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The World Bank

Natural Disaster Risk Management in the Philippines Reducing Vulnerability

FOLLOW-ON STUDY

Final Report

June 2005

Pacific Consultants International

Acknowledgements

This report is prepared under the overall supervision of Ms Idah Pswarayi-Riddihough (EASRD), with the participation of several government organizations, both at the central and Local Government levels. The key counterpart was the National Disaster Coordinating Council (NDCC), and special thanks go to Colonel Elma C. Aldea, Administrator; Director Ronald I. Flores, Special Assistant to the SND/C, NDCC, Civil Defense Executive Officer, Chief Calamity Fund Management Unit; and Mr. Edgardo J. Ollet, Chief, OCD Plans Division. Head, NDCC Secretariat.

The study was designed to follow-on to the "Natural Disaster Risk Management in the Philippines: Enhancing Poverty Alleviation Through Disaster Reduction" which had as an objective: "to document the impacts of natural disasters on the social and economic development of the Philippines; assess the country's current capacity to reduce and manage disaster risk; and identify options for more effective management of that risk". The primary audience of this report is the Government, at all levels, the donor community and stakeholders involved in disaster management. The study is meant to generate additional knowledge that can be used by the Government and stakeholders interested in disaster management in the Philippines.

Special thanks also goes to those who helped make the report a reality, even though they may not be explicitly named here.

EXECUTIVE SUMMARY

Background

The Philippines by virtue of its geographic circumstances is one of the most natural hazard prone countries in the world. Earthquakes, volcanic eruptions, typhoons and floods are the most catastrophic hazards in the country. They have destroyed human, social and physical capital, and derailed social and economic development. Moreover, the social and economic cost of natural disasters in the country is increasing due to population growth, change in land use patterns, migration, unplanned urbanization, environmental degradation and global climate change. Reducing the risk of disasters will be key to achieving the development goals in the Philippines.

The World Bank with assistance from the Philippines Government conducted an informal study titled "Natural Disaster Risk Management in the Philippines: Enhancing Poverty Alleviation Through Disaster Reduction" from May 2003 to March 2004 ("First study"). The objectives of the First study were to: document the impacts of natural disasters on social and economic development of the Philippines; assess the country's current capacity to reduce and manage disaster risk; and identify options for more effective management of that risk. The First study recommends preparing and implementing a national framework plan for comprehensive disaster risk management. The framework should incorporate the essential steps of integrated risk management, which include risk identification, risk reduction and risk sharing/financing. The study identified some specific areas under these key themes that would need to be addressed to improve the current system.

This Follow-on study is intended to support the First study and examine in more detail some of the specific areas under the above themes and provide directions for necessary actions. The following objectives are set in the terms of reference:

1. Assessment of capacity and current loss estimation practices by key departments and agencies, and analysis of probable maximum loss and aggregate losses from potential disasters;
2. Assessment of inventory data requirements of the NDCC and its members, including capacity for collection and manipulation and the potential to eventually develop a shared database inventory; and
3. Review of the mapping requirements for the various hazards to better establish social and infrastructure vulnerability.

Methodology

In response to the terms of reference, the follow-on study focused on reviewing the pattern of disaster occurrences in the Philippines, assessment of available data and evaluation of disaster management capacity with an eye on the overall objectives of the twin studies. The study also focused on the directions for improvement of disaster risk management through gap analyses.

To understand the pattern of disaster occurrences, the study adopted a case study approach. Some of the recent catastrophic events were investigated in detail to get an insight into the cause and effect relationships. Apart from the available published information, field visits were undertaken to get first hand information.

The study has undertaken a detailed assessment of various available datasets – historical event catalogues with parametric data, site conditions like topography, land use, geology, soil, etc., socio-economic data, inventories of building stock, administrative boundaries, hazard zoning, event/damage footprints, and others. Meta data like source, scale, resolution, format, vintage and coverage are collected. A gap analysis of these datasets provided the basis for directions on strengthening the data collection and risk modeling and mapping.

The study has also undertaken an in-depth assessment of disaster management capacity of the government agencies through a questionnaire survey. A questionnaire on recent disaster experiences including event, damage/loss, preparedness, mitigation, response, learning and suggestions was specially designed. Detailed face-to-face interviews were conducted eliciting information from key officers and experts in 16 departments of NDCC and 12 disaster affected PDCCs and CDCCs. Questionnaires were sent to 80 PDCCs. An analysis and synthesis of this information provided the basis for directions on improving the disaster management capacity.

The overall recommendations are presented here, with more detail available in the main text:

Directions for Strengthening Data Networks

1. Updating the topographic maps of NAMRIA (1/50,000) and, updating and increasing the coverage of aerial photographs considering hazard potential areas on priority.
2. Strengthening observation networks for rainfall, river flow, and tidal water level of tsunami and storm surge considering real-time data transmission to the DCCs.
3. Strengthening seismological and volcanological monitoring network. There is a need to evenly allocate 100 seismological stations across the country and install volcanological stations in the very active volcanoes out of 16 active volcanoes.

