNARDO CANERO, JR.
Highway Engineer, Leyte Group	PAQUITO FRANCO
	ALEXANDER FERNANDEZ
Structural Engineer, Leyte Group	LORETO TAPALLA
Traffic Engineer	CESARIO VICENTE
Transport Economist	ROMEO LESCANO
Economist	EDGAR FABREGAS
	JOEL VILORIA
	ELLA DIONEDA
	GLORIA MALINIT
	DOLORES MANZANO
	ROSEMARIE DEL ROSARIO
	REBECCA TENIOZO
	JEANETTE SEE
	ENCARNITA CUBELO
	LILIA NAUNGAYAN

JICA Advisory Committee

Chairman	AKIOMI SHIMAZU
Member	SHOJI OSADA (Sep.1990-Mar.1991)
	ATSUSHI HIKAWA (Apr.1991-Jan.1992)
Member	SHUJI ISHIDA

JICA Study Team

Team Leader/Road Management Expert	KUNIHIKO SAWANO
Road Disaster Analyst	MASAHIKO TOHI
Road Disaster Analyst/Geologist	KAZUMASA SUZUKI
Hydrologist	KAKURO SHIDARA (Sep.1990-Mar.1991)
	TAKAO MITSUISHI (Apr.1991-Jan.1992)
Soil Engineer	YOSHIHIRO GOTO
Construction Expert	TATSURO ITO
Structural Engineer	TAKASHI OKUMURA
Structural Engineer	MASAMI KIMISHIMA
Regional Planner/Transport Economist	TADASHI SATO

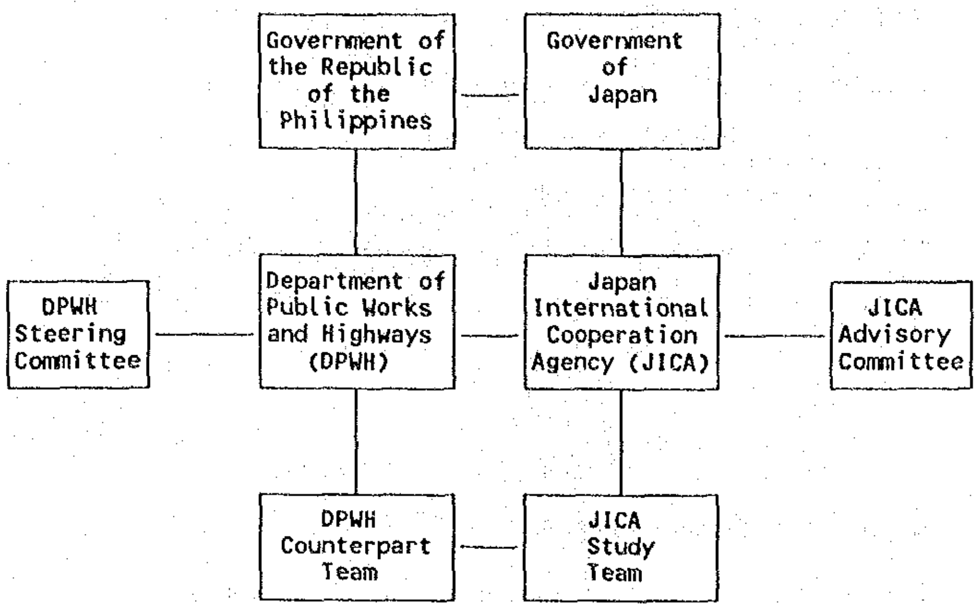


FIGURE 1.4-1 ORGANIZATION CHART

1.5 REPORTS

1.5.1 Organization of the Final Report

The following reports were prepared during the Study:

Inception Report	(October 1990)
Interim Report I	(January 1991)
Progress Report	(March 1991)
Interim Report II	(September 1991)
Draft Final Report	(October 1991)

The final report is organized with the following:

Volume I	:	Executive Summary
Volume II	:	Main Report
Volume III	:	Appendix
Volume IV	:	Drawings
Volume V	:	Rural Road Restoration Manual

1.5.2 Organization of the Main Report

The Main Report is divided into five (5) parts consisting of 18 chapters.

PART I INTRODUCTION

CHAPTER 1 INTRODUCTION gives the background, objectives, scope and organization of the Study.

PART II SELECTION OF PILOT PROVINCES

CHAPTER 2 PHYSICAL AND SOCIO-ECONOMIC PROFILE OF THE COUNTRY provides basic information related to road disaster including topography, geology, meteorology, natural calamities, road network, road disaster and socio-economic profile.

CHAPTER 3 CLASSIFICATION OF PROVINCE shows the classification of province in view of disaster potential and type.

CHAPTER 4 SELECTION OF PILOT PROVINCES presents the selection of pilot provinces including the selection criteria.

CHAPTER 5 PROFILE OF PILOT PROVINCES presents the profile of the selected three pilot provinces including physical profile, socio- economic profile and road network.

PART III ROAD DISASTER IN PILOT PROVINCES

CHAPTER 6 CLASSIFICATION OF ROAD DISASTER shows the classification of road disaster based on the portion of roadway damaged and nature of damage.

CHAPTER 7 IDENTIFICATION OF DISASTER SPOTS presents the identification of disaster spots in the pilot provinces.

CHAPTER 8 SELECTION OF DISASTER SPOTS FOR FEASIBILITY STUDY presents the selection of typical disaster spots to be subjected to feasibility study in PART IV.

PART IV FEASIBILITY STUDY FOR SELECTED DISASTER SPOTS

CHAPTER 9 TRAFFIC FORECAST presents the forecast of traffic demand on the roads where the selected disaster spots are situated.

CHAPTER 10 ENGINEERING SURVEY outlines the engineering survey for preliminary design including topographic survey, geotechnical survey and disaster survey.

CHAPTER 11 CAUSES OF ROAD DISASTER AND CURRENT RESTORATION MEASURES discusses the causes of road disaster and describes common restoration measures currently being taken and the comments thereon.

CHAPTER 12 TYPE OF RESTORATION MEASURES outlines the restoration measures applicable to rural road restoration.

CHAPTER 13 SELECTION OF RESTORATION MEASURES presents the procedure for selection of appropriate measures.

CHAPTER 14 PRELIMINARY DESIGN FOR THE SELECTED SPOTS outlines the preliminary design for the selected disaster spots including cost estimate.

CHAPTER 15 PROJECT EVALUATION presents the technical and economic evaluation of the restoration projects of the selected disaster spots.

PART V PROJECT IMPLEMENTATION

CHAPTER 16 DISASTER MANAGEMENT SYSTEM describes the organization for disaster management and the DPWH standard operation procedure.

CHAPTER 17 IMPLEMENTATION PROGRAM FOR RURAL ROAD RESTORATION PROJECT presents the proposal of the rural road restoration project and its implementation program.

CHAPTER 18 RECOMMENDATIONS FOR FACILITATING RESTORATION WORKS presents two proposals for facilitating restoration works: establishment of gabion factories and stockpile of portable bridges for emergency use.

PART II

SELECTION OF PILOT PROVINCES

CHAPTER 2

PHYSICAL AND SOCIO-ECONOMIC PROFILE OF THE COUNTRY

2.1 TOPOGRAPHY

2.1.1 Location

The Philippines is an archipelago lying within a Pan-Pacific Seismic Belt Zone where earthquakes and volcanic eruptions are common occurrence. The zone is running along the Pacific Coast of North and South America and bordering Continental Asia. In other words, the archipelago is one of the world's most tectonically and seismically active areas. The archipelago is composed of over 7,100 islands and islets, having almost north to south orientation, 22 N to 4N latitude, and 11E to 12E longitude. It is situated along "Typhoon Alley" where tropical cyclones and the accompanying destructive winds develop.

The country is surrounded by large bodies of water, lying between the Pacific Ocean in the east and the South China Sea in the west, straddling Sulu Sea and Celebes Sea. The country has one of the longest coastline in the world. Although the rugged coastline has created natural harbors, it is also easy to be subject to Tsunamis and storm surges.

2.1.2 Land Area

The archipelago has a total of about 300,000 km^2 including all islands, islets and lakes. Among the islands, Luzon and Mindanao comprise the two largest ones with land area of 105,000 and 95,000 km^2, respectively, which together represent two thirds of the total area of the country (Table 2.1-1).

TABLE 2.1-1 THE LARGEST TEN ISLANDS

Name	Area in sq. kms.	Ratio in Percent
1. Luzon	104,688.8	34.9
2. Mindanao	94,730.0	31.6
3. Samar	13,080.0	4.4
4. Negros	12,705.2	4.2
5. Palawan	11,785.0	3.9
6. Panay	11,515.1	3.8
7. Mindoro	9,734.5	3.2
8. Leyte	7,214.4	2.4
9. Cebu	4,421.4	1.5
10. Bohol	3,864.8	1.3
	273,739.7	91.2

Source: Philippine Almanac, 1990

2.1.3 Topography

The Philippines has a variety of topographical features from the low marsh a foot or so above high water at the head of Manila Bay to the high mountain masses, the highest peak being Mt. Apo in Mindanao with an elevation of approximately 2,953 meters. The largest mountainous areas and the most extensive plains are found in the island of Luzon (Figure 2.1-1).

The Cagayan Valley in northern Luzon, located southwest from Aparri, extends to a length of over 190 km with an average width of 64 km. The Cagayan River and its tributaries in this valley drains a basin of approximately 26,000 km^2. The Sierra Madre Mountains to the east rise steeply from both the Cagayan Valley and oceansides, and are largely unexplored, while the Cordillera Mountains lie west of this valley. Mt. Pulog, located in this general locality is the third highest peak in the archipelago with an elevation of 2,930 m. Among these mountain ranges are many fertile valleys several of which extend to the coastal plains along the north and west coasts of Luzon.

The Central Plain of Luzon is drained by the Agno River and its tributaries to Lingayen Gulf in the north and by the Pampanga River and with its tributaries to Manila Bay in the south. the depths of these rivers vary with the seasons, and at times the rivers are navigable only by small launches and bancas. This plain has an area of about 10,000 km^2 and is separated from the Cagayan Valley by the Caraballo Mountains. The Zambales Mountains lie to the west of the Central Plain of Luzon. Southeastern Luzon or Bicol Region has several plateaus and valleys of considerable size but has no river of importance. Mount Mayon which is located in this region is 2,432 m high, and is considered as an almost perfect volcanic cone.

Mindoro Island is mountainous and has coastal plains on the east and southwest sides where its towns and settlements are located, but its hinterlands have remained largely unexplored. Mindoro is considered to be a part of Southern Luzon.

The Visayan Islands are generally rugged with one or more mountain ranges and some coastal plains. Panay, one of its principal islands, has the largest area of level plains and rolling country, while Cebu Island has the least level lands. Negros has high mountains with most of its level lands in the west and northwest. Masbate, Samar, Leyte and Bohol are more in the nature of rolling terrain and high plateaus. These islands have no large rivers although some are wide and deep enough for navigation by launches and small boats.

Palawan Island consists mostly of high ridges and few level lands. It has no river of importance.

Mindanao Island has two large valleys: the Agusan Valley drained by the river of the same name with it sources in the comparatively low divide that separates this valley from the one extending north from Davao Gulf, and the Cotabato Valley drained by the Mindanao (Cotabato) River which empties into the Moro Gulf. The area of this valley excluding Lake Buluan and Liguasan Marsh is roughly 4,700 km^2. Cotabato Valley is separated from the valley to the north of Sarangani Bay by a low divide. Western and Eastern Mindanao are mountainous with narrow coastal plains.

The islands of Basilan, Jolo and Tawi-Tawi are comparatively rugged, while the rest of the Sulu Archipelago is composed mostly of relatively smaller islands.

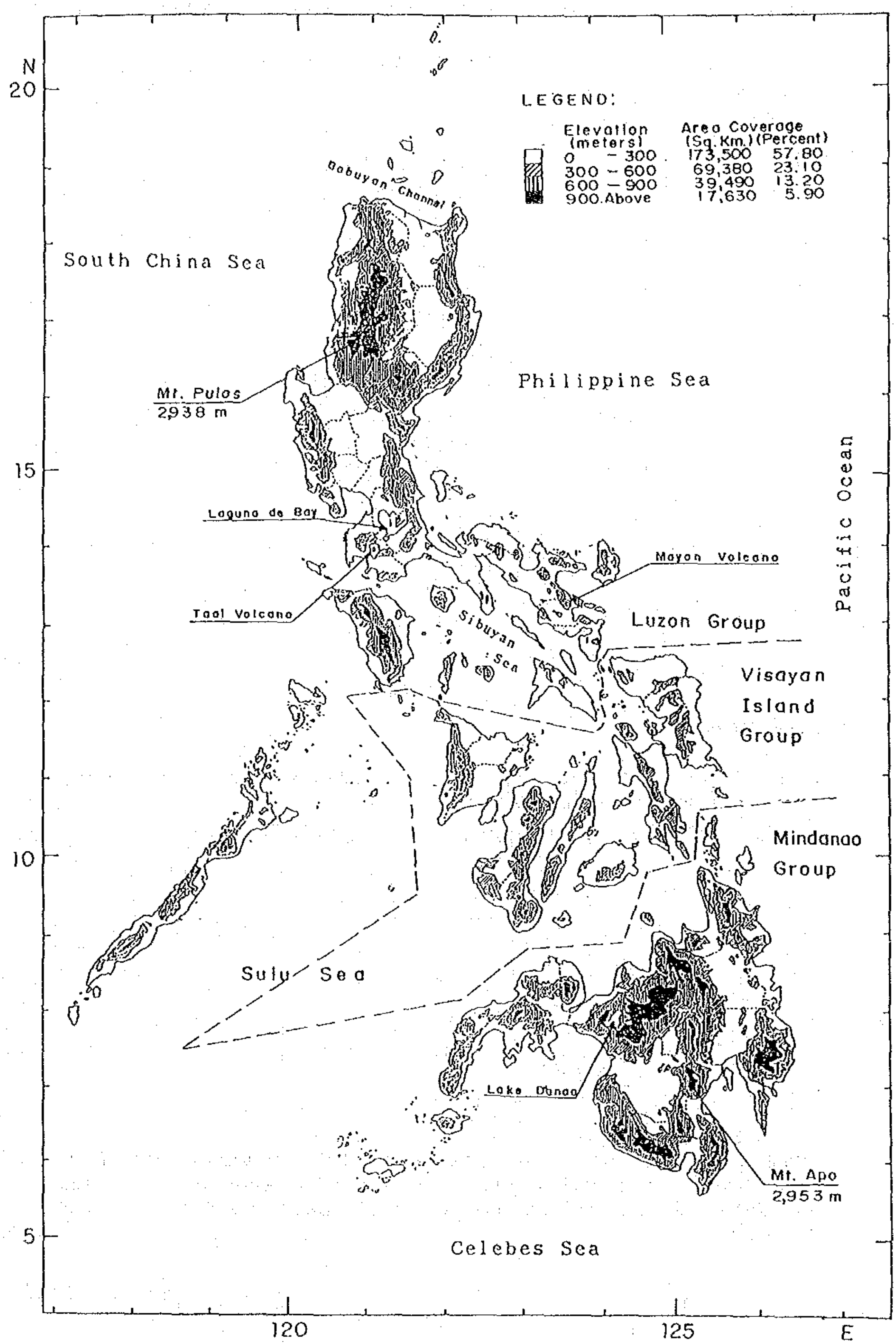


FIGURE 2.1-1 TOPOGRAPHIC MAP

Tables 2.1-2 and 2.1-3 show the area coverages by an elevation and by slope, respectively.

TABLE 2.1-2 AREA COVERAGE BY ELEVATION

Elevation	Area Coverage
0 m - 300 m	173,500 km^2 (57.8%)
300 m - 600 m	69,380 km^2 (23.1%)
600 m - 900 m	39,490 km^2 (13.2%)
900 m or above	17,630 km^2 (5.9%)
Total	300,000 km^2 (100.0%)

TABLE 2.1-3 AREA COVERAGE BY SLOPE

Slope	Area Coverage
0 - 8%	98,210 km^2 (32.7%)
8 - 18%	44,070 km^2 (14.7%)
18 - 30%	55,010 km^2 (18.3%)
30 - 50%	73,350 km^2 (24.5%)
50% or above	29,360 km^2 (9.8%)
Total	300,000 km^2 (100.0%)

2.1.4 River Basins

In the whole country, 421 principal river basins are identified with drainage areas varying from 41 km^2 to 25,649 km^2 (Table 2.1-4).

TABLE 2.1-4 NUMBERS OF RIVER BASIN BY AREA

Number	Drainage Area Km^2
51	50 - 100
113	101 - 200
155	201 - 500
63	501 - 1000
22	1001 - 2000
9	2001 - 5000
5	5001 - 10000
3	10001 - and above
Total:421	

Source: Principal River Basin of the Philippines, 1976

However, some of the smaller river basins are part of the larger basins where the rivers are tributaries of larger principal rivers. From among these principal river basins, 18 are identified as major river basins with drainage areas of at least 1,400 km^2 (Table 2.1-5 and Figure 2.1-2).

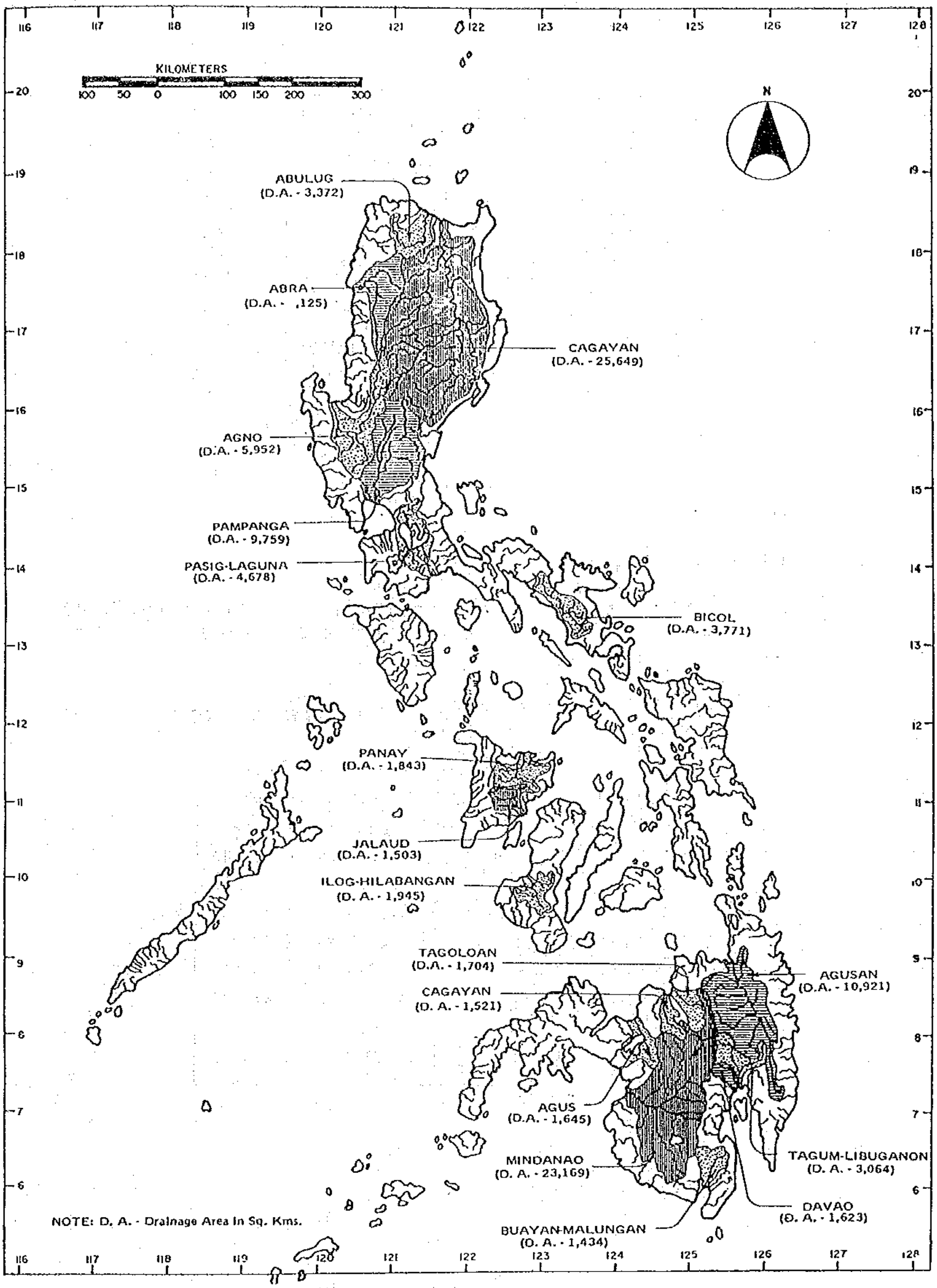


FIGURE 2.1-2 MAJOR RIVER BASINS

Source: Principal River Basins of the Philippines, 1976

TABLE 2.1-5 MAJOR RIVER BASINS

Rank	River Basin	Location	Drainage Area Km^2
1	Cagayan	Cagayan Valley	25,649
2	Mindanao	Southern Mindanao	23,169
3	Agusan	Northern Mindanao	10,921
4	Pampanga	Central Luzon	9,759
5	Agno	Central Luzon	5,952
6	Abra	Ilocos	5,125
7	Pasig-Laguna Bay	Southern Luzon	4,678
8	Bicol	Bicol	3,771
9	Abulug	Cagayan Valley	3,372
10	Tagum-Libuganon	Southeastern Mindanao	3,064
11	Ilog-Hilabangan	Western Visayas	1,945
12	Panay	Western Visayas	1,843
13	Tagoloan	Northern Mindanao	1,704
14	Agus	Southern Mindanao	1,645
15	Davao	Southeastern Mindanao	1,623
16	Cagayan	Northern Mindanao	1,521
17	Jalaud	Western Visayas	1,503
18	Buayan-Malungun	Southeastern Mindanao	1,434

Source: Principal River Basins of the Philippines, 1976

2.2 GEOLOGY

2.2.1 Geological Formation

The geological formation of the Philippines is composed of various kinds of deposits and rocks as shown in Figure 2.2-1. The land area by geological category is shown in Table 2.2-1.

TABLE 2.2-1 LAND AREA BY GEOLOGIC CATEGORY

Geological Category	Area Coverage
Quaternary Deposit	91,820 km^2 (30.6%)
Neogene Deposit	37,100 km^2 (12.4%)
Palaeogene Deposit	39,360 km^2 (13.1%)
Pre-tertiary Deposit	30,610 km^2 (10.2%)
Intrusive Rock	19,140 km^2 (6.45)
Volcanic Rock	81,970 km^2 (27.3%)
T o t a l	300,000 km^2 (100.0%)

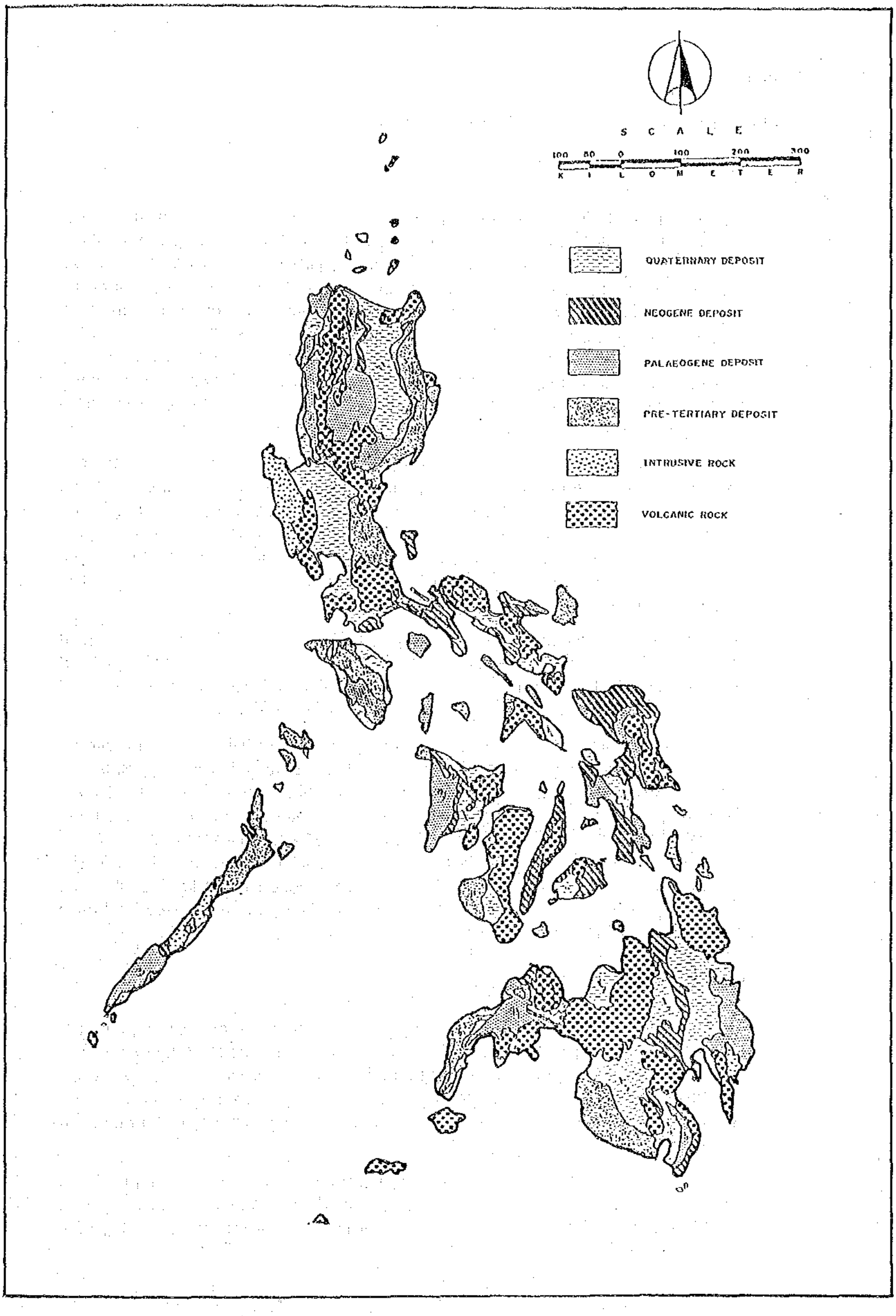


FIGURE 2.2-1 GEOLOGICAL FORMATION OF THE PHILIPPINES

2.2.2 Faults

Major coastal fractures in the Philippines are shown in Figure 2.2-2.