4. Documentation of historical event experience and learning into what is called Event Report. The report contains hazard details, the number of casualties, property damages among others for future use by disaster management agencies.

Directions for Preparing Hazard Maps

1. Given that hazard maps are necessary for controlling land use including houses in hazard potential areas by floods, sediment and landslide, it is recommended that hazard maps based on NAMRIA's topographic maps (1/50,000 or 1/10,000 scales), questionnaire survey on floods, historical sediment and landslide disasters, site reconnaissance and simulation (if necessary) be prepared.
2. For hazard map development for earthquakes, two types of maps are recommended. The first one would be the seismic hazard map for the whole country, defined as a map of physical hazard excluding the potential damages. Examples are earthquake ground motion and fire following the earthquake. The second would be the seismic micro-zonation map at scale 1:10,000 or larger for use in the highly urbanized areas like metro Manila. These maps consider local site conditions like soil and, landslide and liquefaction potential to modify the macro map.
3. Volcanic hazard maps for the six very active volcanoes have been compiled by PHIVOLCS. Base map scale of these hazard maps is 1: 50,000. Although a detailed topographical map, aerial photography and related data on volcanoes are not available at present; detailed scale hazard maps should be compiled to prepare an accurate plan for disaster management especially for Taal and Mayon volcanoes. Compilation of volcanic hazard maps should cover all the active volcanoes and important potentially active volcanoes according to the priority of disaster management.

Directions for Developing Catastrophe Risk Models

1. Assessment of the long-term economic and fiscal implications due to catastrophic natural hazards is the need of the hour. Estimation of losses including average annual loss and probable maximum loss from potential future catastrophes goes a long way in enhancing the resilience of the nation to catastrophic shocks.
2. Apart from hazard mapping, risk mapping at various scales needs to be taken up on priority to provide tools for long-term planning at various levels of administration.
3. Catastrophe risk modeling adopting the best practices in the global insurance industry is highly recommended to meet the above two requirements. These practices include simulation of stochastic events from historical events, modeling physical processes underlying the hazards, engineering response of structures and probabilistic analysis of losses.

Directions for Improving Disaster Management Capacity

1. Development of a disaster management information system (DMIS) is the first step to improving existing disaster management capacity of related agencies. Relevant and accurate information for use in early warning systems should be collected and disseminated on time through a national agency to local municipality. Existing data/information collection and dissemination system of NDCC should be improved through establishment of DMIS in conjunction with national spatial data infrastructure (NSDI).
2. Spatially referenced data and information on themes like population, land use, hydrology, agriculture, climate, economic transactions, etc. are vital to make sound decisions from local to national levels of administration. With the availability of satellite-based remote sensing data and the organization of spatial databases around a Geographical Information System (GIS), combining with the Geo-positioning System (GPS), the process of semantic spatial information systems has now become a reality. Using an effective, efficient, and widely accessible infrastructure, spatial data could be readily transported and easily integrated both thematically and hierarchically. Transparent access to myriad databases could provide the information for countless applications including disaster management. The establishment of National Spatial Data Infrastructure (NSDI) would be the right direction for the country.
3. Disaster management training for MDCC and BDCC staffs should be promoted because these personnel are the key staff of local disaster management. Preparation of basic materials for disaster management for MDCC and BDCC should be promoted. National research agencies related to natural disaster such as Universities, PHIVOLCS and PAGASA should support local activities for disaster management.
4. Community-based disaster management should be promoted. According to past disasters experience in the world, community people have to survive by themselves for at least 72 hours. Therefore, it is important to raise people's awareness on disaster management through community activity, school education and training.
5. In order to be able to develop and implement a national framework plan for integrated disaster risk management as recommended in the First study the following feasibility studies are recommended:
   a. Emergency communication and early warning systems
   b. Information Technology including DMIS and NSDI
   c. Risk management including risk transfer and insurance
   d. Seismic microzonation
   e. Vulnerability analysis and risk assessment

f. Damage and loss estimation methodology

g. Review of building codes

h. Institutional setup including legal aspects

Overall Recommendations

1. Strengthen data observation, collection and dissemination networks, and standard mitigation practices for each hazard.
2. Establish a Disaster Management Information System (DMIS) to collect and disseminate information including warnings to all stakeholders.
3. Establish National Spatial Data Infrastructure (NSDI) to collect, store and share organized spatial (and non-spatial) data.
4. Prepare hazard maps of varying scales for planning and mitigation. Micro zoning, especially in case of earthquakes, needs to be undertaken on priority in urban concentrations like MMR.
5. Develop catastrophe risk models to forecast losses from future potential disasters and prepare risk maps of various scales.
6. Undertake feasibility studies on various aspects of disaster management in order to be able to develop and implement an integrated disaster risk management plan.