1) Transcurrent Fault

The Philippine Fault is the greatest transcurrent fault in the Philippines. It is traceable for about 1200 km. from Lingayen Gulf in the north, then along the southern border of Luzon Central Cordillera, Polillo Strait, Tayabas Isthmus, Masbate, Leyte, Agusan and into the Davao Gulf in the south. Recent study on the segment of the fault in the Tayabas Isthmus, Masbate and Northern Leyte indicated that the fault is an oblique slip fault with horizontal component of displacement being larger than the vertical component. Present movement of the fault is confirmed to be left lateral, displacing Neogene rocks in Northern Leyte for almost 8 km. Activity in the fault appears to have been continuous since the Palaeogene with apparently more intense activity than at present.

Another major fault that is possible transcurrent is the Tablas Lineament. It is manifested by an almost linear physiographic feature traceable for about 350 km from the deep in west of Panay Island through the eastern edge of Tablas Island and then northward to Tayabas Isthmus where it seems to merge with the Philippine Fault. It appears on-shore in northwest Panay where it is recognized as a great fault valley running meridionally from Nabas of Aklan in the north, to Pandan of Antique in the south.

Another major transcurrent fault is crossing Ulugan Bay of Central Palawan. It trends almost N-S and is traceable for about 30 km across the whole width of Palawan Island. It marks the boundary between Carboniferous-Triassic terrain of northern Palawan and the ophiolitic terrain of southern Palawan.

There are probably many other major transcurrent faults that are not still recognized in the archipelago. Interpretation of Earth Resources Technology Satellites (ERTS) imagery reveal a number of major linear faults. One of them, the Bangui Fault in northwest Luzon, is undoubtedly a major transcurrent fault. It is almost parallel to the Luzon segment of the Philippine Fault and an interesting relation is observed between them. The Philippine Fault splits into several splices in the vicinity of Caraballo Mountains in Nueva Ecija. One splice, the Digdig Fault swerves northward and in flank of Luzon Central Cordillera. Both the Bangui and Philippine Faults die out after they intersect the Digdig Fault.

2) Normal Faults

Normal faults of varying magnitude are sporadically distributed throughout the archipelago. These faults are easily observed in the field because they give rise to prominent fault scarpments. Although they do not appear to be structurally dominant as wrench fault and thrust in the archipelago. Normal faults are commonly observed along flanks of major structural basins and actively rising mountain masses.

Normal faults in Northern Luzon are the faults bounding the Laoag Plain in Ilocos Norte, the faults in the Cagayan Valley area and the well-known Marikina Fault. In the Bicol region, the most significant normal fault is a NW-trending fault in the central part of Camarines Sur.

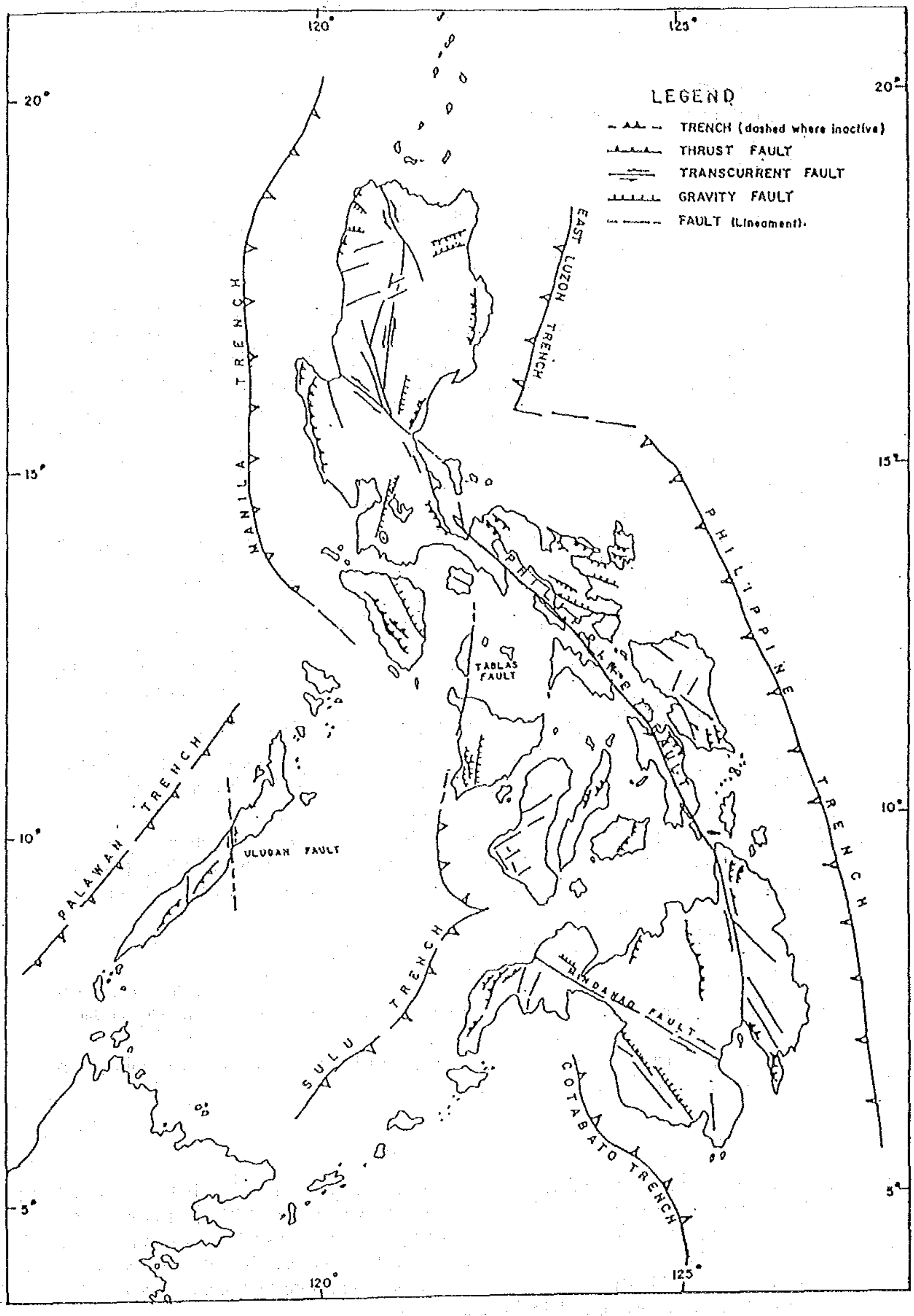


FIGURE 2.2-2 CYSTAL FRACTURES

Source: Geology and Resources of the Philippines

The Mindoro Fault which runs across the northeastern side of the island of Mindoro is a normal fault which is observable from both topographics maps and aerial photographs.

Another fault of considerable extent is the Cotabato Fault along the eastern edge of Daguma Range in Cotabato.

3) Thrust Faults

Many thrust faults occur in the archipelago but most of them are minor. The prominent ones are generally along the borders of the main Philippine Trench and Sulu Trench in the western edges of Mindoro and Panay.

The thrust faults in the Bicol region are located in the northeastern parts of Camarines Norte, Camarines Sur and Catanduanes Island. In the Visayas, a number of thrust faults are in the southwestern part of Samar islands.

In Mindanao, thrust faults of varying orientations are in Surigao del Sur, Central Mindanao, Davao Oriental, some parts of Lanao and Cotabato, and the Zamboanga area is a major thrusted zone.

2.3 METEOROLOGY

The climate of the Philippines is tropical and maritime. It is characterized by relatively high temperature, high humidity and abundant rainfall.

2.3.1 Temperature

The Philippines has high temperatures because the warm air currents flowing over its land masses. The mean annual temperature at the 57 weather stations, excluding Baguio of Luzon and Malaybalay of Mindanao, is about 26.9C.

The hottest months are April with 27.5C, May with 27.8C, and June with 27.4C. The coldest months are December with 26.2C. January with 25.7C and February with 26.0C.

The seasonal variation of temperature is small with an average annual range of 2.9C. The maximum temperatures for most places in the Philippines occur between 1:00 p.m. and 3:00 p.m. while the minimum temperatures occur between 5:00 a.m. and 7:00 a.m.

2.3.2 Relative Humidity

Because of the warm moist airstream of the archipelago, the surrounding seas, rich vegetation and abundant rainfall, the humidity of the air throughout the Philippines is high.

The average annual relative humidity for the whole Philippines is about 81.6% varying from 78.6% in April to 83.3% in November/December.

2.3.3 Prevailing Wind

Prevailing Winds in the Philippines are divided into three groups: 1) the northeast monsoon, streaming along the easterly and southeasterly side of the great Asiatic high pressure area: 2) the southwest monsoon or equatorial air, which pushes its way across the equator from the strong high pressure areas of the southern hemisphere; and 3) the trade winds reaching the islands from a generally easterly direction and coming from the tropical high pressure area of the Pacific.

2.3.4 Rainfall

Table 2.3-1 shows the mean monthly and annual rainfall recorded by 59 PAGASA weather stations in the past 35 years from 1951 till 1985. Based thereon, the isohyet map is prepared as shown in Figure 2.3-1 for annual rainfall and Appendix 2-2 for monthly rainfall.

<u>Annual Rainfall</u>

The average annual rainfall in the Philippines is 2,405 mm. Luzon has an average of 2,572 mm, Visayas has 2,235 mm, and Mindanao has 2,090 mm.

The average annual rainfall varies from less than 1,000 mm to more than 5,000 mm.

Itbayat of Batanes Island, northermost of the Philippine Islands has the highest annual value of 5,237 mm, followed by Hinatuan along the coast of Surigao del Sur of Mindanao with a value of 4,328 mm.

General Santos, situated in a valley in southern Mindanao, has the lowest annual value of 955 mm followed by Zamboanga City with 1,212 mm.

<u>Monthly Rainfall</u>

Monthly rainfall distribution is quite different between eastern and western coasts of the archipelago as follows:

- Two pronounced seasons; dry from November to April and wet during the rest of the year along western coasts.

- No dry season with a pronounced maximum rainfall from November to January along the eastern coasts.

They are affected strongly by the seasonal monsoons and tropical cyclones. See Figure 2.3-2.

TABLE 2.3-1 (1) MEAN MONTHLY AND ANNUAL RAINFALL

WEATHER STATION	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL RAINFALL	MONTHLY HIGHEST
Region: NCR														
1. NAIA (MIA)	12.3	3.6	13.4	15.9	109.4	253.6	332.6	417.0	308.7	180.3	116.7	54.1	1,817.6	417.0
2. Port Area	13.5	7.3	21.4	18.7	138.6	283.8	364.1	476.3	334.1	200.5	111.4	56.0	2,025.7	476.3
3. Science Garden	17.2	9.7	22.1	28.3	172.7	339.6	448.1	504.8	381.8	234.0	144.0	53.8	2,356.1	504.8
Region: CAR														
4. Baguio	12.1	35.8	55.9	102.9	331.1	480.6	670.8	847.9	582.3	262.4	152.3	28.8	3,562.9	847.9
Region: I														
5. Dagapan	6.2	6.2	17.6	73.2	216.1	346.6	462.1	608.4	324.8	158.5	63.1	13.8	2,296.6	608.4
6. Laoag	11.8	1.1	2.5	19.8	125.1	376.8	386.4	547.3	324.1	86.1	45.1	10.2	1,936.3	547.3
7. Vigan	2.3	3.3	5.0	17.4	145.9	404.3	483.3	738.9	355.7	112.5	35.1	9.1	2,312.8	738.9
Region II														
8. Aparri	141.1	76.0	45.6	35.4	100.6	184.1	183.2	225.5	274.7	343.0	396.0	208.7	2,213.9	396.0
9. Basco	183.9	126.1	102.6	83.1	138.4	278.3	259.2	43.0	370.1	330.1	317.1	259.9	2,491.8	370.1
10. Calayan	188.6	109.7	72.3	46.2	107.0	196.1	242.5	323.0	330.0	349.0	394.3	317.7	2,676.4	394.3
11. Itbayat	240.6	135.1	111.1	82.9	297.3	785.7	669.5	935.0	482.1	722.2	464.4	311.1	5,237.0	935.0
12. Tuguegarao	21.4	16.5	57.2	73.6	172.1	161.6	192.8	246.5	209.1	252.9	274.2	93.9	1,771.8	274.2
Region III														
13. Cabanatuan	7.5	4.9	16.4	19.7	150.1	267.6	340.8	395.8	305.2	190.8	134.8	39.9	1,873.5	395.8
14. Iba Zambales	3.0	2.7	12.1	28.8	280.7	579.0	763.1	1,105.9	615.8	203.9	80.9	25.6	3,701.5	1,105.9
15. Munoz	9.4	1.7	8.5	55.4	88.9	385.3	299.6	446.2	258.7	16.7	90.6	15.6	1,849.6	466.2
Region IV-A														
16. Alabat	250.8	133.5	99.3	81.5	109.5	200.2	226.4	174.9	253.4	510.1	530.9	571.4	3,141.9	571.4
17. Ambulog	22.1	9.9	16.3	37.4	105.3	237.5	289.9	323.7	259.7	234.1	156.6	97.6	1,790.1	323.7
18. Baler	193.1	150.8	213.1	232.4	301.4	272.3	240.5	218.6	300.6	416.0	444.4	327.9	3,311.1	444.4
19. Casiguran	217.2	157.5	192.8	138.9	236.6	237.9	261.2	238.2	296.9	412.3	601.7	437.2	3,427.4	601.7
20. Infanta	353.8	220.1	187.3	179.7	225.2	249.4	258.7	196.4	325.2	607.8	597.4	597.2	3,998.2	607.8
21. Lucena City	89.3	60.3	42.5	54.6	90.0	160.3	184.6	198.0	225.5	336.2	305.3	235.2	1,982.7	336.2
22. San Francisco	49.3	17.9	27.1	25.1	88.9	162.7	222.2	187.5	179.2	220.2	173.9	126.4	1,480.4	222.2
23. Sangley Pt.	25.3	2.1	7.4	13.6	102.2	259.3	259.5	460.5	243.8	185.6	91.7	32.8	1,683.8	460.5
24. Tayabas	155.1	72.3	72.3	103.2	227.5	257.9	260.6	172.6	316.1	512.7	519.9	413.7	3,083.9	519.9

TABLE 2.3-1 (2) MEAN MONTHLY AND ANNUAL RANFALL

WEATHER STATION	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL RAINFALL	MONTHLY HIGHEST
Region: IV-B														
25. Calapan	91.4	54.8	52.7	90.2	159.2	200.9	183.4	199.5	189.9	298.3	237.5	172.4	1,930.4	298.3
26. Coron	25.7	8.0	5.7	30.4	184.4	378.6	480.1	551.4	436.6	288.9	135.2	82.1	2,607.1	551.4
27. Cuyo	13.2	2.5	8.2	44.1	187.3	376.2	437.7	409.7	375.0	272.1	148.2	55.1	2,329.3	437.7
28. Puerto Princesa	30.7	16.7	37.2	42.2	142.4	184.2	177.6	183.6	196.4	210.0	205.2	137.4	1,563.8	210.0
29. Romblon	114.4	48.3	48.3	71.4	125.4	205.7	249.5	227.9	252.4	323.1	234.3	204.6	2,105.3	323.1
30. San Jose	3.1	2.3	18.7	140.5	88.9	343.4	433.1	559.3	391.8	245.2	55.4	8.7	2,290.4	559.3
Region: V														
31. Daet	312.0	175.0	153.9	126.1	139.1	173.9	235.7	222.3	267.6	518.6	590.2	591.9	3,506.3	591.9
32. Legaspi	296.9	195.6	192.6	152.1	181.3	240.9	251.3	264.2	259.9	325.5	483.7	456.0	3,300.0	483.7
33. Masbate	163.2	80.3	65.5	54.9	134.0	153.4	191.2	180.3	218.8	212.8	232.7	257.1	1,949.2	257.1
34. Virac Radar	360.5	209.1	160.5	175.2	184.8	225.9	245.7	164.2	273.9	377.3	549.5	544.1	3,470.7	549.5
35. Virac	219.9	132.2	119.2	128.6	185.6	225.2	223.8	174.1	248.8	373.9	486.4	412.5	2,930.2	486.4
Luzon Average:													2,571.6	
Region: VI														
36. Iloilo City	42.8	25.3	34.3	52.4	115.1	271.6	300.8	348.0	276.4	251.1	179.7	96.9	1,994.4	348.0
37. Roxas City	115.9	50.4	56.7	57.7	146.2	253.0	246.9	232.6	240.4	321.6	225.0	172.4	2,118.8	321.6
Region: VII														
38. Cebu City	106.5	67.6	54.4	50.4	107.6	183.5	206.5	184.4	196.7	195.5	157.8	127.3	1,638.2	206.5
39. Dumaguete City	80.8	54.3	54.3	49.5	75.6	134.3	139.6	123.5	137.4	183.1	162.8	113.7	1,308.9	183.1
40. Mactan Airport	96.5	78.6	46.8	34.3	68.4	181.9	187.3	164.9	189.1	137.6	150.9	145.6	1,481.9	189.1
41. Tagbilaran city	105.0	78.5	71.8	57.8	80.3	131.0	134.8	107.8	136.0	212.8	190.5	117.2	1,423.5	212.8
Region: VIII														
42. Borongan	625.3	414.1	306.9	256.1	296.9	232.0	198.8	182.0	204.5	312.7	555.4	663.3	4,248.0	663.3
43. Catarman	417.4	250.8	215.2	146.7	149.8	179.3	208.8	157.8	212.0	372.5	525.8	493.0	3,329.1	525.8
44. Catbalogan	225.3	144.8	129.8	102.6	170.1	200.0	243.7	224.9	263.0	301.5	321.4	309.6	2,636.7	321.4
45. Guiuan	255.7	284.7	152.9	161.6	121.3	278.4	185.5	133.1	212.3	180.3	321.5	368.5	2,655.8	368.5
46. Maasin	186.5	145.4	109.9	60.3	64.9	108.5	170.3	161.5	163.8	202.4	168.2	230.7	1,772.4	230.7
47. Tacloban City	261.8	205.2	137.6	121.2	146.1	154.7	167.0	129.1	146.8	184.4	244.8	316.9	2,115.6	316.9
Visayas Average:													2,235.3	

TABLE 2.3-1 (3) MEAN MONTHLY AND ANNUAL RAINFALL

WEATHER STATION	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL RAINFALL	MONTHLY HIGHEST
Region: IX														
48. Cagayan de Sulu	194.4	118.1	23.3	50.1	103.7	215.9	267.6	192.2	242.8	300.2	305.1	272.8	2,286.2	305.1
49. Dipolog	158.8	72.2	75.7	97.9	185.0	254.1	239.8	225.8	234.1	297.2	356.1	280.8	2,477.5	356.1
50. Jolo	104.1	94.5	85.8	145.1	226.4	242.4	187.1	161.6	194.1	264.1	194.7	150.1	2,050.0	264.1
51. Zamboanga City	43.9	44.2	37.7	51.0	94.8	142.3	135.1	128.5	145.1	192.4	108.7	88.1	1,211.8	192.4
Region: X														
52. Butuan City	435.9	205.4	100.1	63.4	124.6	124.4	161.2	73.3	182.1	181.1	158.7	223.5	2,033.7	435.9
53. Cagayan de Oro	107.4	64.7	56.7	38.4	102.7	198.8	214.0	199.1	216.7	178.2	125.0	116.3	1,618.0	214.0
54. Lumbia Airport	93.7	62.4	29.8	24.6	98.5	209.0	230.5	221.4	181.2	206.9	91.0	100.0	1,549.0	230.5
55. Malaybalay	124.5	95.9	103.2	104.4	222.5	307.1	315.9	300.3	327.0	299.4	187.3	149.8	2,537.3	327.0
Region: XI														
56. Davao City	114.7	99.0	77.9	144.9	206.7	190.1	175.9	173.2	180.1	174.8	145.7	109.7	1,792.7	206.7
57. General Santos	64.1	73.2	39.5	50.5	87.5	112.5	104.3	87.2	80.6	94.4	87.0	74.1	954.9	112.5
58. Hinatuan	730.3	523.1	434.8	320.5	275.3	257.6	214.4	190.1	213.3	232.5	350.1	586.4	4,328.4	730.3
Region: XII														
59. Cotabato City	71.3	90.9	95.3	131.8	257.2	251.4	248.9	323.3	238.3	253.6	176.7	98.7	2,237.8	323.7
Mindanao Average:													2,089.8	
Total Average :													2,405.1	

Source: PAGASA (1951-1985)

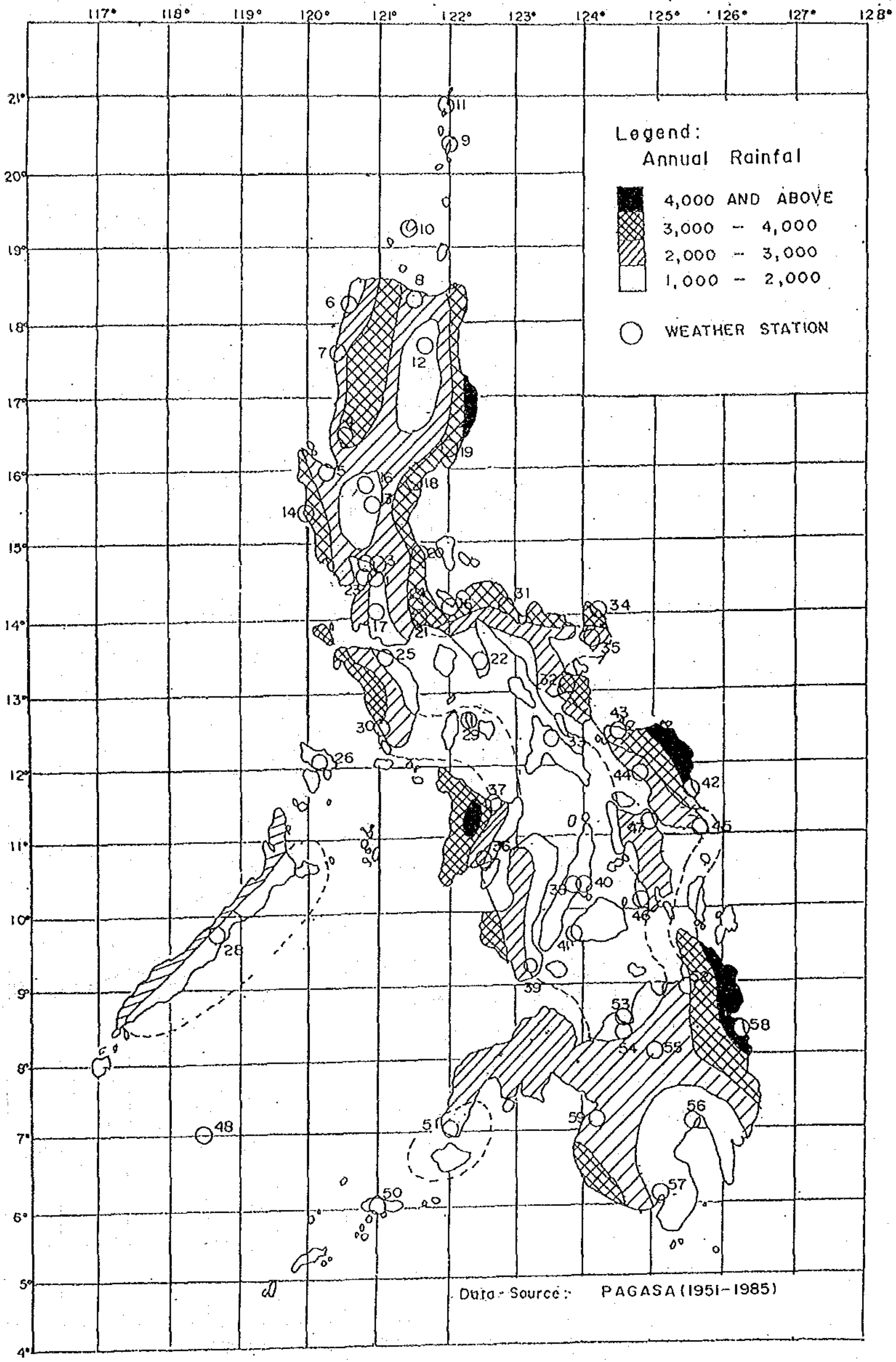


FIGURE 2.3-1 ISOHYET MAP

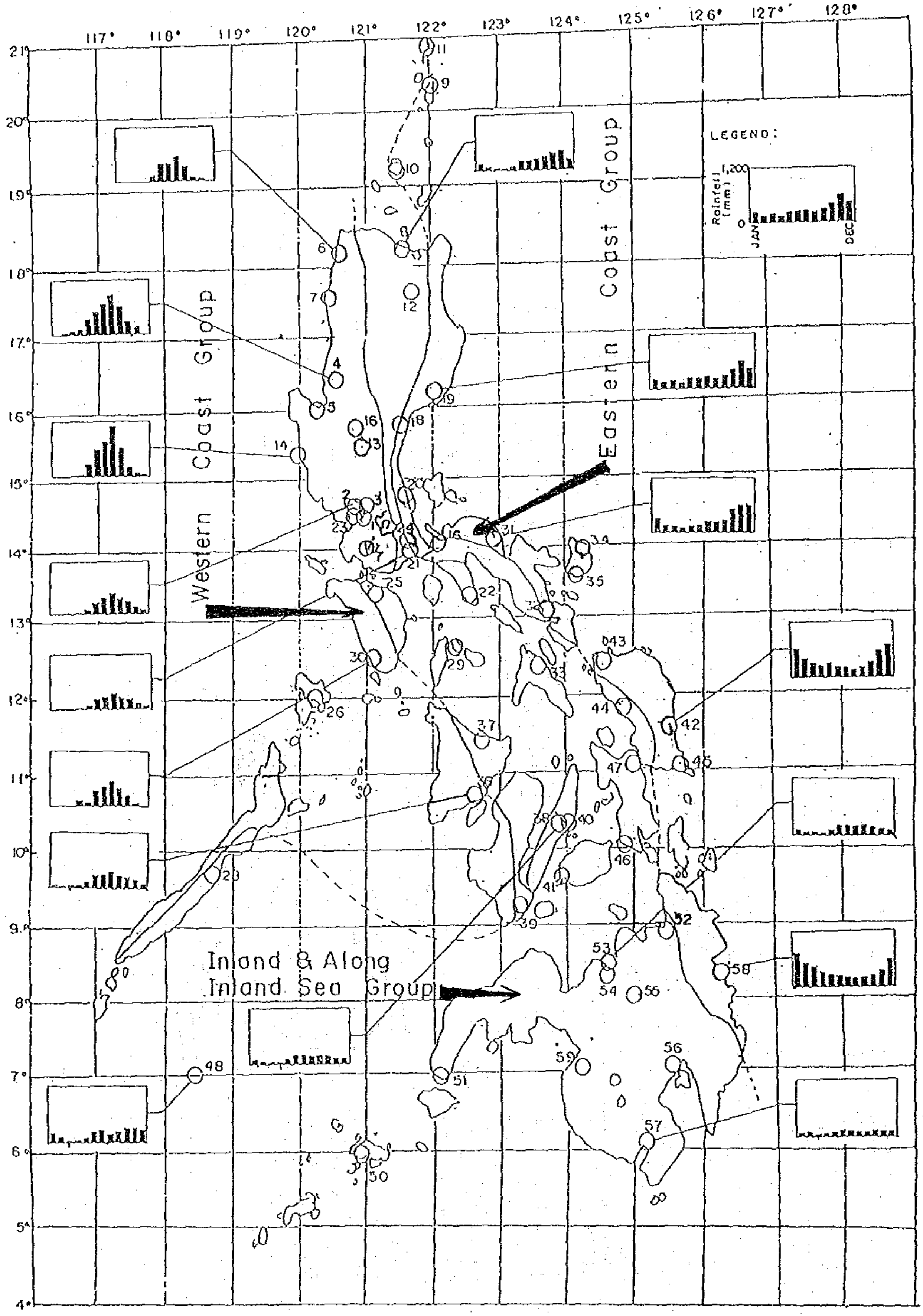


FIGURE 2.3-2 MONTHLY RAINFALL DISTRIBUTION

2.3.5 Climate Type

The climate of the Philippines is classified into four (4) types by PAGASA following Modified Corona's Classification System (Figure 2.3-3).

Type I : Two pronounced seasons, dry in winter and spring, wet in summer and autumn. Maximum rain period is from June to September during the prevalence of the southwest monsoon. The dry season lasts from three to six or seven months.

Type II : No dry season with a very pronounced maximum rain period in winter. The maximum monthly rainfall generally occur in December and January. There is no single dry month. The minimum monthly rainfall occurs, in some places, in spring and in other places, in summer.

Type III : No very pronounced maximum rain period with a short dry season lasting only from one to three months. This type is intermediate between the preceding two although it resembles the first type more closely since it has a short dry season. The short dry season is either in winter or spring.

Type IV : Rainfall is more or less evenly distributed throughout the year. This, also, is an intermediate between the first and second types, but it resembles the second more closely since it has no dry season.

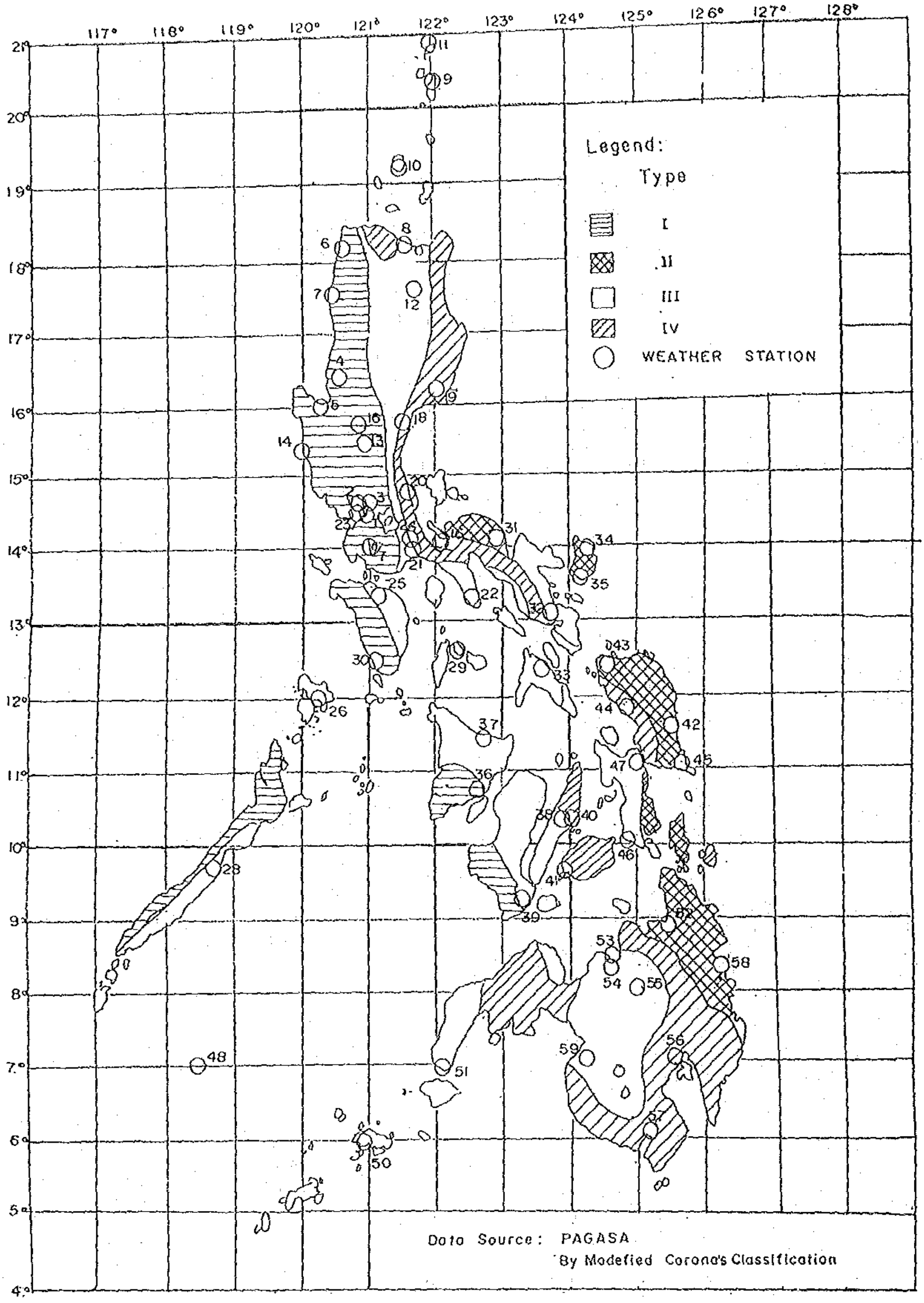


FIGURE 2.3-3 CLIMATE TYPE

2.4 NATURAL CALAMITIES

2.4.1 Volcanoes

The Philippines has 220 Quaternary volcanoes, 22 of which are considered active having erupted during historic times or within the last 600 years. Table 2.4-1 shows the volcanoes which have erupted in the 20th century.

Volcanic centers are divided into the following belts: Sta. Ana, Luzon Central Cordillera, Central Luzon, Bicol, Negros, Sulu, Lanao volcanic area, Mindanao Central Cordillera, Cotabato and Cuyo (Figure 2.4-1).

The eastern boundary of Sta. Ana Belt is well defined but the western part appears to merge with the Luzon Central Cordillera. The latter follows the axis of the Cordillera to the Baguio District and swings eastward to include the volcanic centers in the Caraballo Mountains. The departure between the Luzon Central Cordillera Belt and Central Luzon Belt is defined by the Philippine Fault Zone which displace the belts in right-lateral sense.

The Central Luzon Belt consists of heavy concentration of volcanic centers in its western side marking the eastern foothills of the Zambales and Mindoro Ranges. It also covers the extensive volcanic region of southern Luzon including Taal Volcano, Mt. Makiling and Mt. Banahaw. The Pliocene volcanic centers in the southeastern tip of Mindoro is also included and if further extended it may include the Pliocene centers in the Cuyo Island Group.

The Bicol Belt covers the greater part of the Bicol Peninsula extending southward through Central Leyte and thence through the western foothills of Diwata Range. Like the Central Luzon Belt, it terminates at the Tablas Lineament.

The Negros and Sulu Belts are parallel to the Negros and Sulu Sea trenches respectively. This indicates a relationship between magmatic activity along the belts with tectonic activities along the trench. Similarly, the Cotabato Belt can be related with the tectonic activity along the Cotabato Trench.

The Mindanao Central Cordillera Belt is related to a possible sutured trench along the Agusan - Davao trough. The occurrence of Flood basalts in the Lanao highlands is in contrast with the strato-volcanic structure in other volcanic belts.

Volcanic hazards include flowing of fast-moving molten rocks and other ejecta. The ejecta fragments range in size from fine dust (volcanic ash) to large boulders (volcanic bombs or blocks). Besides liquid and solid materials, volcanoes give off poisonous gases. Other hazards are the associated volcanic earthquakes, fissuring caused by the force of upward moving magma, tsunami and water displacement, subsidence due to retreat or withdrawal of magma, landslides too much bulging on one side of the volcano or those triggered by earthquakes or rainfall.

TABLE 2.4-1 VOLCANOES HAVING ERUPTED IN THE 20TH CENTURY

N a m e	Height (m)	Province/Island	E r u p t i o n
Mayon	2,462	Albay/Luzon	1988,1985,1984,1978 1977,1968,1947,1943 1941,1940,1938,1928 1902,1900,1893,1928 1971,1890,1989,1888 1987,1885,1882,1876 1873,1872,1862,1860 1859,1858,1845,1835 1828,1800,1776,1616
Taal	400	Batangas/Luzon	1977,1976,1990,1969 1968,1967,1966,1965 1911,1904,1878,1842 1825,1808,1754,1749 1716,1717,1709,1701 1591,1572
Canloan	2,465	Negros Occ. and Or./Negros	1988,1987,1986,1985 1980,1978,1969,1933 1927,1905,1904,1902 1893
Bulusan	1,559	Sorsogon/Luzon	1985,1984,1983,1981 1980,1979,1933,1928 1921,1919,1918,1894 1886,1852
Hibok-Hibok	1,332	Camiguin/Mindanao	1952,1951,1902,1871 1862,1852,1848,1827
Ragang	2,815	Lanao and Cotabato /Mindanao	1916,1873,1871,1858 1856,1840,1834,1756
Didicas	244	Batanes/Babuyan Island	1978,1969,1900,1860 1857,1773
Smith	688	Batanes/Babuyan Island	1924,1919,1917,1907 1652,1651
Pinatubo	1,780	Pampanga/Zambales and Tarlac/Luzon	1991
Cagua	1,158	Cagayan/Luzon	1907

Source: Philippine Almanac, 1990

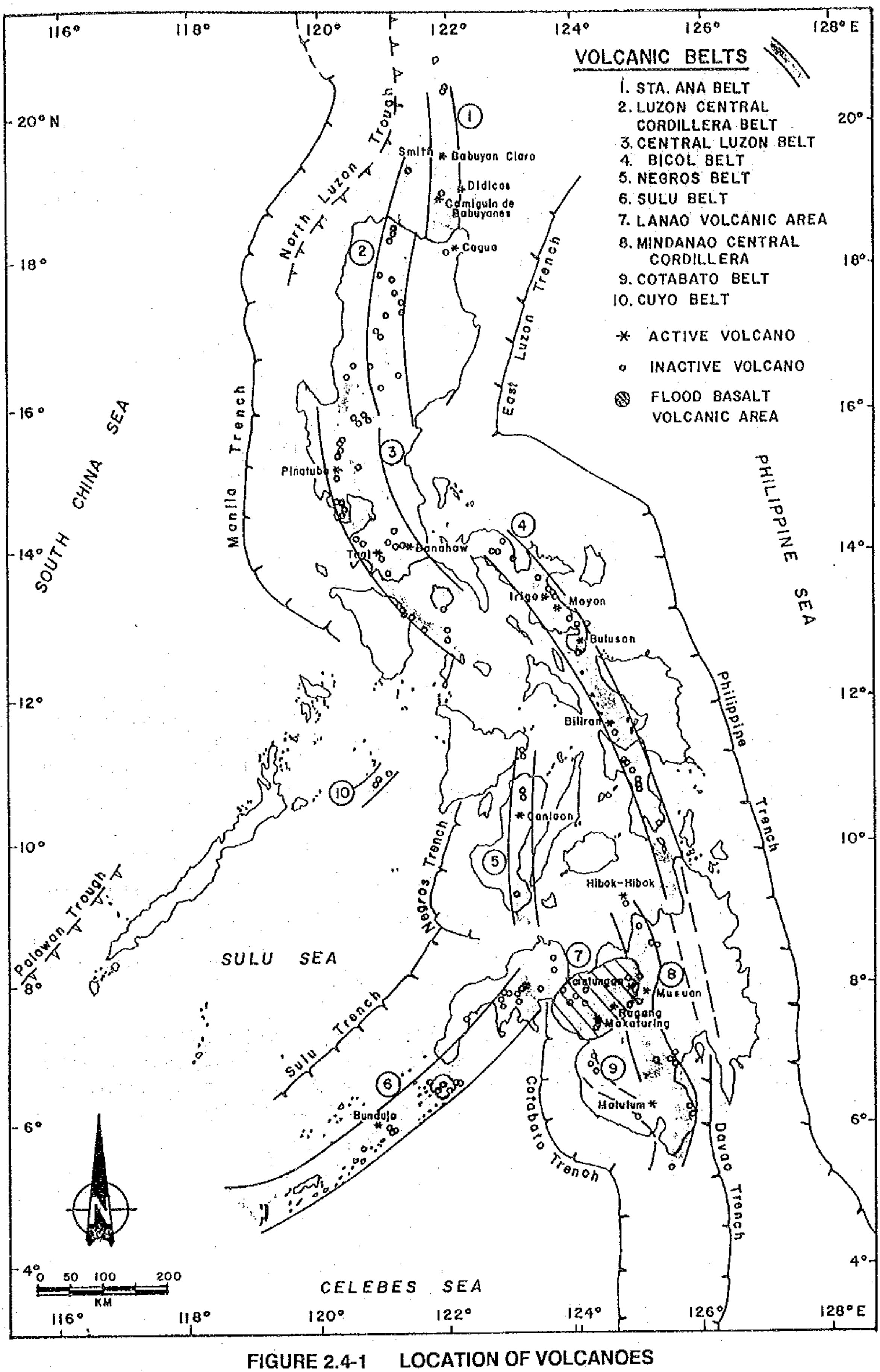


FIGURE 2.4-1 LOCATION OF VOLCANOES

Source: PAGASA Geologic Hazards and Disaster Preparedness, 1987
Note : Volcanic Belts Supplement from "Geology and Mineral Resources, 1981

Eruption of Mt. Pinatubo

Mt. Pinatubo is located on the boundaries of three provinces of Pampanga, Zambales and Tarlac. It continuously erupted from June 09 to 15, 1991. The worst eruption was recorded in June 14 and 15 and as a result, heavy casualties and huge damages of infrastructure were reported. A total of twelve major rivers around the Mt. Pinatubo is being affected by mudflow after the eruption. The affected river are listed below:

River	Province
Bamban (Sacobia)	Tarlac
Abacan	Pampanga
Pasig	Pampanga
Porac	Pampanga
Gumain	Pampanga
Pamatawan	Zambales
Sto. Tomas (Marella)	Zambales
Maloma	Zambales
Tanguay	Zambales
Bucao (Maraunot, Balin Baguera)	Zambales
Motorones	Tarlac
O'Donnel	Tarlac

All of the rivers are fully filled with flow deposit in the upstream as well as filled by debris flow deposit in the middle part and heavily silted by mudflow in the downstream. The flow of volcanic debris and flood water caused by the eruption and heavy monsoon rain damaged roads and bridges around the Mt. Pinatubo.

2.4.2 Earthquake

The Philippines, being situated within a Pan-Pacific Seismic Belt Zone have been very frequently shaken by an earthquake of various intensities.

According to the Philippine Institute of Volcanology and Seismology, 40 destructive earthquakes were experienced during 1599-1988 (Figure 2.4-2).

The earthquake hazard in the Philippines was analyzed by the Earthquake Hazard Mitigation Programme in Southeast Asia held in April 1986. The average return period for experiencing a site intensity of VII MM, population at risk, area and maximum observed intensity for each region are listed in Table 2.4-2 and illustrated in Figure 2.4-3.

TABLE 2.4-2 FREQUENCY OF EARTHQUAKE OCCURRENCE BY REGION

Region	Observation Period	Average Return Period (Years)	Population at Risk (x 106)	Area (103 KM2)	Maximum MM Intensity (1589-1983)
I	1865-1983	1.2	3.903	21.6	X-XI
II	1850-1979	2.5	2.520	36.5	X
III	1850-1979	2.2	5.456	18.2	IX
IV	1850-1979	1.8	6.330	11.9	X
V	1860-1979	1.7	3.922	17.7	X
VI	1880-1979	4.4	5.092	20.2	X
VI	1860-1979	9.0	4.195	14.9	IX-X
VIII	1870-1979	1.9	3.073	21.5	IX
IX	1880-1979	3.0	2.863	18.7	X
X	1860-1979	1.4	3.179	28.4	X
XI	1860-1979	1.7	3.836	31.7	X
XII	1820-1976	3.0	2.598	23.2	X
NCR	1820-1976	4.6	6.942	0.636	X

Source: Earthquake Hazard Mitigation Programme in Southeast Asia

The 16 July 1990 Earthquake

On 16 July 1990, a strong earthquake struck Luzon Island which is counted as one of the most destructive earthquakes in the Philippines. The biggest had a magnitude of 7.7 on the Ritcher Scale and traced its epicenter at Cabanatuan City of the Nueva Ecija Province.

Figure 2.4-4 shows the isoseimal map in the Modified Ross-Forel (M.R.F.) scale[1]. The highest intensity was VIII, covering Nueva Ecija, Pangasinan, and parts of Tarlac, Nueva Vizcaya, Benguet, La Union and Aurora.

Note: [1]

The Rossi-Forel scale has originally ten grades, while the Modified Rossi-Forel (M.R.F.) scale used in the Philippines consists of nine grades. This scale is not familiar to other seismic countries. For example, the Modified Mercalli (M.M.) scale with 12 grades is used in the United States, South American countries and Italy, and the Japan Meteorological Agency (J.M.A.) scale with 8 grades is used in Japan and Taiwan.Correspondence among the Modified Rossi-Forel (M.R.F.), the Modified Mercalli (M.M.), and the Japan Meteorological Agency (J.M.A.) Scales is shown below.

M.R.F. | I | II | III | IV | V | VI | VII | VIII | IX

M.M. | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII

J.M.A. | 0 | I | II | III | V | VI | VIII

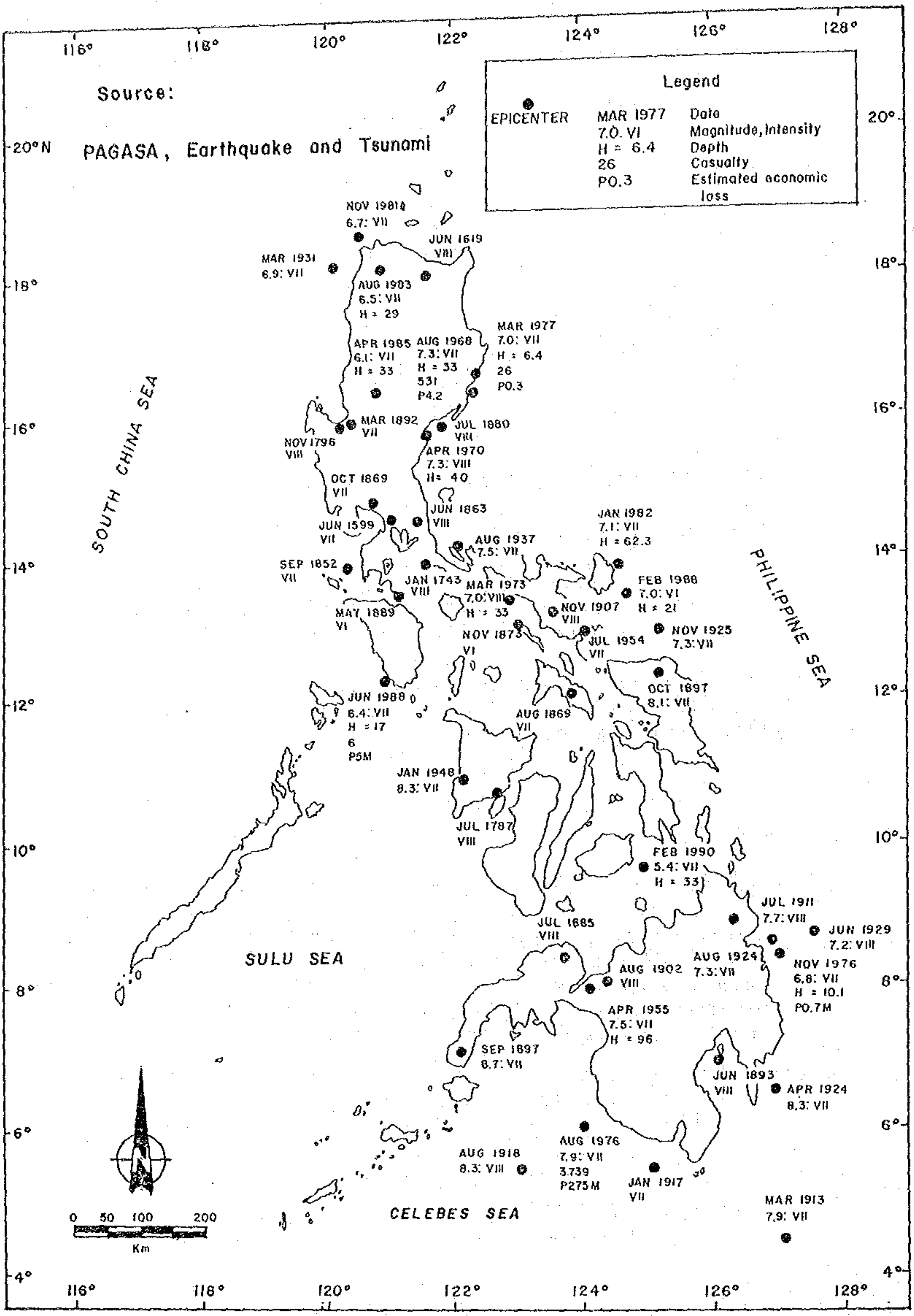


FIGURE 2.4-2 LOCATION OF DESTRUCTIVE EARTHQUAKES (1599-1988) (M > 6.0 AND/OR INTENSITY > VI)

Source: NEDA, Reconstruction and Development Program, Nov. 1990

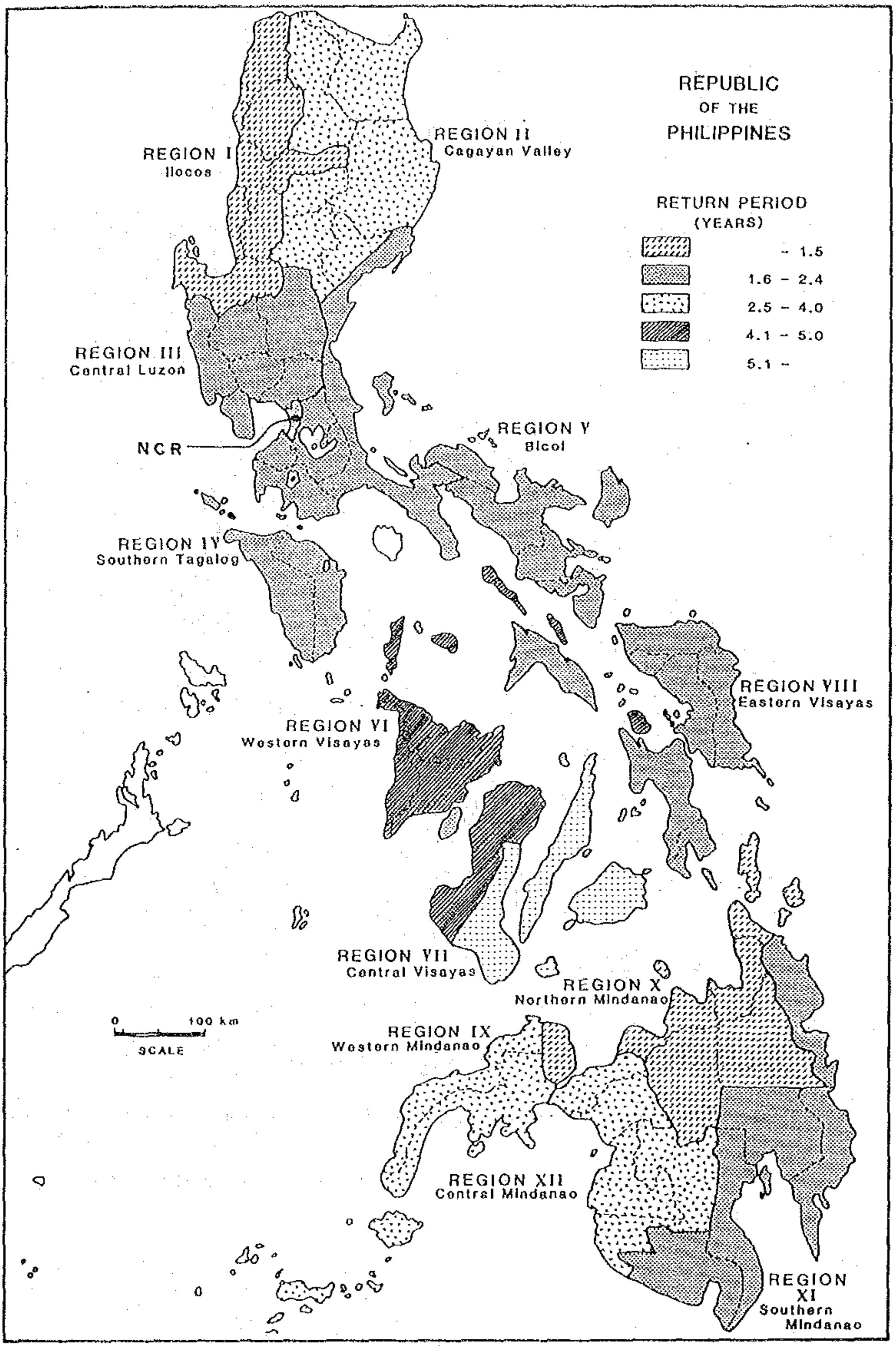


FIGURE 2.4-3 FREQUENCY OF EARTHQUAKE OCCURRENCE BY REGION (SITE INTENSITY VIII AND ABOVE)

Source: Southeast Asia and Association of Seismology and Earthquake Engineering: Series of Seismology Volume 1, Earthquake Hazard Mitigation Programme in Southeast Asia, April 1986

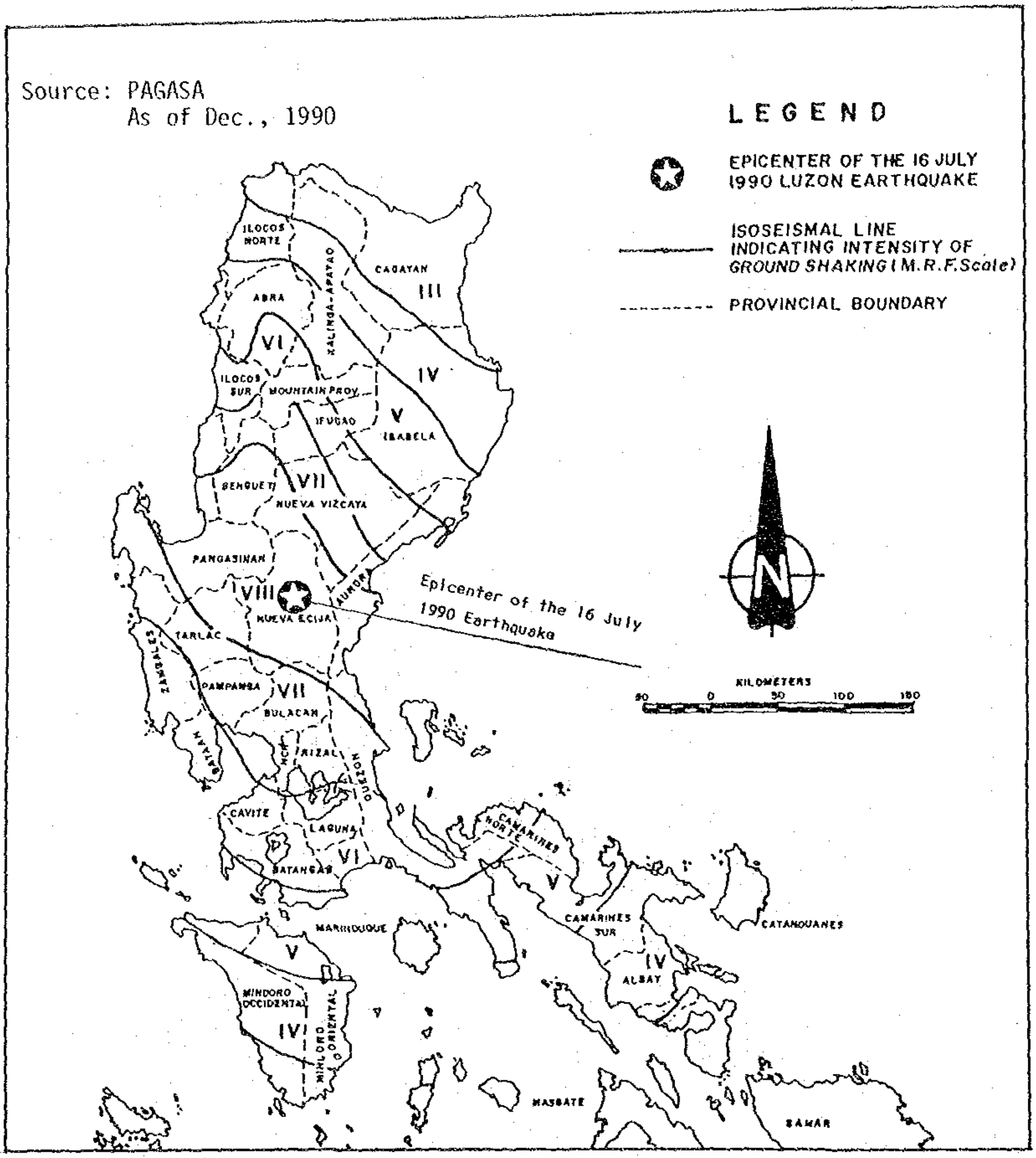


FIGURE 2.4-4 ISOSEISMAL MAP OF THE JULY 1990 EARTHQUAKE

It affected a widespread area of about 20,000 square kilometers, and caused extensive damage. At least 1,666 persons were killed and more than 900 were still missing. Over 3,500 were seriously injured. More than 25,000 homes were totally destroyed, and some 60,000 were partially damaged. Based on the survey of differential movement phenomena on ground surface and the cluster of aftershocks distributing along the fault lines, the earthquake was supposed to had been generated by the Philippines Fault movement.

It also caused extensive damage to commercial and residential buildings, roads and bridges. The major arterial roads and bridges damaged are San Jose - Sta. Fe Section of the Pan-Philippine Highway in Nueva Ecija, Carmen Bridge in Pangasinan, Baguio-Bontoc (Halsema) Road and the access roads to Baguio City; Kennon Road, Agoo-Baguio Road and Naguilian Road.

2.4.3 Tsunami

Tsunamis are giant sea waves generated by under-the-sea earthquakes and volcanic eruptions. Tsunamis in the Philippines had been recorded on several occasions affecting various coastal areas of the archipelago and their source regions ranging from as far as Alaska to Krakatau in Indonesia. Local earthquake events are also known to generate tsunamis. The areas prone to tsunami hits are particularly the coastal areas of Southern Mindoro facing the Celebes Sea because tsunamigenic earthquake of ten originate from the bottom of Celebes Sea (Figure 2.4-5).

2.4.4 Tropical Cyclones

A tropical cyclone is characterized by a low pressure center and cloud band spiralling inward in counterclockwise direction from all sides in the northern hemisphere. The Philippines is prone to such natural disaster agents as tropical cyclones accompanying destructive winds, floods and storm surges.

The tropical cyclone season in the Philippines is from June to December, with an average monthly frequency of more than one tropical cyclone. The period of the rest months, however, is not free from tropical cyclones.

A total of 690 tropical cyclones of all intensities during 35- year period or an average of 19.7 cyclones per year crossed the Philippine Area of Responsibility (PAR). See Table 2.4-3.

By PAGASA, 5-year average frequency of passage of tropical cyclone's center for the period from 1884 to 1975 (91 years) is presented as in Figure 2.4-6. An average of 22 tropical cyclones form annually in the northwest Pacific Ocean, about 19 of which enter the Philippine Area of Responsibility (PAR) and about 9 of them cross the country per year.

A great part of damage by natural calamities are caused by typhoons and floods, because they are annual occurrence in the Philippines and affect wide area.

TABLE 2.4-3 TROPICAL CYCLONES ENTERING THE PAR

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1948	1	0	0	0	1	0	3	1	3	2	6	3	20
1949	1	0	0	0	0	2	5	2	4	3	3	2	22
1950	0	0	0	0	0	2	2	1	3	2	2	1	13
1951	0	0	0	1	0	1	1	4	2	1	1	2	13
1952	0	0	0	0	0	5	2	3	4	4	4	4	26
1953	1	1	0	0	1	2	0	5	2	2	3	2	19
1954	0	0	1	0	1	0	1	6	2	3	3	1	18
1955	1	1	0	1	0	0	2	3	1	4	1	1	15
1956	0	0	1	2	0	0	4	4	5	1	5	3	25
1957	2	0	0	1	0	2	1	2	3	3	1	0	15
1958	1	0	0	0	0	1	4	2	4	2	3	0	17
1959	0	1	1	0	0	0	1	4	2	4	3	2	18
1960	1	0	0	1	1	2	2	6	1	3	0	2	19
1961	1	1	1	0	1	3	4	4	4	1	1	2	23
1962	0	1	0	0	2	0	4	6	4	1	3	0	21
1963	0	0	0	0	1	3	4	2	3	1	0	2	16
1964	0	0	0	0	2	1	9	5	5	3	3	1	29
1965	2	1	1	0	2	2	6	2	3	1	1	0	21
1966	0	0	0	1	3	1	7	1	3	2	2	2	22
1967	0	1	1	1	1	2	4	5	0	2	3	1	21
1968	0	1	0	0	0	2	2	3	3	1	3	0	15
1969	0	0	0	1	1	0	4	2	4	1	2	0	15
1970	0	1	0	0	0	3	2	4	4	4	2	1	21
1971	1	0	1	3	3	2	5	2	3	5	2	0	27
1972	2	0	0	0	0	2	4	2	4	1	1	1	17
1973	0	0	0	0	0	1	2	3	2	3	1	0	12
1974	1	0	0	0	0	3	4	4	2	3	2	2	21
1975	1	0	0	0	0	0	1	3	3	3	2	1	14
1976	1	1	0	1	1	3	3	3	4	0	2	3	22
1977	1	0	0	0	1	1	4	2	4	2	2	2	19
1978	0	0	0	1	0	3	1	7	6	4	2	1	25
1979	0	0	1	1	2	1	3	3	3	4	2	2	22
1980	0	1	1	1	3	2	4	3	2	2	3	1	23
1981	0	1	0	0	0	3	5	4	3	2	3	2	23
1982	0	0	2	0	1	0	5	4	4	3	0	2	21
Total	18	12	11	16	28	55	115	117	109	83	77	49	690
Average	0.5	0.3	0.3	0.5	0.8	1.6	3.3	3.3	3.1	2.4	2.2	1.4	19.7

Note : Area of Responsibility during the 35-year period (1948- 1982)
Source : PAGASA

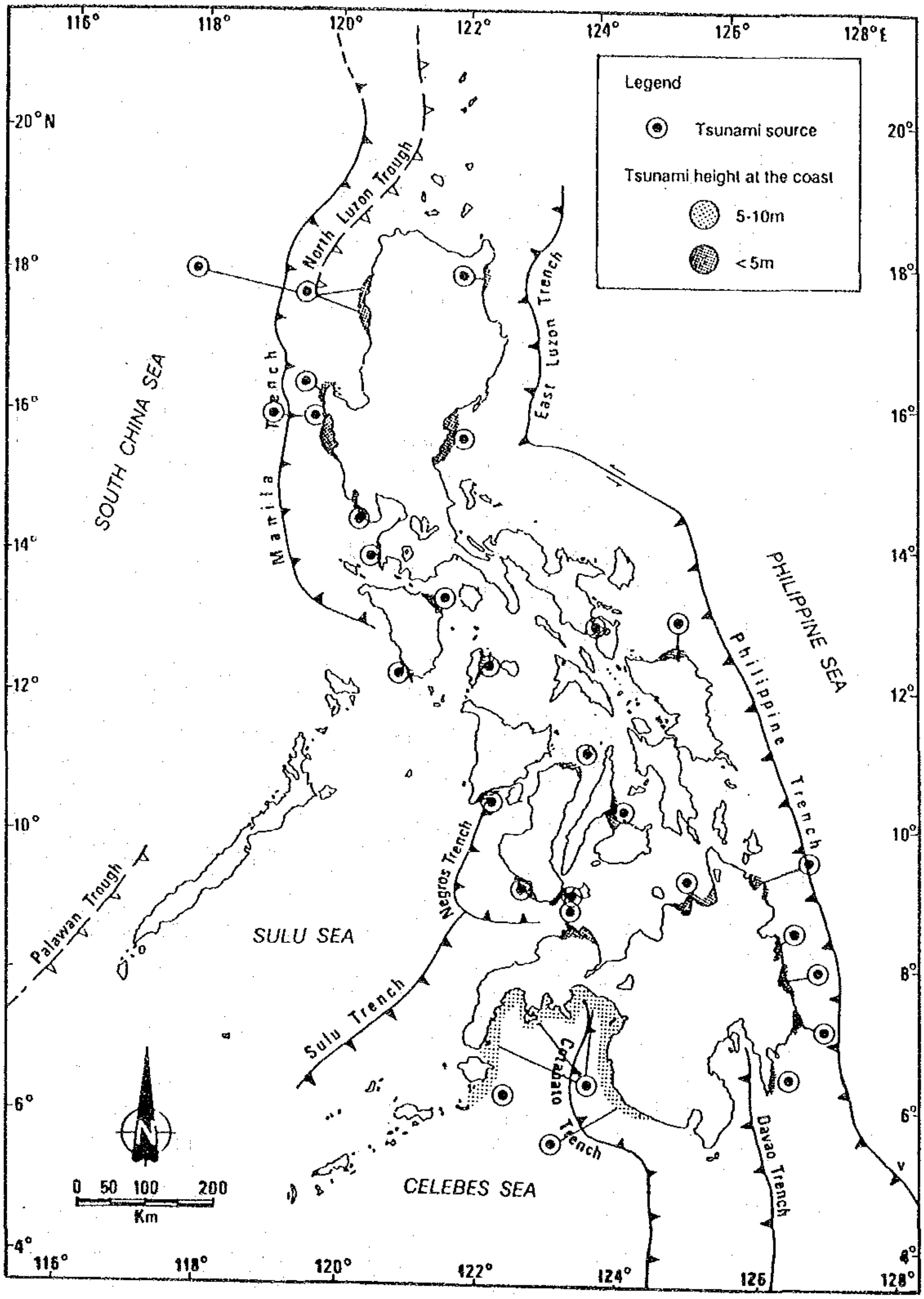


FIGURE 2.4-5 PAST TSUNAMI AREA

Source: PAGASA, Earthquake and Tsunami

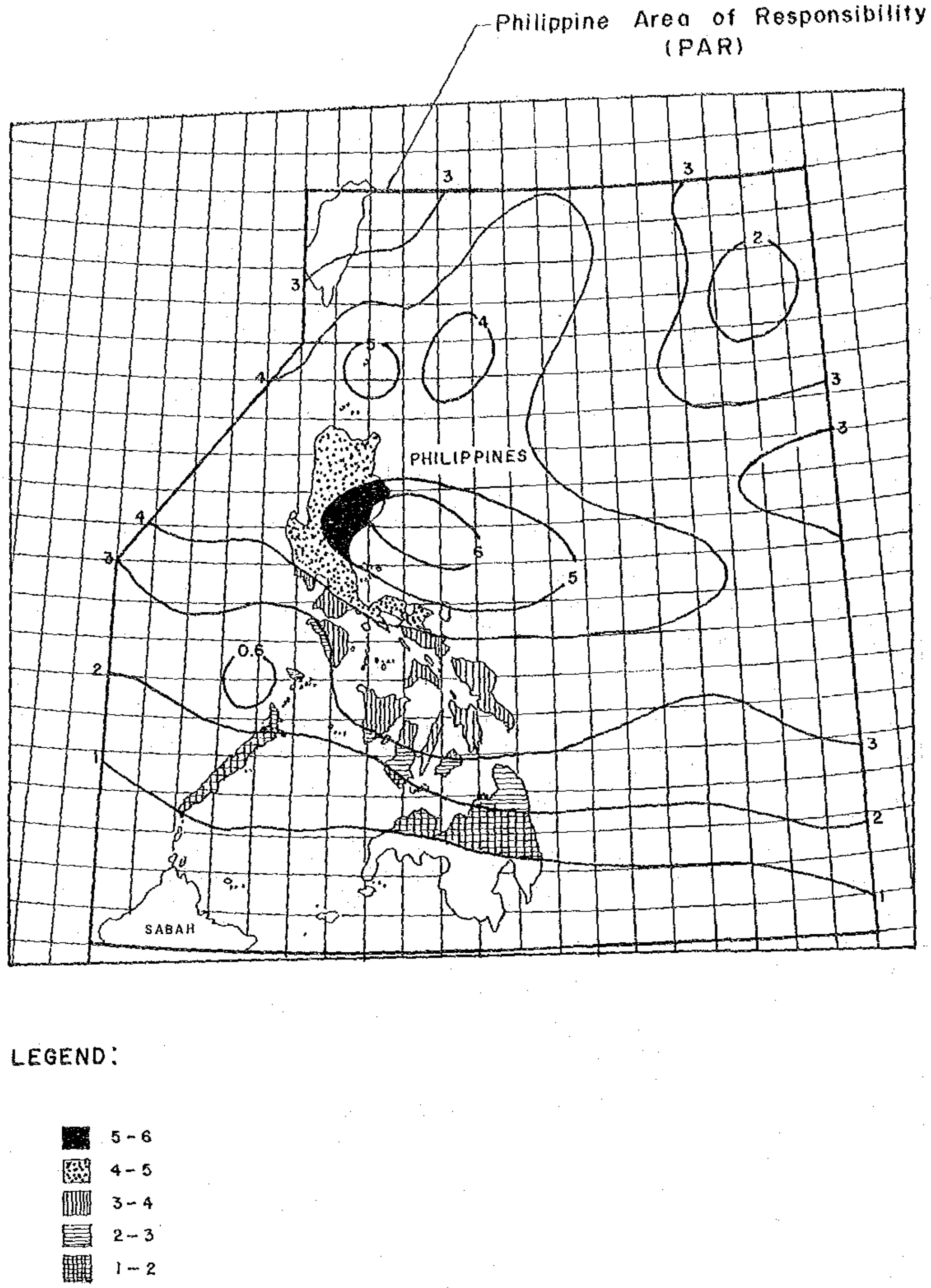


FIGURE 2.4-6 5-YEAR AVERAGE FREQUENCY OF TROPICAL CYCLONE PASSAGE

Source: PAGASA, 1987

2.5 ROAD NETWORK

2.5.1 Transport Modal Split

The transport system in the Philippines consists of four (4) modes: sea, road, rail and air. Table 2.5-1 shows freight and passenger traffic by mode. Due to its geography, the Philippines depends to a great extent on inter-island shipping and ferry services to link the main island of Luzon with the other islands. Nevertheless, road transport handles about 78% of the country's passenger movements and about 46% of freight movements. Sea transport handles about 9% and 49% of passenger and freight traffic, respectively. Rail and air transport handle the remaining 14% passenger traffic and 4% of freight traffic. Thus, the Philippine transport system is a predominantly bimodal system, with road and sea transport generally complementing, rather than competing with each other.

TABLE 2.5-1 PASSENGER AND FREIGHT MOVEMENT BY MODE: 1985

	Passenger Movement		Domestic Freight Movement	
Mode	Passenger-Km (million)	Share (%)	Ton-Km (million)	Share (%)
Road	46,000	77.7	11,200	46.4
Sea	5,080	8.6	11,900	49.4
Rail	3,050	5.1	970	4.0
Air	5,085	8.6	39	0.2
Total	59,215	100.0	24,109	100.0

Source: NEDA

2.5.2 Road Network System

The public road network system in the Philippines consists of:

- National Roads
- Provincial Roads
- City Roads
- Municipal Roads
- Barangay Roads

National Roads are all roads that form part of the main trunkline system continuous in extent; all roads leading to national airports, national seaports, national parks or coast-to-coast roads.

Provincial Roads are those roads connecting one municipality with another, the termini to be public plazas; all roads extending from a municipality or from a provincial or national road to a public wharf or railway station; and any other road to be designated as such by the Sangguniang Panlalawigan.

City Roads are those roads/streets within the urban area of the city to be designated as such by the Sangguniang Panglungsod.

Municipal Roads are those roads/streets within the poblacion area of a municipality to be designated as such by the Sangguniang Bayan.

Barangay Roads are rural roads located either outside the urban area of a city or outside industrial, commercial or residential subdivisions which act as feeder or farm-to-market roads, and which are not otherwise classified as national, provincial, city or municipal roads.

Responsibility for planning, construction and maintenance of national roads and barangay roads is with the Department of Public Works and Highways (DPWH). The provincial, city and municipal government units, all under the general supervision of the Department of Interior and Local Government (DILG), are responsible for provincial, city and municipal roads in their areas, through the Provincial, City and Municipal Engineer's Offices, respectively.

As of 1987, the Philippines has a road network of some 157,800 km, consisting of 26,100 km of national, 28,900 km of provincial, 4,000 km of city, 12,900 km of municipal and 85,900 km of barangay roads.

2.5.3 Growth of Road Network

Major road improvement activities began in 1969 following completion of the Philippine Transport Survey conducted under UNDP financing with the World Bank as the executing agency, which recommended improvement of about 6,000 km of national roads. Also greatly impacting on the road network development was construction of the Pan-Philippine Highway, on which construction was started in 1969 and completed in 1979 with financial assistance from Japan. As shown in Table 2.5-2 and Figure 2.5-1, road length expanded sharply in the late 1960s and constantly increased until 1985. After that, road length decreased slightly due to the latest re-inventory where some roads were excluded from the list of national and barangay roads as they do not quality as such.

TABLE 2.5-2 GROWTH OF ROAD LENGTH

(km)

Year	National Road	Provincial Road	City Road	Municipal Road	Barangay Road	Total
1961	15,143	18,777	3,447	12,238	-	49,605
1962	15,223	20,055	3,755	13,595	-	52,628
1963	15,457	20,569	3,841	14,432	-	54,299
1964	15,677	20,878	4,064	14,692	-	55,311
1965	15,922	21,363	4,184	14,309	-	55,778
1966	16,189	21,421	4,613	15,332	-	57,555
1967	16,616	22,337	4,875	14,774	-	58,602
1968	17,434	22,588	5,006	15,498	-	60,526
1969	18,540	23,312	5,232	16,176	-	63,260
1970	19,198	25,219	6,254	16,855	10,425	77,951
1971	20,066	27,879	6,805	18,781	12,069	85,600
1972	21,315	28,103	6,714	18,636	13,714	88,482
1973	21,415	28,123	7,397	19,444	16,651	93,030
1974	21,516	28,144	8,340	21,561	18,769	98,330
1975	21,665	28,175	2,680	7,512	44,399	104,431
1976	21,796	28,186	2,726	7,902	52,271	112,881
1977	22,333	28,224	3,004	9,141	56,518	119,220
1978	22,790	28,243	3,133	9,524	61,445	125,135
1979	23,552	29,034	3,406	10,657	80,960	147,609
1980	23,641	29,753	3,692	11,445	83,337	151,918
1981	23,489	29,953	3,723	11,914	84,449	153,528
1982	23,783	29,544	3,741	12,142	85,264	154,474
1983	24,140	29,725	3,718	12,240	85,847	155,670
1984	25,117	28,826	3,896	12,432	86,868	157,139
1985	26,191	28,193	3,987	12,825	90,671	161,867
1986	26,230	28,334	3,987	12,841	87,107	158,499
1987	26,082	28,928	3,984	12,875	85,941	157,810

Source: 1. Monitoring and Statistics Division, PES, DPWH
2. Bureau of Maintenance, DPWH

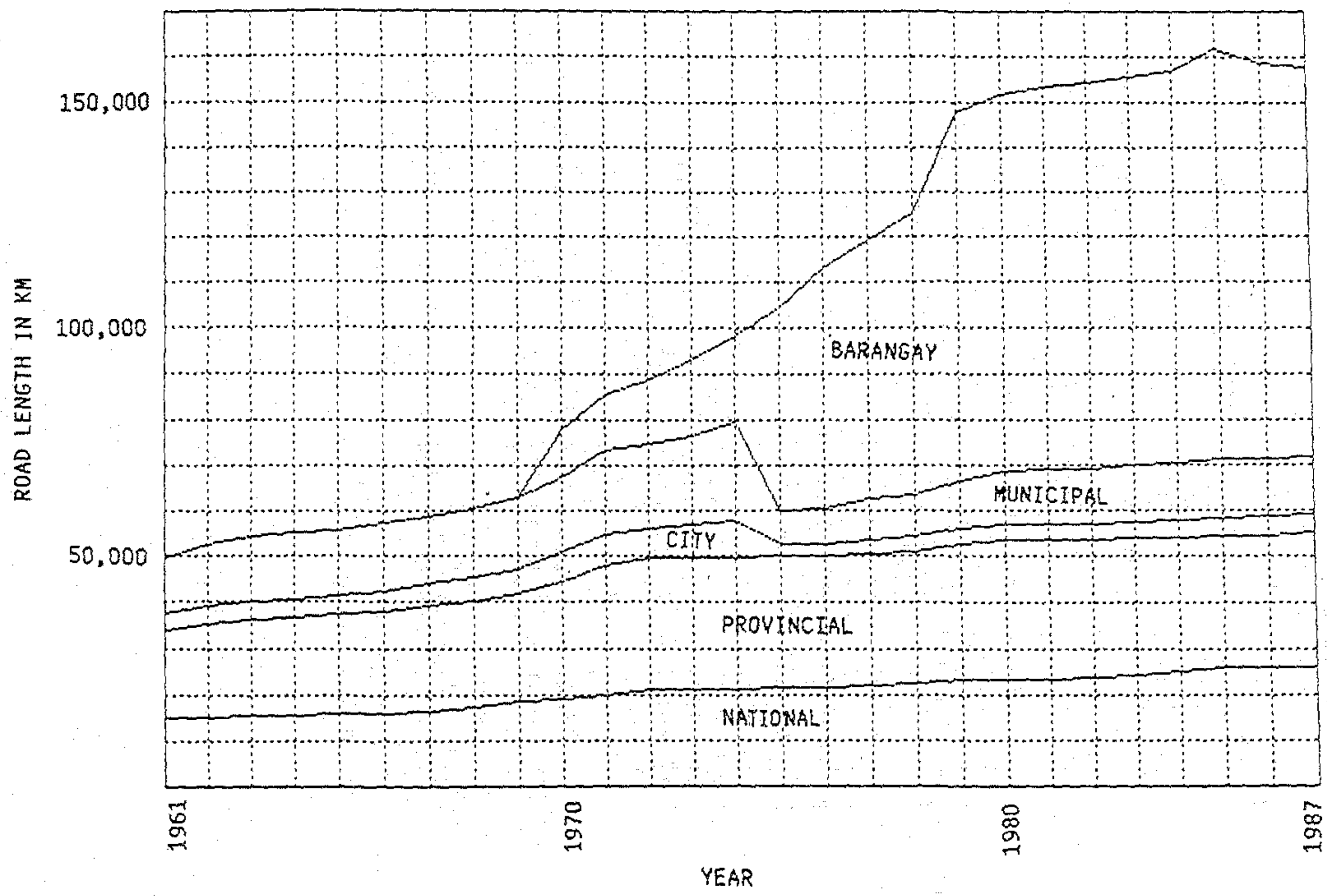


FIGURE 2.5-1 GROWTH OF ROAD LENGTH

2.5.4 Road Density

In general, road network requirement depends on both land area and population. Therefore, the road density defined as follows is used as an indicator to assess adequacy of road:

$$\text{Road Density} = L/\sqrt{AP}$$

where, L = road length, in km
A = land area, in km^2
P = population, in 1,000

Road density of each province is presented in Table 2.5-3 and graphically shown in Figure 2.5-2. Figure 2.5-3 shows the classification of province according to road density.

The provinces which have a lower road density are:

- Aurora, Quezon and Camarines Norte in the eastern part of Central Luzon

- Zambales in the western part of Central Luzon

- Sorsogon, Masbate, Northern Samar and Samar on the coast of Samar Sea

- Oriental Mindoro, Palawan and Negros Oriental in Visayas

- Agusan del Sur, Davao Oriental, North Cotabato, Maguindanao and Tawi-Tawi in Mindanao.

The provinces which have a higher road density are:

- Ilocos Norte, Ilocos Sur and Abra on northwest Luzon

- Nueva Vizcaya in Central Luzon

- Bohol, Siquijor, Camiguin, Misamis Oriental, Misamis Occidental, Bukidnon and Lanao del Sur on the coast of Bohol Sea and in its vicinity

- South Cotabato in south Mindanao

- Batanes and Romblon being small island provinces

Provincial disparity in road density is quite notable. Excluding very small island provinces, Lanao del Sur has the highest road density (3.297) and Samar the lowest (0.438), whose road density is only about one eighth that of the former.

As found in Figure 2.5-2, paved road ratio is also quite disparate. In addition to length of road, quality of road should be taken into consideration in assessing adequacy of road since there are many roads which are not accessible to motorized vehicles at all times. From this point of view, the road density defined with fair condition road length instead of total road length is used in the "Pilot Study on the Rural Road Network Development Project, JICA, 1989". The said road density is defined as follows:

Road Density = $L'/\sqrt{AP}$

where, L' = fair condition road length

= $\alpha L_{pcc} + \beta L_{AC} + \gamma L_{GR} + \delta L_{ET}$

$L_{pcc}, L_{AC}, L_{GR}, L_{ET}$ = length of PCC, AC, gravel and earth roads, respectively, in km.

$\alpha, \beta, \gamma, \delta$ = ratio of length in acceptable condition of each type of road (assumed as $\alpha = 1.0$, $\beta = 0.6$, $\gamma = 0.15$ for barangay roads and 0.30 for other roads, and $\delta = 0$)

A = land area, in km^2

P = population, in 1,000

Road density, $L'/\sqrt{AP}$ is also presented in Table 2.5-3. Excluding very small island provinces, Ilocos Norte is the highest and Masbate the lowest in terms of the road density, $L'/\sqrt{AP}$.

2.5.5 Road Density in Comparison with Other Countries

In order to have an idea of the current level of road network development, the road density in the Philippines is compared with those in other Asean countries as shown in Table 2.5-4, wherein road density is expressed by $L/\sqrt{AP}$ (L = road length in km, A = land area in km^2, and P = population in 1,000 person). Road densities are plotted against per capita GDP in Figure 2.5-4. Per capita GDP is considered as a representative indicator of economic activity and therefore related to transport demand. While per capita GDP of the Philippines is between those of Indonesia and Thailand, road density of the Philippines is higher by more than two times than those of the two countries but in terms of only paved roads, the Philippines is a little behind them. Thus, the road in the Philippines is considered quite adequate quantitatively but inadequate qualitatively. Therefore, the Philippine government places priority on improvement/rehabilitation/maintenance of existing roads.

TABLE 2.5-3 ROAD DENSITY (1/2)

	Land Area (km2) A	1987 Population P	1987 Road Length (km) National	Provinc'l	City	Municipal	Barangay	Total L	Road Density L/√(AP/1000)	Road Density L'/√(AP/1000)
All Philippines	300,000.2	57,356,069	26,081.9	28,927.8	3,984.4	12,875.3	85,940.8	157,810.2	1.203	0.322
NCR	636.0	7,354,177	882.1	-	1,273.8	554.4	271.2	2,981.5	1.379	0.94
CAR	18,293.7	1,077,532	1,613.2	1,402.0	142.2	429.1	3,499.9	7,086.4	1.596	0.358
Abra	3,975.6	183,757	179.1	479.9	-	252.0	1,309.6	2,220.6	2.598	0.469
Benguet	2,655.4	431,260	467.1	321.1	142.2	35.6	791.2	1,757.2	1.642	0.485
Mountain Province	2,097.3	112,863	316.1	272.8	-	37.3	172.9	799.1	1.642	0.404
Ifugao	2,517.8	127,803	252.6	154.4	-	18.4	557.8	983.2	1.733	0.370
Kalinga-Apayao	7,047.6	221,849	398.3	173.8	-	85.8	668.4	1,326.3	1.061	0.212
Region I	12,840.2	3,327,781	1,428.8	1,783.6	167.7	1,079.8	7,716.1	12,176.0	1.863	0.477
Ilocos Norte	3,399.3	440,087	356.7	422.2	130.9	294.8	1,867.1	3,071.7	2.511	0.647
Ilocos Sur	2,579.6	508,274	370.1	263.1	-	245.5	1,933.5	2,812.2	2.456	0.527
La Union	1,493.1	532,118	216.0	251.9	-	121.6	638.9	1,228.4	1.378	0.435
Pangasinan	5,368.2	1,847,302	486.0	846.4	36.8	417.9	3,276.6	5,063.7	1.608	0.425
Region II	26,837.7	2,298,163	1,650.9	1,644.1	-	1,037.5	6,228.1	10,560.6	1.345	0.331
Batanes	209.3	13,395	65.7	64.6	-	30.5	116.4	277.2	5.235	1.306
Cagayan	9,002.7	829,709	592.0	527.0	-	202.6	2,135.2	3,456.8	1.265	0.331
Isabela	10,664.6	1,052,180	421.5	580.2	-	430.4	2,318.9	3,751.0	1.120	0.279
Nueva Vizcaya	3,903.9	295,246	313.2	369.7	-	285.7	1,434.4	2,403.0	2.238	0.481
Quirino	3,057.2	107,633	258.5	102.6	-	88.3	223.2	672.6	1.173	0.306
Region III	18,230.8	5,725,563	1,692.2	2,364.0	258.5	1,036.8	7,725.0	13,076.5	1.280	0.394
Bataan	1,373.0	411,539	295.9	225.2	-	52.5	501.1	1,074.7	1.430	0.563
Bulacan	2,625.0	1,334,696	257.7	352.2	-	245.0	1,689.7	2,544.6	1.359	0.497
Nueva Ecija	5,284.3	1,245,862	427.3	697.6	39.6	324.3	1,739.5	3,228.3	1.258	0.359
Pampanga	2,180.7	1,415,226	279.7	321.5	128.4	118.0	1,532.2	2,379.8	1.355	0.394
Tarlac	3,053.4	785,271	209.6	552.3	-	132.7	1,661.6	2,556.2	1.651	0.420
Zambales	3,714.4	532,969	222.0	215.2	90.5	164.3	600.9	1,292.9	0.919	0.291
Region IV	46,924.1	7,488,360	4,028.5	3,866.4	292.7	1,380.9	8,788.0	18,356.5	0.979	0.296
Aurora	3,239.5	137,174	218.4	115.9	-	55.1	241.3	630.7	0.946	0.237
Batangas	3,165.8	1,372,047	507.5	637.0	37.3	237.1	2,234.7	3,653.6	1.753	0.525
Cavite	1,287.6	1,003,900	302.0	429.5	91.6	67.9	717.3	1,608.3	1.415	0.508
Laguna	1,759.7	1,215,027	346.3	252.1	79.8	146.8	645.3	1,470.3	1.006	0.463
Marinduque	959.2	199,133	217.9	173.3	-	135.1	138.8	665.1	1.522	0.452
Occidental Mindoro	5,879.8	269,305	358.9	321.8	-	131.6	794.2	1,606.5	1.277	0.284
Oriental Mindoro	4,364.7	546,107	276.7	734.7	-	66.5	242.5	1,320.4	0.855	0.263
Palawan	14,896.3	464,815	551.4	504.2	66.7	109.1	1,386.6	2,618.0	0.995	0.214
Quezon	8,706.7	1,346,948	720.1	368.4	17.3	214.1	793.6	2,113.5	0.617	0.213
Rizal	1,308.9	719,413	244.2	66.8	-	143.4	782.8	1,237.2	1.275	0.478
Romblon	1,355.9	214,491	285.1	262.7	-	74.2	810.9	1,432.9	2.657	0.585
Region V	17,632.5	4,104,522	1,936.8	1,796.6	245.3	781.6	3,851.3	8,611.6	1.012	0.321
Albay	2,552.6	945,248	385.4	374.7	26.9	166.6	684.0	1,637.6	1.054	0.385
Camarines Norte	2,112.5	370,364	185.0	134.8	-	86.2	320.7	726.7	0.822	0.338
Camarines Sur	5,266.8	1,308,911	457.4	695.3	218.4	243.2	1,815.2	3,429.5	1.306	0.375
Catanduanes	1,511.5	200,277	252.4	223.6	-	71.7	240.3	788.0	1.432	0.378
Masbate	4,047.7	685,483	359.0	117.8	-	86.6	441.0	1,004.4	0.603	0.155
Sorsogon	2,141.4	594,239	297.6	250.4	-	127.3	350.1	1,025.4	0.909	0.340

TABLE 2.5-3 ROAD DENSITY (2/2)

	Land Area (km2) A	1987 Popu-lation P	1987 Road Length (km) National	Provinc'l	City	Municipal	Barangay	Total L	Road Density L/√AP/1000	Road Density L/√ AP/1000
Region VI	20,223.2	5,322,784	2,632.8	2,453.1	297.3	696.6	7,902.1	13,981.9	1.348	0.370
Aklan	1,817.9	379,063	141.9	286.1	-	80.3	623.1	1,131.4	1.363	0.364
Antique	2,522.0	405,994	362.8	96.7	-	97.1	753.6	1,310.2	1.295	0.334
Capiz	2,633.2	585,938	306.1	365.5	27.8	81.4	877.4	1,658.2	1.335	0.348
Iloilo	5,324.0	1,660,767	949.3	814.8	31.8	224.8	2,332.8	4,353.5	1.464	0.422
Negros Occidental	7,926.1	2,291,022	872.7	890.0	237.7	213.0	3,315.2	5,528.6	1.297	0.356
Region VII	14,951.5	4,362,062	1,666.7	2,336.7	315.2	908.7	5,485.5	10,712.8	1.327	0.353
Bohol	4,117.3	899,732	585.3	922.2	65.4	288.3	2,666.3	4,527.5	2.352	0.535
Cebu	5,088.4	2,426,444	623.4	930.1	189.3	403.3	1,630.1	3,776.2	1.075	0.333
Negros Oriental	5,402.3	957,509	382.4	299.6	60.5	196.5	1,108.7	2,047.7	0.900	0.240
Siquijor	343.5	78,377	75.6	184.8	-	20.6	80.4	361.4	2.203	0.664
Region VIII	21,431.7	3,185,293	1,963.5	1,403.7	70.6	713.9	4,319.6	8,471.3	1.025	0.314
Leyte	6,268.3	1,478,953	959.0	520.6	60.5	351.5	1,913.1	3,804.7	1.250	0.386
Southern Leyte	1,734.8	350,971	265.4	350.8	-	81.2	661.4	1,358.8	1.741	0.588
Eastern Samar	4,339.6	373,825	258.7	250.5	-	135.3	968.8	1,613.3	1.267	0.287
Northern Samar	3,498.0	451,989	248.1	146.7	10.1	89.4	446.3	940.6	0.748	0.233
Samar	5,591.0	529,555	232.3	135.1	-	56.5	330.0	753.9	0.438	0.178
Region IX	18,685.0	2,994,373	1,019.1	2,094.8	121.5	836.6	5,438.1	9,510.1	1.271	0.281
Basilan	1,327.2	241,370	62.1	229.1	-	47.9	332.0	671.1	1.186	0.239
* Sulu	1,600.4	421,073	134.8	217.3	-	19.4	481.8	853.3	1.039	0.258
* Tawi-Tawi	1,087.4	227,913	92.8	29.9	-	25.0	184.7	332.4	0.668	0.141
Zamboanga del Norte	6,618.1	688,006	260.1	807.8	46.6	344.8	1,710.0	3,169.3	1.485	0.329
Zamboanga del Sur	8,051.9	1,416,011	469.3	810.7	74.9	399.5	2,729.6	4,484.0	1.328	0.291
Region X	28,327.8	3,350,016	2,151.7	2,751.6	217.4	1,210.6	8,578.1	14,909.4	1.530	0.361
Agusan del Norte	2,590.3	442,313	215.1	232.9	66.0	91.3	597.6	1,202.9	1.124	0.357
Agusan del Sur	8,965.5	329,572	300.1	266.9	-	161.9	766.4	1,495.3	0.870	0.239
Bukidnon	8,293.8	766,149	613.3	787.1	-	400.9	2,899.3	4,700.6	1.865	0.364
Camiguin	229.8	61,904	63.5	94.5	-	28.0	160.0	346.0	2.901	0.752
Misamis Occidental	1,939.3	451,601	199.4	507.9	71.4	170.1	1,398.4	2,347.2	2.508	0.522
Misamis Oriental	3,570.1	855,759	417.5	501.5	63.5	158.9	2,060.1	3,201.5	1.832	0.464
Surigao del Norte	2,739.0	442,718	342.8	360.8	16.5	199.5	696.3	1,615.9	1.467	0.378
Region XI	31,692.9	4,032,431	1,954.2	3,009.4	453.7	1,261.2	8,769.4	15,447.9	1.366	0.296
Davao del Norte	8,129.8	853,452	351.5	743.7	-	305.1	1,641.1	3,041.4	1.155	0.294
Davao del Sur	6,377.6	1,388,733	513.2	425.7	267.9	257.8	2,521.0	3,985.6	1.339	0.298
Davao Oriental	5,164.5	406,202	308.3	548.9	-	73.8	418.2	1,349.2	0.932	0.217
South Cotabato	7,468.8	925,887	464.8	1,012.5	185.8	512.1	3,379.1	5,554.3	2.112	0.383
Surigao del Sur	4,552.2	458,157	316.4	278.6	-	112.4	810.0	1,517.4	1.051	0.252
Region XII	23,293.1	2,733,012	1,461.4	2,021.8	128.5	947.6	7,368.4	11,927.7	1.495	0.293
Lanao del Norte	3,092.0	559,392	224.5	201.3	67.9	229.7	1,047.5	1,770.9	1.347	0.335
* Lanao del Sur	3,872.9	465,386	281.6	416.6	27.3	244.6	3,456.3	4,426.4	3.297	0.537
* Maguindanao	5,474.1	631,301	248.4	341.8	33.3	108.6	1,057.5	1,789.6	0.963	0.200
North Cotabato	6,565.9	693,716	555.0	447.8	-	249.6	778.7	2,031.1	0.952	0.218
Sultan Kudarat	4,288.2	383,217	151.9	614.3	-	115.1	1,028.4	1,909.7	1.490	0.262

* ARMM (Autonomous Region of Muslim Mindanao)

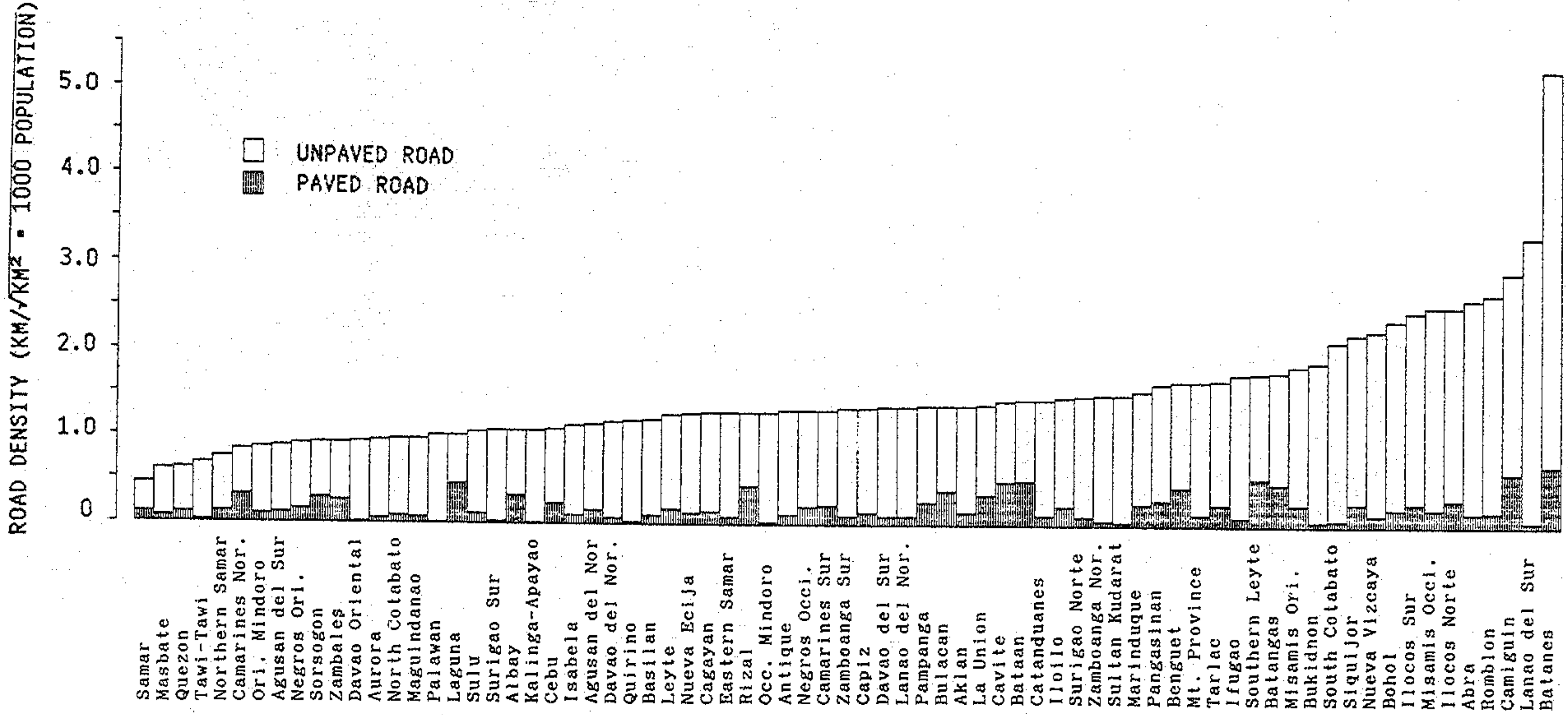


FIGURE 2.5-2 ROAD DENSITY

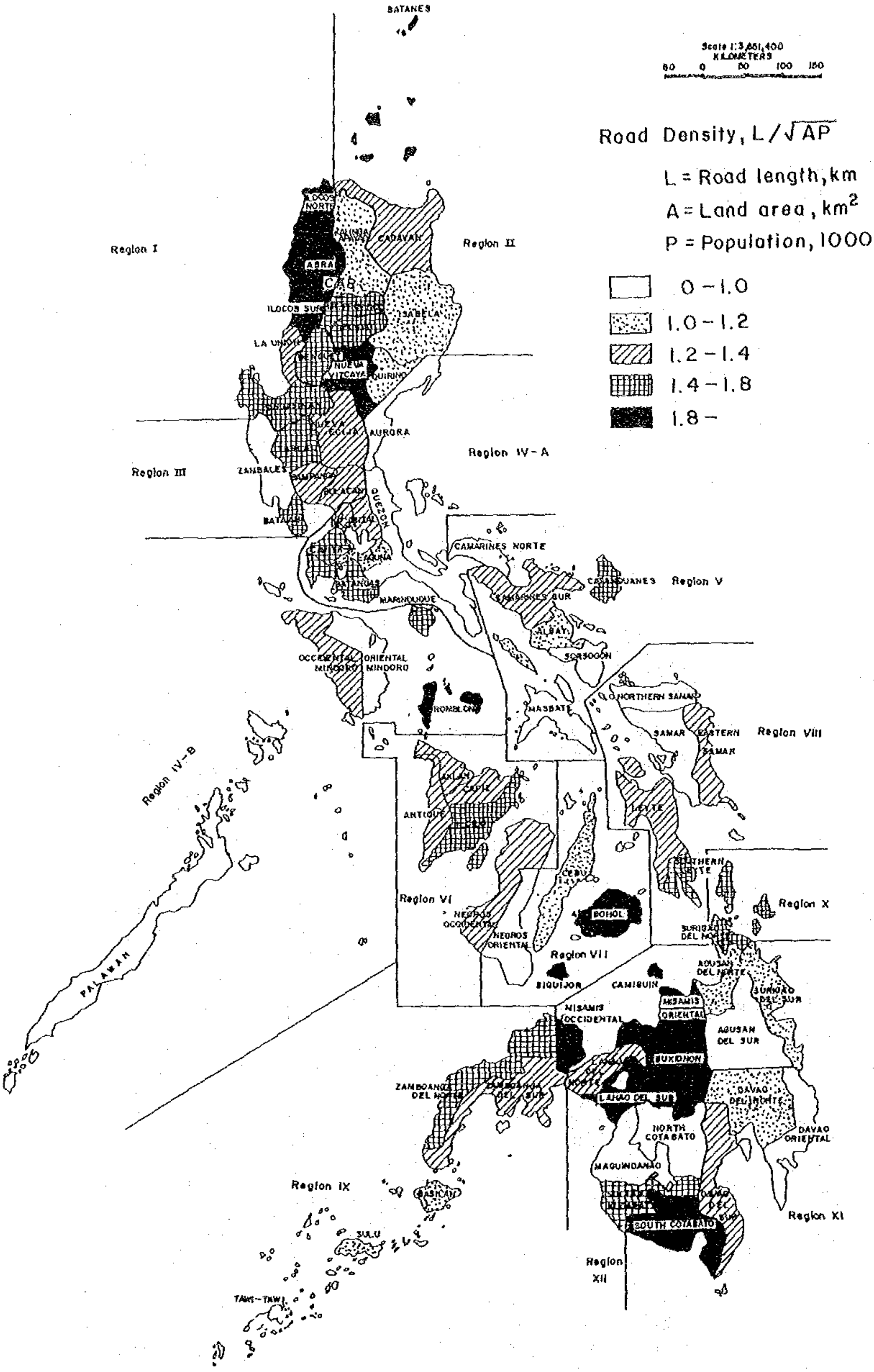


FIGURE 2.5-3 ROAD DENSITY

TABLE 2.5-4 ROAD DENSITY IN SELECTED ASEAN COUNTRIES

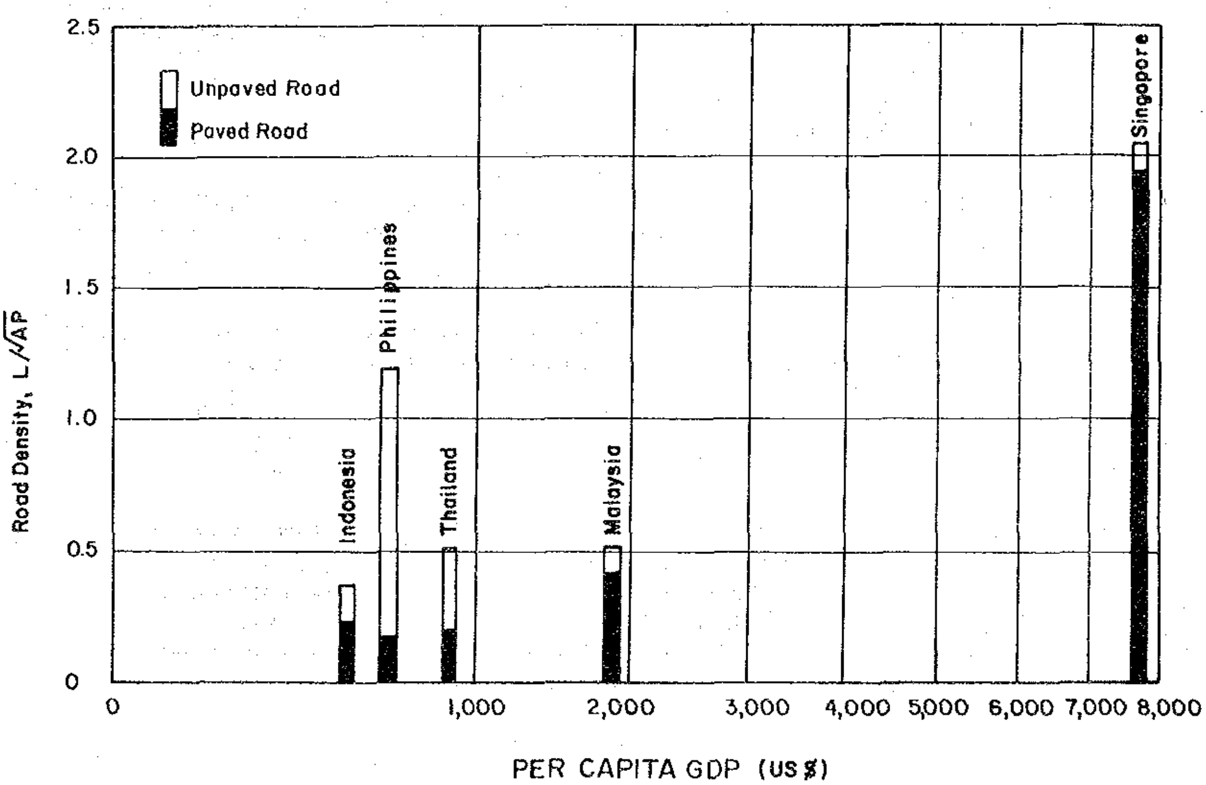
As of 1989

Country	Land Area [A] (km²)	Popu-lation [P] (1,000)	Road Length [I] (km)	Road Density [L/√AP]	Paved Ratio (%)	Per Capita GDP (US$)
Philippines	300,000	57,356	157,810	1.203	14.0	596
Thailand	513,115	53,873	85,430	0.514	40.5	890
Indonesia	1,948,732	172,010	219,009	0.378[1]	62.2[1]	440
Malaysia	329,749	16,528	39,069	0.529	80.0	1,914
Singapore	623	2,613	2,644	2.072[2]	94.8[2]	7,743

Note : 1) 1986
2) 1985

Source: World Road Statistics 1985-1989, IRF
: Asean Affairs, 1990, Institute of Developing Economies

TABLE 2.5-4 ROAD DENSITY IN SELECTED ASEAN COUNTRIES



2.6 ROAD DISASTER

2.6.1 Natural Environment and Road Construction

As previously described, roads and bridges in the Philippines are exposed to a stern natural environment. In most of the country, the topography is mountainous with rugged terrain. The geology is generally of fragile structure of the tertiary period that has been fractured due to numerous tectonic lines, the most severe representative of which is the Philippine Fault. The Philippines is also prone to earthquake and volcanic eruption. Most rivers are still uncontrolled and changing their courses. Furthermore, the Philippines is located in the South Pacific Typhoon Belt and strong typhoons hit the country six (6) times annually in average.

Major road development began in early 1970's and continued since then. Primary objectives of road development in the 1970's and early 1980's were placed on the following:

- To expand road length in order to provide basic access throughout the country, and
- To improve road surface conditions

In order to achieve the above objectives within the limited resources, roads were constructed or improved with minimum costs. Many roads thus constructed have improper provisions for surface/underground drainages, slope protections, etc., and are not strong enough to withstand against stern natural environment of the Philippines. As a result, roads have been recurrently damaged by typhoons, heavy rains and other kinds of calamities, and huge amount of costs have been spent to restore damaged roads every year.

2.6.2 Road Damage By Typhoon

Among various kinds of calamities, the typhoon calamities are most frequent and causing huge amount of damages to agricultural products, houses, infrastructures, etc. every year.

Table 2.6-1 shows estimated cost of damages to infrastructure and roads/bridges caused by typhoons for the past ten (10) years, which is summarized as follows:

	Average of the past 10 years
• Number of typhoons affected	6 times a year
• Estimated cost of damages to all infrastructure (in 1989 prices)	1,025 million pesos per annum
• Estimated cost of damages to roads/bridges only (in 1989 prices)	463 million pesos per annum

Annual average costs of damages to all infrastructure and roads/bridges alone in 1989 prices were 1,025 million pesos and 463 million pesos, respectively. About 20 to 30% of calamity fund was appropriated for aid and relief operation, therefore, capital outlay for repair and reconstruction of damaged infrastructure was not always enough for restoration works, thus many damaged infrastructures were left without having been restored.

TABLE 2.6-1 TYPHOON DAMAGES FOR THE PAST TEN YEARS

Year	No. of Typhoons Entering the PAR[1]	No. of Typhoons Affecting the Country	Estimated Cost of Damage[2] (Million Peso)						Calamity Fund[3] (Million Peso)	
			Total		All Infrastructure		Roads and Bridges			
			Current Price	1989 Price	Current Price	1989 Price	Current Price	1989 Price	Current Price	1989 Price
1980	23	9	1,465.2	4,634.4	366.4	1,158.9	78.9	249.6	300.0	948.9
1981	21	7	1,274.5	3,564.8	361.6	1,011.4	71.5	200.0	400.0	1,118.8
1982	23	8	1,659.4	4,209.8	58.7	148.9	32.9	83.5	600.0	1,522.2
1983	14	4	522.1	1,204.5	142.1	327.8	48.4	111.7	600.0	1,384.2
1984	20	4	5,869.3	9,003.4	1,850.9	2,839.2	1,099.7	1,686.9	1,500.0	2,301.0
1985	17	4	2,724.7	3,395.0	316.1	393.9	123.8	154.3	1,500.0	1,869.0
1986	21	6	1,776.8	2,197.9	526.0	650.7	330.6	409.0	1,000.0	1,237.0
1987	16	6	4,083.0	4,866.9	970.0	1,156.2	411.4	490.4	442.7	527.7
1988	20	5	8,675.6	9,508.5	1,224.9	1,342.5	589.1	645.7	442.7	485.2
1989	19	7	4,494.4	4,494.4	1,221.0	1,221.0	598.5	598.5	1,000.0	1,000.0
Total	194	60	32,545.0	47,079.6	7,037.7	10,250.5	3,384.8	4,629.6	7,785.4	12,394.0
Ave-rage	19.4	6	3,254.5	4,708.0	703.8	1,025.1	335.5	463.0	778.5	1,239.4

Note: 1) PAR = Philippine Area of Responsibility
2) Source: Asean Natural Disaster Center, Department of National Defense
3) Source: General Appropriations Act (Released amount is not available.)

2.7 SOCIO-ECONOMIC CHARACTERISTICS

Major socio-economic statistics are presented in Appendix 2-1.

Population: The total population in 1990 is estimated at about 61.5 million with a population density of 204.9 persons per square kilometer. The average population growth rate is estimated at 2.4% per annum.

Gross Domestic Product : In 1988, the gross domestic product (GDP) was registered at P101,534 million at constant 1972 prices (826,749 million pesos at current price), expanding by 6.36% with all the major sectors posting positive growth rates. The agriculture, industry and service sectors shares of the GDP were 27.4%, 32.7% and 39.9%, respectively. The sectorial shares of employed persons were 46.3%, 15.7% and 38.0% in agriculture, industry and service sectors, respectively.

Income : According to the 1988 family income and expenditures survey, the average annual family income was estimated at P39,728 while average expenditures amounted to P32,214. Families belonging to the lower half of the income bracket had 20.3% share of the total income. Families in urban areas earned an average of P58,948 annually which was twice more than that of rural families at P27,826.

Incidence of Poverty: The incidence of poverty refers to the proportion of families that fall below the poverty line out of the total number of families, where the poverty line is defined as the income required to satisfy 100% of the nutritional requirements and other needs. The incidence of poverty is 1985 was as follows:

National Average	=	59.3%
NCR	=	44.1%
Outside NCR	=	61.6%
Urban	=	56.1%
Rural	=	63.7%

CHAPTER 3
CLASSIFICATION OF PROVINCE

3.1 APPROACH

Figure 3.1-1 shows the procedure for classification of province.

1) Analysis of disaster records and physical data

To assess the disaster potential by province and classify province according thereto, disaster records and physical data were compiled by province and analyzed. Input data used in the analysis are as follows:

Disaster records:

- Annual amount of road damage by typhoon, 1980 - 1989
- Typhoon damage by spot, 1988 and 1989

Topography:

- Land area by slope category (5 categories: 0-8%; 8-18%; 18-30%; 30-50%; and 50% or more)

Geology:

- Land area by geological category (6 categories: Quaternary deposit; Neogene deposit; Palaeogene deposit; Pre-tertiary deposit; Intrusive rock; and volcanic rock)

Meteorology:

- Climate type (4 categories: 1st type; 2nd type; 3rd type; and 4th type)
- Annual rainfall
- Monthly rainfall
- Frequency of typhoon passage

Basic data by province are presented in Appendix 3-1.

2) Selection/establishment of indicators

Indicators representing the following factors were selected/established:

Road disaster	:	Intensity and frequency Type
Physical factors	:	Topography Geology Meteorology

Based on these indicators, provinces were classified disaster- wisely, topographically, geologically and meteorologically.

3) Correlation analysis between disaster intensity/frequency/type and physical factors

The correlation between the indicators established above were analyzed to examine their mutual connection.

4) Assessment of disaster potential

Based on the above correlation analysis, disaster potential was assessed regarding intensity, frequency and type of disaster.

5) Classification of province

Based on the above assessment, provinces were classified with respect to disaster potential.

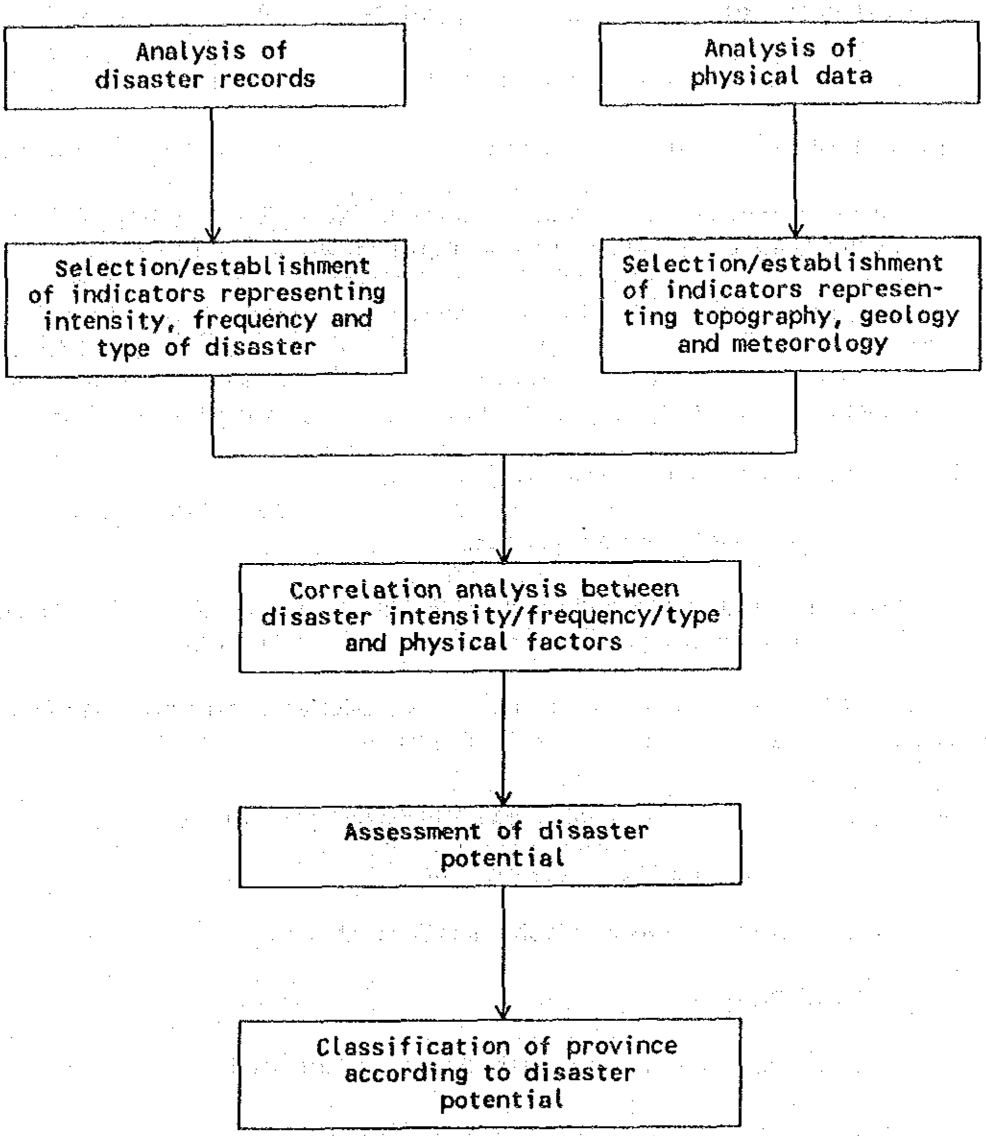


FIGURE 3.1-1 PROCEDURE FOR CLASSIFICATION OF PROVINCE

3.2 INTENSITY, FREQUENCY AND TYPE OF ROAD DISASTER

3.2.1 Intensity and Frequency of Road Disaster

The input data used for the analysis on the intensity and frequency of road disaster is:

- Annual amount of road damage by typhoon, 1980-1989 (Asean Natural Disaster Center, Office of Civil Defense, Department of National Defense)

Total amount of road damage reflects the intensity and frequency of road disaster in the area. The total amount of road damage in a province for 10 years from 1980 to 1989 divided by a certain unit such as land area or road length in the province may be used as an indicator for intensity and frequency of road disaster in the province for the period.

Road length is a better unit than land area, because:

- Only road damage is under discussion.

- In the preliminary analysis, it was found that the damage per length of road shows better correlation with physical factor than damage per land area.

In view of the above, the following indicator was selected to represent intensity and frequency of road damage and termed "Damage Rate":

Damage Rate = D/L
where, D = total amount of road damage by typhoon for 10 years (1980 to 1989) in 1,000 pesos,
L = total length of road in km.

The damage rate of each province is shown in Table 3.5-3.

3.2.2 Type of Road Disaster

The input data used for the analysis on the type of road disaster is:

- Typhoon damage by spot, 1988 and 1989 (BOM, DPWH)

Data on disaster by spot are available only for two years, 1988 and 1989.

Typhoon damages by spot in 1988 and 1989 were classified into the following three categories:

1. Road damage, including scour/washout of roadbed or shoulder, and heavy damage of pavement.

2. Bridge damage, including washout/collapse of bridge, and damage in bridge approach and culvert.

3. Slope damage, including slope failure, fall, landslide and debris flow.

Damage category composition in terms of damage amount was calculated by province and graphically shown in Figure 3.2-1. Based on the composition, provinces were classified into the following four types:

Type A:	Mostly road damage (road damage more than 80%)
Type B:	Road damage and bridge damage combined (bridge damage more than 20%)
Type C:	Remarkably slope damage (slope damage more than 40%)
Type D:	All categories of damage combined (each more than 10%)

This classification was used as indicator for type of road disaster of a province.

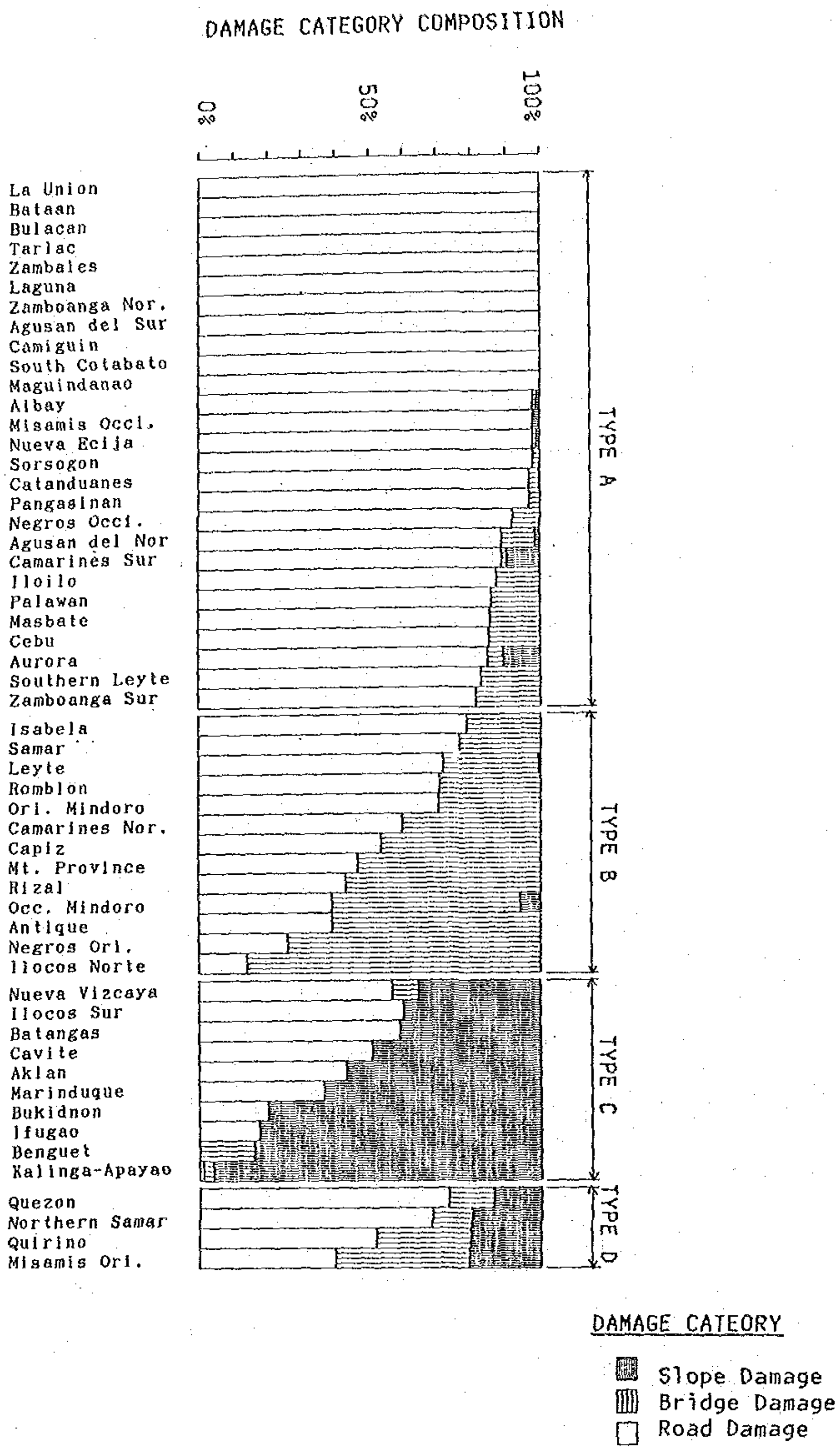


FIGURE 3.2-1 DISASTER TYPE CLASSIFICATION OF PROVINCE

3.3 PHYSICAL FACTORS

3.3.1 Topography

Land areas by slope category were used as input data. Slope categories are as follows:

1. 0 - 8%
2. 8 - 18%
3. 18 - 30%
4. 30 - 50%
5. 50% or more

Average slope calculated as follows was selected as indicator for topography:

$$\text{Average slope (\%)} = 4 \times A_1, + 13 \times A_2 + 24 \times A_3 + 40 \times A_4 + 64 \times A_5$$

where, A_1, A_2, A_3, A_4 and A_5 = ratios of land area with slope 0- 8%, 8-18%, 18-30%, 30-50% and 50% or more, respectively.

Figure 3.3-1 shows relationship between slope category composition and average slope, wherein dotted lines show regression curves.

Provinces were topographically classified according to the average slope as shown in Figure 3.3-2.

3.3.2 Geology

Land areas by geological category were used as input data. Geological categories are as follows:

1. Quaternary Deposit (Q)
2. Neogene Deposit
3. Palaeogene Deposit (T)
4. Pre-tertiary Deposit
5. Intrusive Rock
6. Volcanic Rock (I)

Based on geological category composition, provinces were classified into the following six types:

Type Q	:	Predominantly quaternary deposit	(Q)
Type T	:	Predominantly tertiary deposit	(T)
Type I	:	Predominantly igneous rock	(I)
Type QT	:	Predominantly quaternary/tertiary deposit	(Q + T)
Type QI	:	Predominantly quaternary deposit/igneous rock	(Q + I)
Type TI	:	Predominantly tertiary deposit/igneous rock	(T + I)

This geological classification was used as indicator for geology of a province.

Figure 3.3-3 shows the geological category composition and geological classification of province.

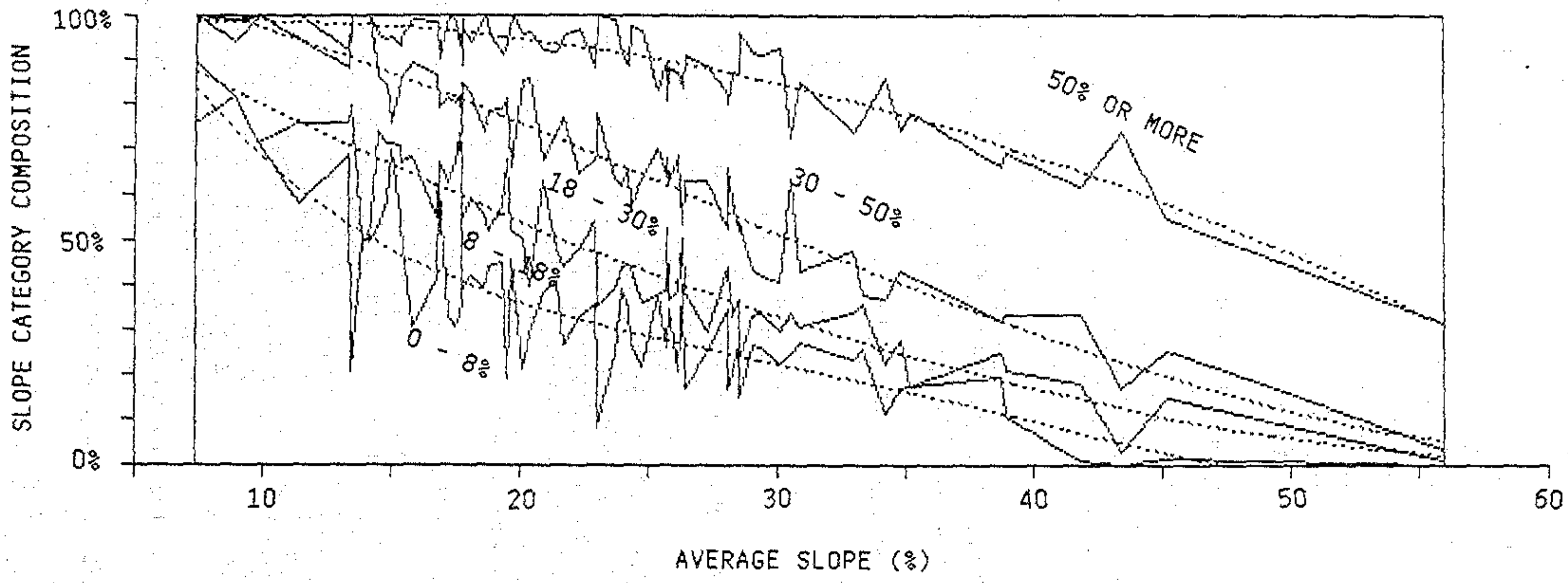


FIGURE 3.3-1 SLOPE CATEGORY COMPOSITION VS. AVERAGE SLOPE

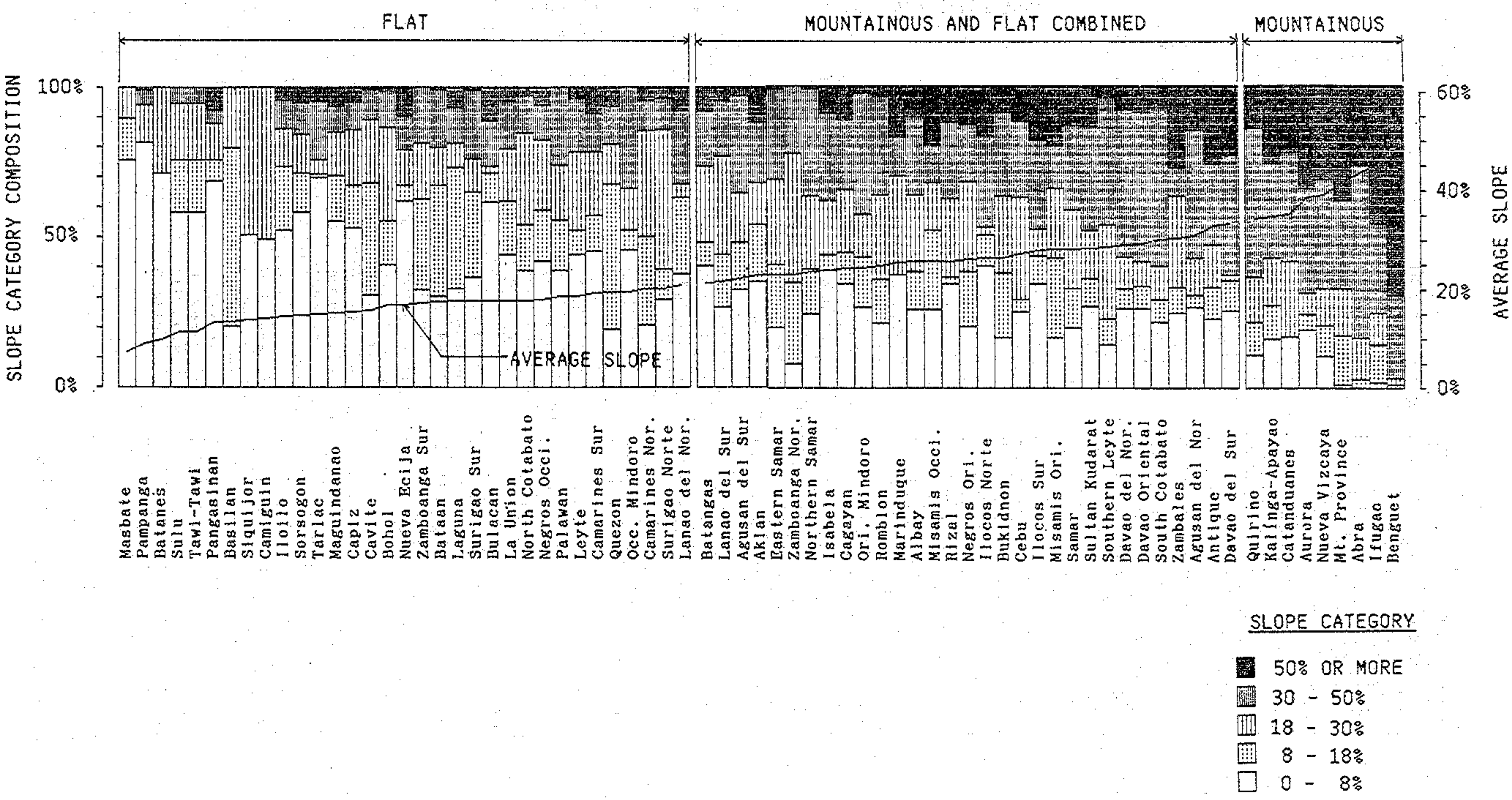


FIGURE 3.3-2 TOPOGRAPHICAL CLASSIFICATION OF PROVINCE

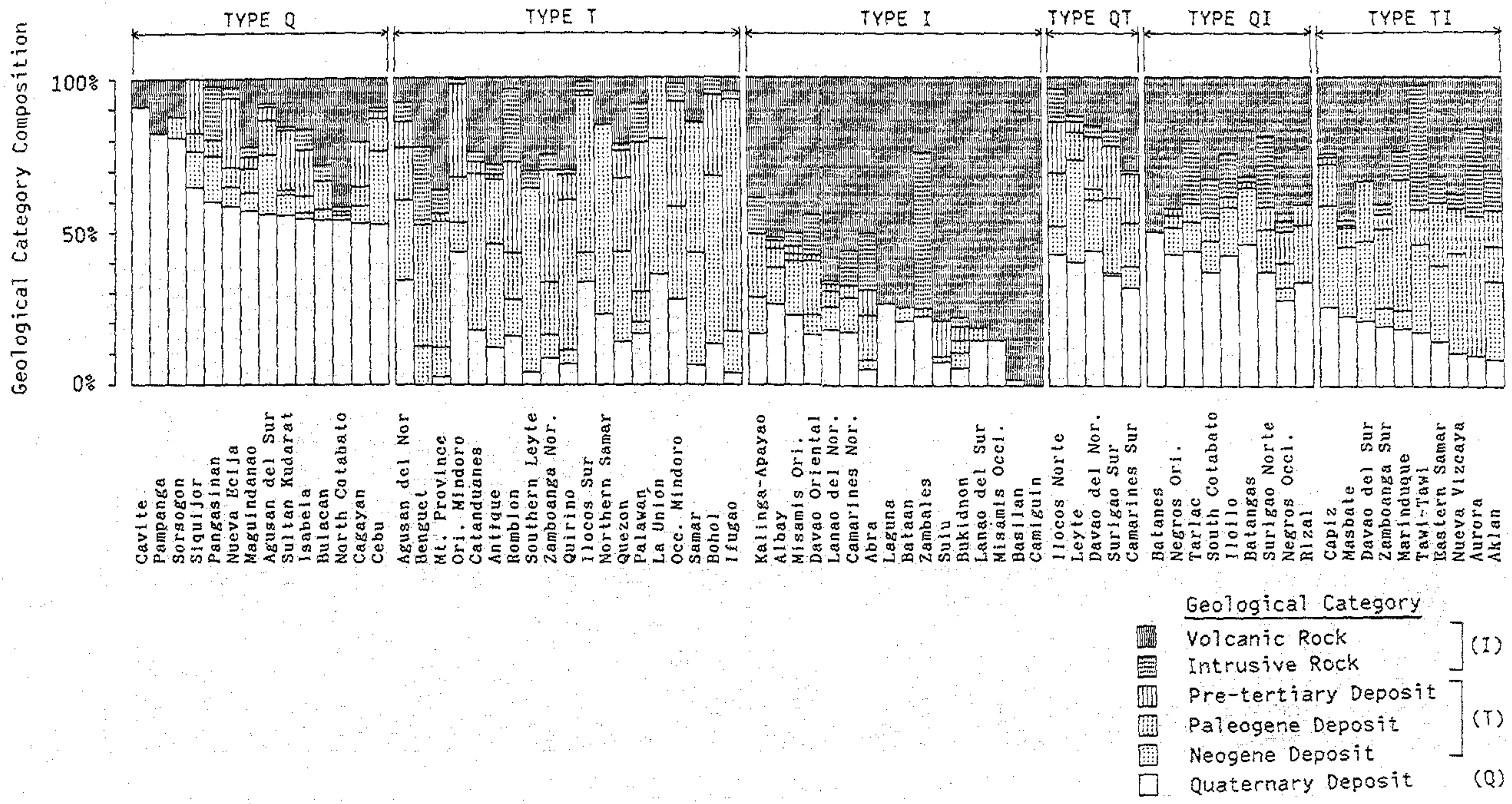


FIGURE 3.3-3 GEOLOGICAL CLASSIFICATION OF PROVINCE

3.3.3 Meteorology

The following data were used as input data:

- Climate type as categorized into four types as follows:

  1st type : two pronounced seasons; dry from November to April, wet during the rest of the year.

  2nd type: no dry season with a very pronounced maximum rainfall from November to January.

  3rd type : seasons not very pronounced; relatively dry from November to April and wet during the rest of the year.

  4th type : rainfall more or less evenly distributed through the year.

- Annual rainfall

- Monthly rainfall

- Frequency of typhoon passage

For the simplicity of the analysis, a single indicator representing meteorological characteristics of a province in relation to road disaster was introduced as follows:

1) Selection of indicator representative of all rainfall related factors.

   Climate type classification is based on rainfall distribution through the year and does not depend on volume of rainfall. Figure 3.3-4 shows the relationship between maximum monthly rainfall and annual rainfall with regression curves by climate type. Correlation coefficients for the regressions are as follows:

   1st type : 0.92
   2nd type: 0.95
   3rd type : 0.96
   4th type : 0.92

   Thus, maximum monthly rainfall is well predicted by climate type and annual rainfall. It means that maximum monthly rainfall represents combined effect of climate type and annual rainfall.

   Furthermore, maximum monthly rainfall is more closely correlated with damage rate than climate type or annual rainfall.

   In view of the above, maximum monthly rainfall was selected as representative indicator for rainfall factors.

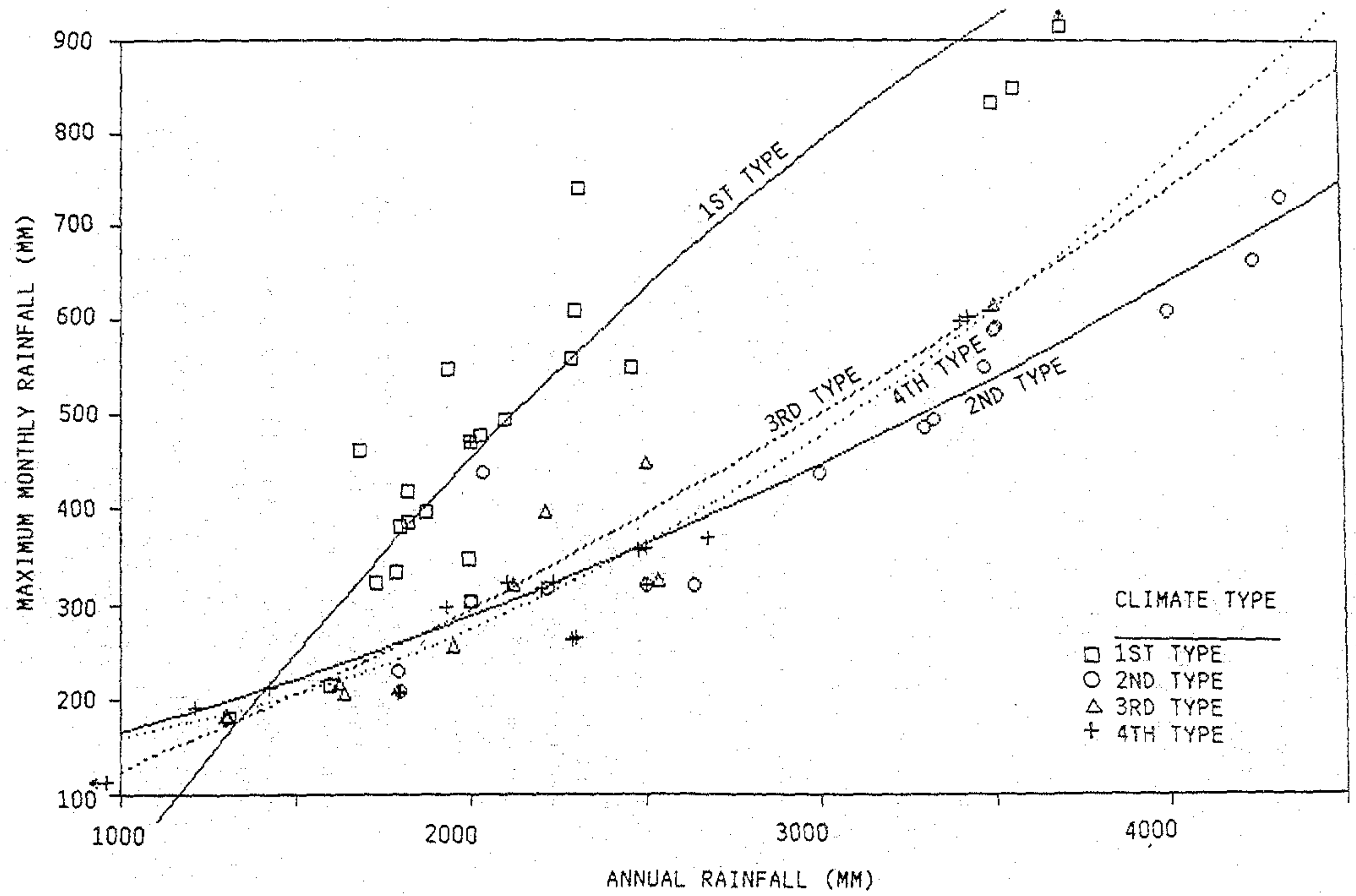


FIGURE 3.3-4 RELATIONSHIP BETWEEN MAXIMUM MONTHLY RAINFALL AND ANNUAL RAINFALL

2) Establishment of rainfall and typhoon combined indicator

This indicator is expressed by:

$$Nt + k\ Rm$$

where, Nt = average number of typhoons per year
Rm = maximum monthly rainfall in mm
k = coefficient

k was determined to be 1/900 by the multiple regression analysis so that the indicator may have the best correlation with damage rate.

The indicator thus developed is defined as follows and termed "Meteorological Effect Index".

Meteorological Effect Index = Nt + Rm/900

where, Nt = average number of typhoons per year
Rm = maximum monthly rainfall in mm

Provinces were meteorologically classified according to the meteorological effect index as shown in Figure 3.3-5.

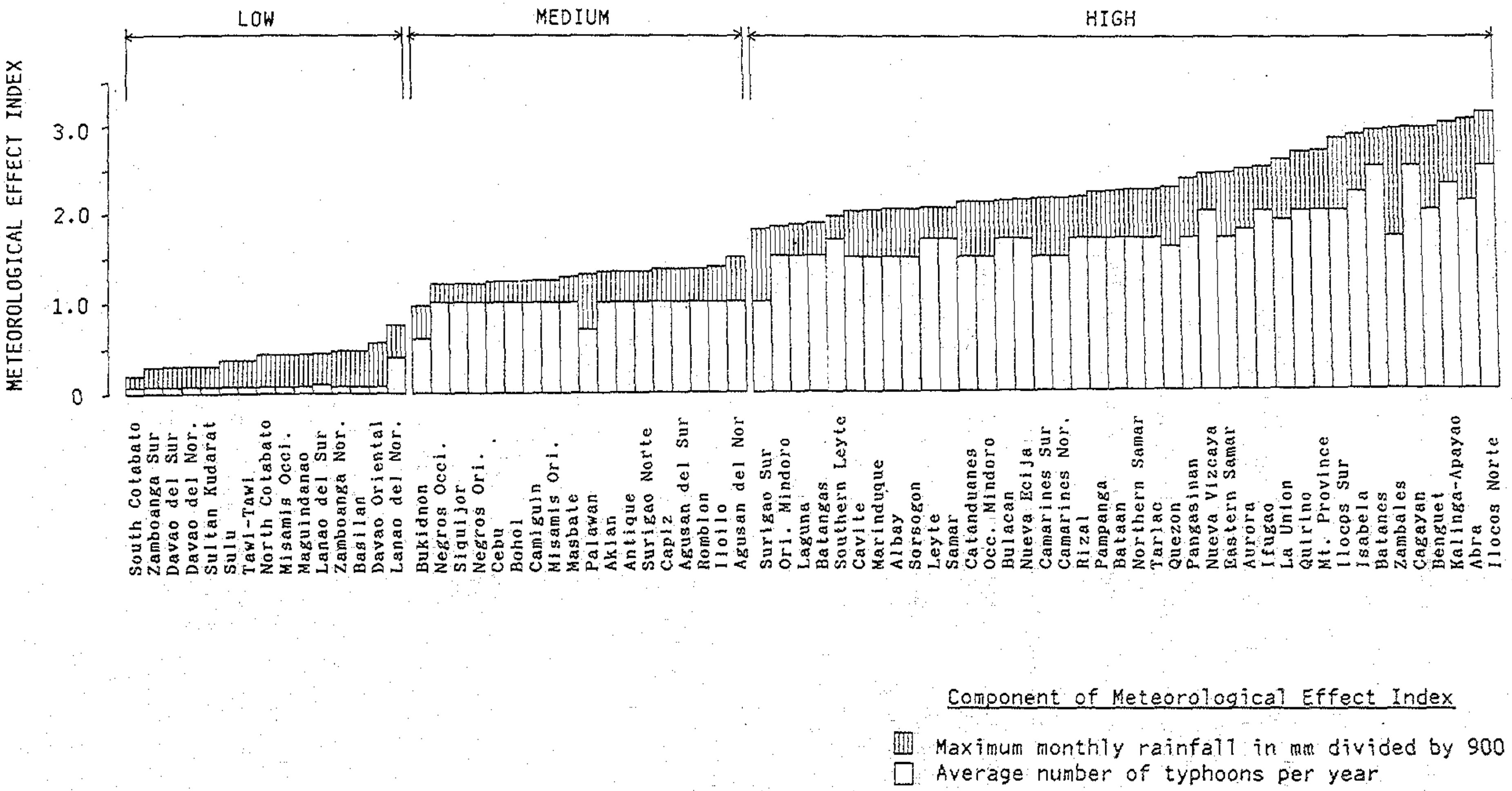


FIGURE 3.3-5 METEOROLOGICAL CLASSIFICATION OF PROVINCE

3.4 CORRELATION BETWEEN ROAD DISASTER AND PHYSICAL FACTORS

As discussed in Chapter 3.2 and 3.3, the indicators for intensity, frequency and type of disaster and physical factors were selected/established as follows:

Factor	Indicator
Intensity and frequency of disaster	Damage rate
Type of disaster	Disaster type classification
Topography	Average slope
Geology	Geological classification
Meteorology	Meteorological effect index

Figures 3.4-1 to 3.4-3 show the relationship between physical indicators and disaster-wise indicators. The correlation coefficient in each combination of two indicators is shown in Table 3.4-1.

TABLE 3.4-1 CORRELATION COEFFICIENTS BETWEEN INDICATORS

	Damage Rate	Disaster Type Classification	Average Slope	Geological Classification	Meteorological Effect Index
Damage Rate	-	0.030	0.298	0.259	0.571
Disaster Type Classification	0.030	-	0.495	0.359	0.349
Average Slope	0.298	0.495	-	0.411	0.289
Geological Classification	0.259	0.359	0.411	-	0.258
Meteorological Effect Index	0.571	0.349	0.289	0.258	-

The following were observed from the correlation analysis:

(1) There is no connection between damage rate and disaster type classification. Disaster intensity/frequency and disaster type are independent to each other.

(2) There is little connection between any two physical factors, except that a slight correlation is found between topography and geology.

(3) Among physical factors, meteorology is the most closely correlated with disaster intensity/frequency.

(4) Among physical factors, topography is the most closely correlated with disaster type.

Shortly, disaster potential may be assessed mainly based on meteorological factor, while disaster type is mainly related to topography.

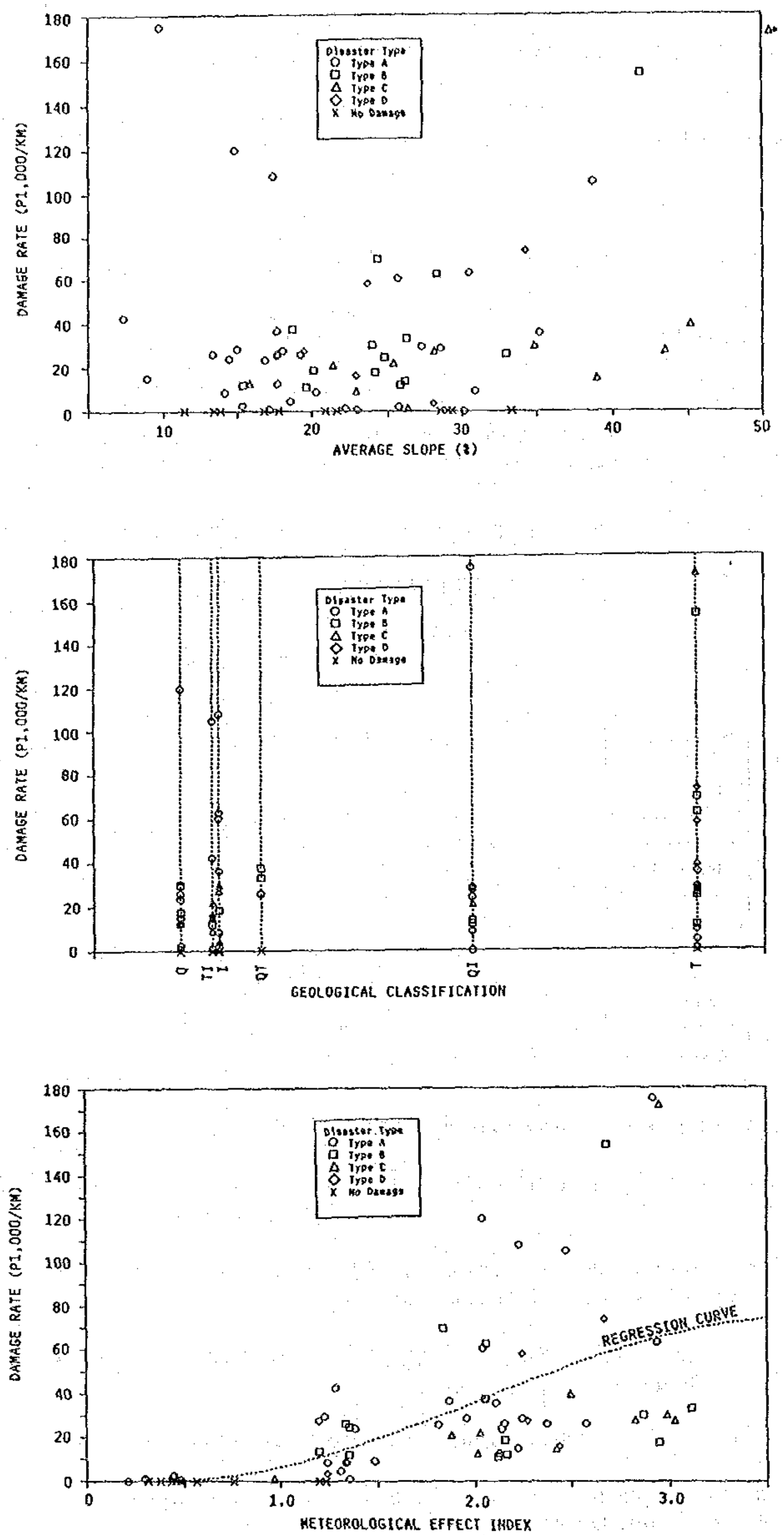


FIGURE 3.4-3 DAMAGE RATE VS. METEOROLOGICAL EFFECT INDEX

3.5 CLASSIFICATION OF PROVINCE

The connection between road disaster and physical factor is summarized as follows:

- Disaster potential is mainly related to meteorology.
- Disaster type is mainly related to topography.
- There is no connection between disaster potential and disaster type, nor between meteorology and topography.

Consequently, it is appropriate to classify province according to two factors; meteorology and topography represented by meteorological effect index and average slope, respectively.

Average slope vs. meteorological effect index are plotted in Figure 3.5-1. Based on this figure, the classification of province was made as shown in Table 3.5-1.

TABLE 3.5-1 CLASSIFICATION OF PROVINCE WITH RESPECT TO ROAD DISASTER

		Disaster Potential		
		Low	Medium	High
Topography	Mountainous	-	-	Group H-M
	Mountainous and Flat Combined	Group L-MF	Group M-MF	Group H-MF
	Flat	Group L-F	Group M-F	Group H-F

The provinces belonging to each group are listed in Table 3.5-2 and shown on map in Figure 3.5-2.

Major characteristics of provinces are summarized in Table 3.5-3 with mean values of group.

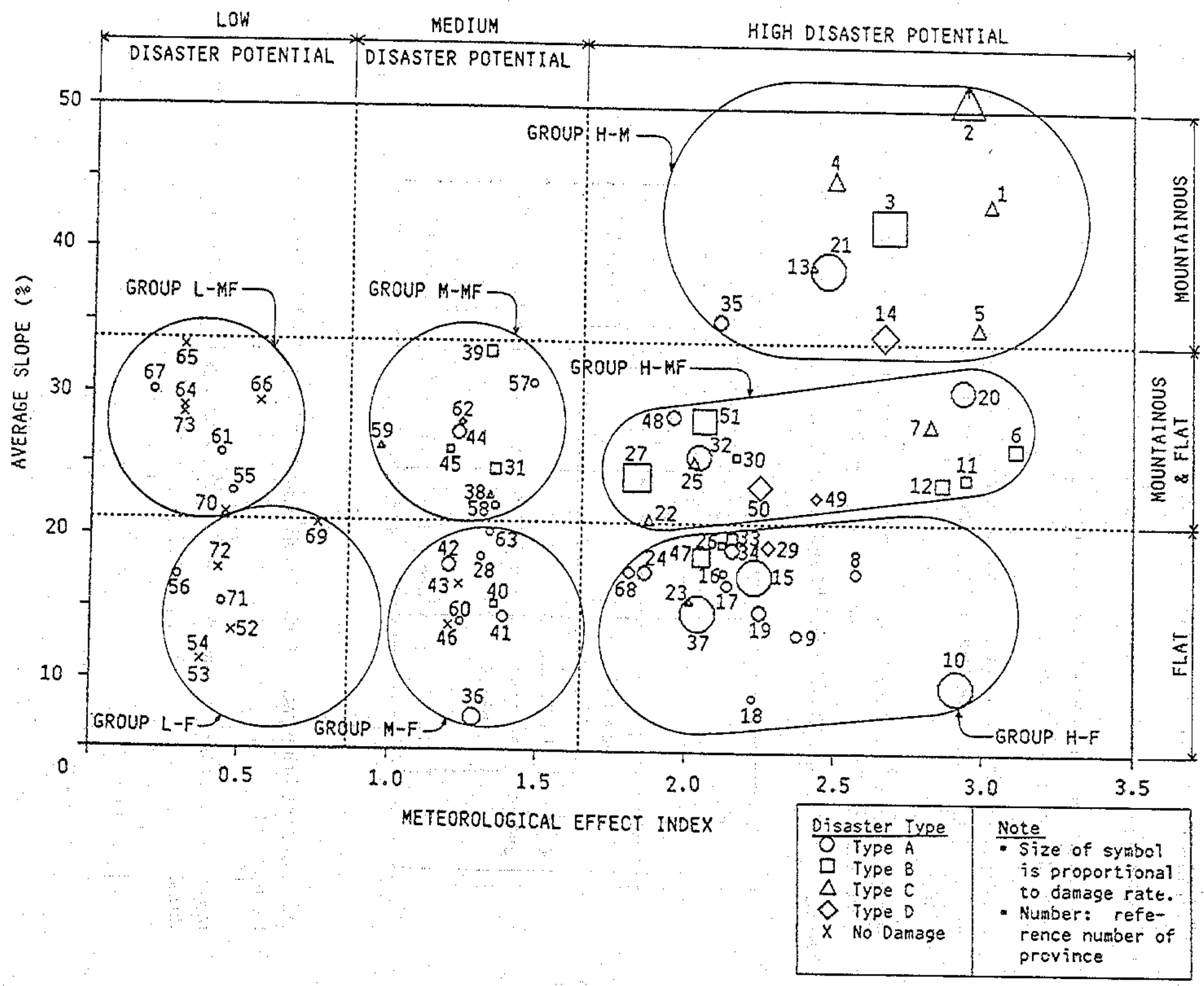


FIGURE 3.5-1 AVERAGE SLOPE VS. METEOROLOGICAL EFFECT INDEX

TABLE 3.5-2 CLASSIFICATION OF PROVINCE

		DISASTER POTENTIAL								
		L (LOW)			M (MEDIUM)			H (HIGH)		
Topography	M (Mountainous)							Group H-M		
								(CAR)	Benguet	2
								(CAR)	Ifugao	4
								(CAR)	Abra	1
								(CAR)	Mountain Province	3
								(2)	Nueva Vizcaya	13
								(4)	Aurora	21
								(5)	Catanduanes	35
								(CAR)	Kalinga-Apayao	5
								(2)	Quirino	14
	MF (Mountainous and Flat)	Group L-MF			Group M-MF			Group H-MF		
		(11)	Davao del Sur	65	(6)	Antique	39	(3)	Zambales	20
		(11)	South Cotabato	67	(10)	Agusan del Norte	57	(8)	Southern Leyte	48
		(11)	Davao Oriental	66	(10)	Misamis Oriental	62	(8)	Samar	51
		(11)	Davao del Norte	64	(7)	Cebu	44	(1)	Ilocos Sur	7
		(12)	Sultan Kudarat	73	(10)	Bukidnon	59	(1)	Ilocos Norte	6
		(10)	Misamis Occidental	61	(7)	Negros Oriental	45	(4)	Rizal	30
		(9)	Zamboanga del Norte	55	(4)	Romblon	31	(5)	Albay	32
		(12)	Lanao del Sur	70	(6)	Aklan	38	(4)	Marinduque	25
					(10)	Agusan del Sur	58	(4)	Oriental Mindoro	27
								(2)	Cagayan	11
								(2)	Isabela	12
								(8)	Northern Samar	50
								(8)	Eastern Samar	49
								(4)	Batangas	22
	F (Flat)	Group L-F			Group M-F			Group H-F		
		(12)	Lanao del Norte	69	(10)	Surigao del Norte	63	(5)	Camarines Norte	33
		(12)	North Cotabato	72	(4)	Palawan	28	(4)	Occidental Mindoro	26
		(9)	Zamboanga del Sur	56	(6)	Negros Occidental	42	(4)	Quezon	29
		(12)	Maguindanao	71	(7)	Bohol	43	(5)	Camarines Sur	34
		(9)	Basilan	52	(6)	Capiz	40	(8)	Leyte	47
		(9)	Tawi-Tawi	54	(6)	Iloilo	41	(1)	La Union	8
		(9)	Sulu	53	(10)	Camiguin	60	(3)	Bulacan	16
					(7)	Siquijor	46	(11)	Surigao del Sur	68
					(5)	Masbate	36	(4)	Laguna	24
								(3)	Bataan	15
								(3)	Nueva Ecija	17
								(4)	Cavite	23
								(3)	Tarlac	19
								(5)	Sorsogon	37
								(1)	Pangasinan	9
								(2)	Batanes	10
								(3)	Pampanga	18

NOTE: ( ): Region Number
Number at the end of province name: reference number of province

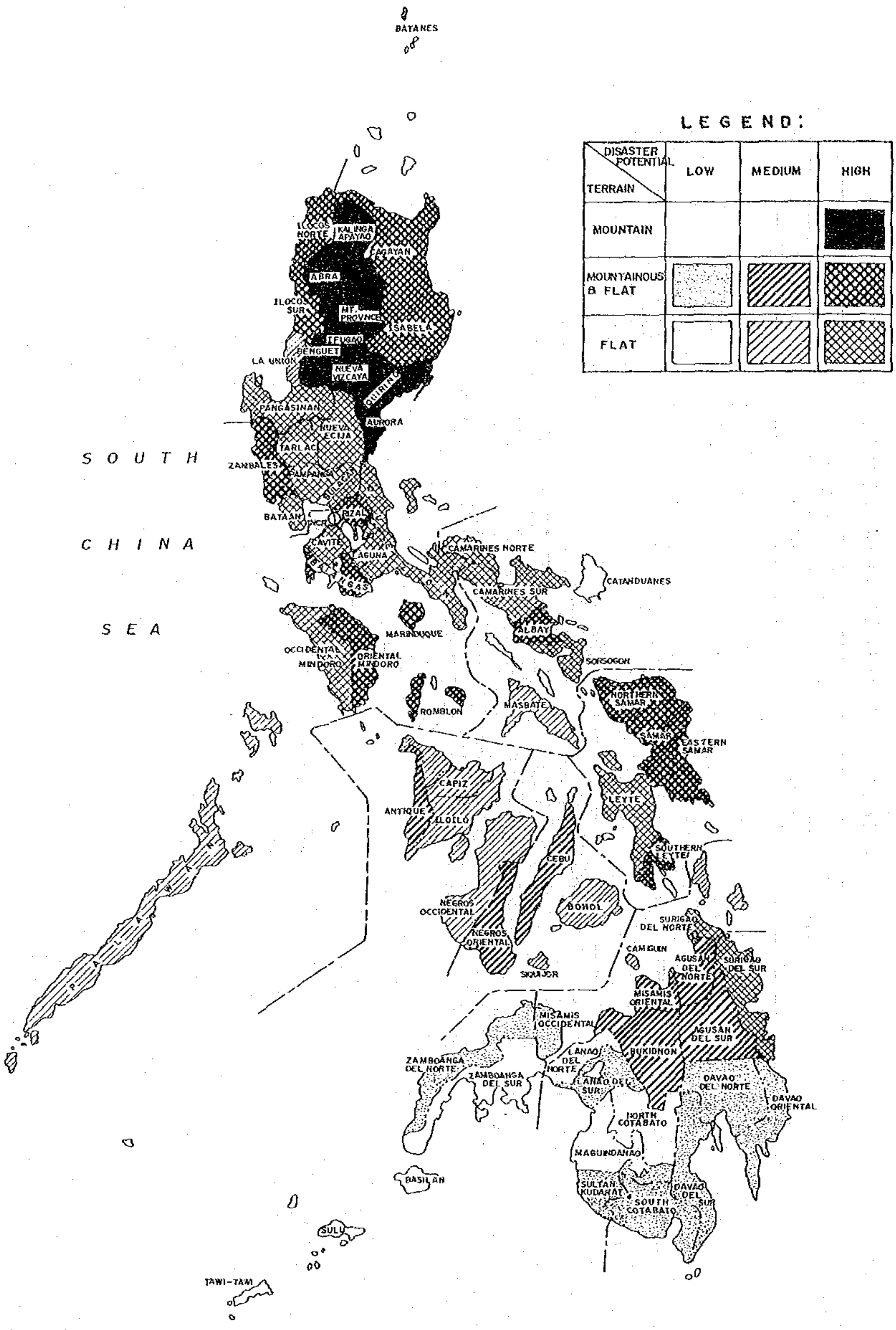


FIGURE 3.5-2 CLASSIFICATION OF PROVINCE

TABLE 3.5-3 MAJOR CHARACTERISTICS OF PROVINCES

Group H-M

Region	Province	Ref No.	Land Area (km2)	Road Length (km)	Average Slope (%)	Geological Classifi-cation	Meteoro'l Effect Index	10-year Damage (Mp)	Damage Rate (1000p/km)	Disaster Type
(CAR)	Benguet	2	2655.4	1757.2	55.9	T	2.94	301.83	171.8	C
(CAR)	Ifugao	4	2517.8	983.2	45.1	T	2.50	38.76	39.4	C
(CAR)	Abra	1	3975.6	2220.6	43.4	I	3.03	61.06	27.5	C
(CAR)	Mountain Province	3	2097.3	799.1	41.9	T	2.68	122.85	153.7	B
(2)	Nueva Vizcaya	13	3903.9	2403.0	39.0	TI	2.42	35.53	14.8	C
(4)	Aurora	21	3239.5	630.7	38.7	TI	2.47	66.08	104.8	A
(5)	Catanduanes	35	1511.5	788.0	35.2	T	2.11	27.90	35.4	A
(CAR)	Kalinga-Apayao	5	7047.6	1326.3	34.8	I	2.98	39.91	30.1	C
(2)	Quirino	14	3057.2	672.6	34.2	T	2.67	49.53	73.6	D
	Average		3334.0	1286.7	40.1	TI	2.64	82.61	24.8	C

Group H-MF

Region	Province	Ref No.	Land Area (km2)	Road Length (km)	Average Slope (%)	Geological Classifi-cation	Meteoro'l Effect Index	10-year Damage (Mp)	Damage Rate (1000p/km)	Disaster Type
(3)	Zambales	20	3714.4	1292.9	30.5	I	2.93	81.69	63.2	A
(8)	Southern Leyte	48	1734.8	1358.8	28.5	T	1.96	38.41	28.3	A
(8)	Samar	51	5591.0	753.9	28.3	T	2.06	47.30	62.7	B
(1)	Ilocos Sur	7	2579.6	2812.2	28.0	T	2.82	77.83	27.7	C
(1)	Ilocos Norte	6	3399.3	3071.7	26.3	QT	3.11	101.69	33.1	B
(4)	Rizal	30	1308.9	1237.2	25.8	QI	2.16	14.59	11.8	B
(5)	Albay	32	2552.6	1637.6	25.7	I	2.04	99.13	60.5	A
(4)	Marinduque	25	959.2	665.1	25.4	TI	2.02	14.65	22.0	C
(4)	Oriental Mindoro	27	4364.7	1320.4	24.3	T	1.83	91.57	69.4	B
(2)	Cagayan	11	9002.7	3456.8	24.2	Q	2.94	61.06	17.7	B
(2)	Isabela	12	10664.6	3751.0	23.9	Q	2.86	112.22	29.9	B
(8)	Northern Samar	50	3498.0	940.6	23.6	T	2.25	54.64	58.1	D
(8)	Eastern Samar	49	4339.6	1613.3	22.9	TI	2.44	25.63	15.9	D
(4)	Batangas	22	3165.8	3653.6	21.4	QI	1.87	75.85	20.8	C
	Average		4062.5	1968.9	25.2	QT	2.38	64.02	15.8	A

Group H-F

Region	Province	Ref No.	Land Area (km2)	Road Length (km)	Average Slope (%)	Geological Classifi-cation	Meteoro'l Effect Index	10-year Damage (Mp)	Damage Rate (1000p/km)	Disaster Type
(5)	Camarines Norte	33	2112.5	726.7	20.1	I	2.16	13.46	18.5	B
(4)	Occidental Mindoro	26	5879.8	1606.5	19.6	T	2.12	18.00	11.2	B
(4)	Quezon	29	8706.7	2113.5	19.5	T	2.28	57.62	27.3	D
(5)	Camarines Sur	34	5266.8	3429.5	19.3	QT	2.16	89.73	26.2	A
(8)	Leyte	47	6268.3	3804.7	18.7	QT	2.05	142.16	37.4	B
(1)	La Union	8	1493.1	1228.4	17.7	T	2.58	31.93	26.0	A
(3)	Bulacan	16	2625.0	2544.6	17.7	Q	2.13	31.88	12.5	A
(11)	Surigao del Sur	68	4552.2	1517.4	17.7	QT	1.81	38.97	25.7	A
(4)	Laguna	24	1759.7	1470.3	17.7	I	1.86	53.56	36.4	A
(3)	Bataan	15	1373.0	1074.7	17.5	I	2.23	116.07	108.0	A
(3)	Nueva Ecija	17	5284.3	3228.3	16.8	Q	2.14	75.75	23.5	A
(4)	Cavite	23	1287.6	1608.3	15.8	Q	2.01	19.82	12.3	C
(3)	Tarlac	19	3053.4	2556.2	15.0	QI	2.25	72.67	28.4	A
(5)	Sorsogon	37	2141.4	1025.4	14.8	Q	2.04	123.22	120.2	A
(1)	Pangasinan	9	5368.2	5063.7	13.4	Q	2.38	130.51	25.8	A
(2)	Batanes	10	209.3	277.2	9.8	QI	2.91	48.55	175.1	A
(3)	Pampanga	18	2180.7	2379.8	8.9	Q	2.22	35.43	14.9	A
	Average		3503.6	2097.4	17.4	QT	2.19	64.67	18.5	A

Group M-MF

Region	Province	Ref No.	Land Area (km2)	Road Length (km)	Average Slope (%)	Geological Classifi-cation	Meteoro'l Effect Index	10-year Damage (Mp)	Damage Rate (1000p/km)	Disaster Type
(6)	Antique	39	2522.0	1310.2	33.0	T	1.34	33.86	25.8	B
(10)	Agusan del Norte	57	2590.3	1202.9	30.9	T	1.48	11.09	9.2	A
(10)	Misamis Oriental	62	3570.1	3201.5	28.1	I	1.24	10.82	3.4	D
(7)	Cebu	44	5088.4	3776.2	27.3	Q	1.23	110.86	29.4	A
(10)	Bukidnon	59	8293.8	4700.6	26.4	I	0.96	5.73	1.2	C
(7)	Negros Oriental	45	5402.3	2047.7	26.1	QI	1.20	27.61	13.5	B
(4)	Romblon	31	1355.9	1432.9	24.8	T	1.36	35.43	24.7	B
(6)	Aklan	38	1817.9	1131.4	22.9	TI	1.34	10.32	9.1	C
(10)	Agusan del Sur	58	8965.5	1495.3	22.2	Q	1.36	1.35	0.9	A
	Average		4400.7	2255.4	26.2	QI	1.28	27.45	6.2	D

Group M-F

Region	Province	Ref No.	Land Area (km2)	Road Length (km)	Average Slope (%)	Geological Classifi-cation	Meteoro'l Effect Index	10-year Damage (Mp)	Damage Rate (1000p/km)	Disaster Type
(10)	Surigao del Norte	63	2739.0	1615.9	20.3	QI	1.34	13.34	8.3	A
(4)	Palawan	28	14896.3	2618.0	18.6	T	1.31	11.52	4.4	A
(6)	Negros Occidental	42	7926.1	5528.6	18.1	QI	1.20	151.17	27.3	A
(7)	Bohol	43	4117.3	4527.5	16.8	T	1.24	0.00	0.0	-
(6)	Capiz	40	2633.2	1658.2	15.4	TI	1.36	20.07	12.1	B
(6)	Iloilo	41	5324.0	4353.5	14.5	QI	1.39	103.80	23.8	A
(10)	Camiguin	60	229.8	346.0	14.1	I	1.24	3.02	8.7	A
(7)	Siquijor	46	343.5	361.4	13.9	Q	1.20	0.00	0.0	-
(5)	Masbate	36	4047.7	1004.4	7.3	TI	1.29	42.72	42.5	A
	Average		4695.2	2445.9	16.6	TI	1.28	38.40	8.2	A

Group L-MF

Region	Province	Ref No.	Land Area (km2)	Road Length (km)	Average Slope (%)	Geological Classifi-cation	Meteoro'l Effect Index	10-year Damage (Mp)	Damage Rate (1000p/km)	Disaster Type
(11)	Davao del Sur	65	6377.6	3985.6	33.3	TI	0.31	0.00	0.0	-
(11)	South Cotabato	67	7468.8	5554.3	30.1	QI	0.21	0.06	0.0	A
(11)	Davao Oriental	66	5164.5	1349.2	29.4	I	0.56	0.00	0.0	-
(11)	Davao del Norte	64	8129.8	3041.4	29.0	QT	0.31	0.00	0.0	-
(12)	Sultan Kudarat	73	4288.2	1909.7	28.5	Q	0.31	0.00	0.0	-
(10)	Misamis Occidental	61	1939.3	2347.2	25.7	I	0.44	4.92	2.1	A
(9)	Zamboanga del Norte	55	6618.1	3169.3	23.0	T	0.48	1.00	0.3	A
(12)	Lanao del Sur	70	3872.9	4426.4	21.6	I	0.45	0.00	0.0	-
	Average		5482.4	3222.9	28.1	TI	0.38	0.75	0.1	A

Group L-F

Region	Province	Ref No.	Land Area (km2)	Road Length (km)	Average Slope (%)	Geological Classifi-cation	Meteoro'l Effect Index	10-year Damage (Mp)	Damage Rate (1000p/km)	Disaster Type
(12)	Lanao del Norte	69	3092.0	1770.9	20.9	I	0.76	0.00	0.0	-
(12)	North Cotabato	72	6565.9	2031.1	17.7	Q	0.43	0.00	0.0	-
(9)	Zamboanga del Sur	56	8051.9	4484.0	17.2	TI	0.29	4.27	1.0	A
(12)	Maguindanao	71	5474.1	1789.6	15.3	Q	0.44	4.33	2.4	A
(9)	Basilan	52	1327.2	671.1	13.4	I	0.48	0.00	0.0	-
(9)	Tawi-Tawi	54	1087.4	332.4	11.4	TI	0.38	0.00	0.0	-
(9)	Sulu	53	1600.4	853.3	11.4	I	0.37	0.00	0.0	-
	Average		3885.6	1704.6	16.6	QI	0.45	1.23	0.3	A