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Acronyms

ALMED	Agricultural Lands Management & Evaluation Division
BDCC	Barangay Disaster Coordinating Council
BEIS	Basic Edication Information System
BFP	Bureau of Fire Protection
BRS	Bureau of Reserch and Standard-DPWH
BSWM	Bureau of Soil and Water Management
CBDM	Community Based Disaster Management
CDCC	City Disaster Coordinating Council
CPI	Consumer Price Index
DA	Department of Agriculture
DATOS	Data Kit of Official Philippine Statistics
DCC	Disaster Coordinating Council
DepEd	Department of Education
DOH	Department of Health
DPWH	Department of Public Works and Highways
EFCOS	Effective Flood Control Operating System
EMIS	Emergency Management Information System
FFWS	Flood Forecasting and Warning System
FFWSDO	Flood Forecasting and Warning System for Dam Operation
GIS	Geographic Information System
GOP	Government of the Philippines
GRDP	Gross Regional Domestic Product
GTZ	German Agency for Technical Cooperation
ITCZ	Inter Tropical Convergence Zone
JAFTA	Japan Forest Technical Association
JBIC	Japan Bank for International Cooperation
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
LGU	Local Government Unit
LGU	Local Government Unit
LPG	Liquefied Petroleum Gas
LREP	Land Resource Evaluation Project
MDCC	Municipal Disaster Coordinating Council
MGB	Mines and Geosciences Bureau
MMEIRS	Earthquake Impact Reduction Study for Metropolitan Manila
Ms	Surface Magnitude
MSL	Mean Sea Level
NAMRIA	national Mapping and Resource Information Authority
NCR	National Capital Region
NCSB	National Statistical Coordination Board
NDCC	National Disaster Coordination Committee
NIA	National Irrigation Administration
NIA	National Irrigation Authority
NPC	National Power Corporation
NSCB	National Statistical Coordination Board
NSO	National Statistics Office

NSO	National Statistics Office
NTMS	National Topographic Mapping Series
NWRB	National Water Resources Board
OCD	Department of national defense, Office of Civil Defense
OECF	Overseas Economic Cooperation Fund
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Seervices Administration
PDCC	Provincial Disaster Coordinating Council
PFZ	Philippine Fault Zone
PGA	Peak Ground Acceration
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PRS 92	Philippine Reference System 92
PUF	Public Use File
PVT	Private
RDCC	Regional Disaster Coordinating Council
RHU	Regional Health Units
RLUA	Regional Land Use Assessment
SEASEE	South East Asia Association of Seismology and Earthquake Engineering
SEDIP-SME	Secondary Education Development & Improvement Project - School Mapping Exercise
SSC	Swedish Space Corporation
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific, Cultural Organization
USAID	United States Agency for International Development
USGS	United States Geographic Survey
VFS	Valley Fault System

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NIA	National Irrigation Authority
NPC	National Power Corporation
NSCB	National Statistics Coordination Board
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NTMS	National Topographic Mapping Series
NWRB	National Water Resources Board
OCD	Department of national defense, Office of Civil Defense
OECF	Overseas Economic Cooperation Fund
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Chapter 1. Introduction

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1.1 Background

The World Bank ("Bank") with the cooperation of the National Disaster Coordinating Council (NDCC), chaired by Office of Civil Defense (OCD) and composed of its member agencies of the Philippines, carried out a study on "Natural Disaster Risk Management in the Philippines: Enhancing Poverty Alleviation Through Disaster Reduction" from May 2003 to May 2004 ("First study"). The First study provides an overview of the impacts of natural disasters on the social and economic development of the Philippines, assesses the country's current capacity to reduce and manage disaster risk, and identifies options for more effective management of that risk. The First study emphasizes the importance of balance between pre-disaster efforts such as appropriate land-use planning, construction, as well as other preventive measures to avoid the creation of disaster-prone conditions, and post disaster efforts such as relief, short-term preparedness (forecasting, evacuation, etc.) as well as post-disaster support for economic recovery, such as rehabilitation and livelihood regeneration. Finally, the First study recommends formulating and implementing a "National Framework Plan for Comprehensive Disaster Risk Management" incorporating the following essential steps of integrated risk management:

1. Risk identification including improving reliable data and hazard maps;
2. Risk reduction including reviewing institutional arrangements focusing more on bottom-up and participatory approaches; and
3. Risk sharing / financing including insurance system.

Based on the results of the above First study, the Bank and NDCC jointly held a workshop on "Enhancing Poverty Alleviation Through Disaster Reduction in the Philippines" on 29-30th January, 2004 with participation from the representatives of various groups of stakeholders such as Philippine governmental agencies, international agencies, agencies of donor countries, Non-Government organizations (NGOs) and private sectors relating to disaster management or insurance systems etc.

During the workshop, the results of the First study were presented, as well as some of the important projects of the member agencies of the NDCC such as Department of Social Welfare and Development (DSWD), Philippine Institute of Volcanology and Seismology (PHIVOLCS), Department of Education, Culture and Sports (DECS), Department of Health (DOH), Department of Interior and Local Government (DILG), National Mapping and Resource Information Authority (NAMRIA), Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Mines and Geosciences Bureau (MGB) and Department of Agriculture – Bureau of Agricultural Research, which relate to disaster management policy, tsunami risk mitigation, hazard

assessment of schools, health emergency management, spatial database, hydrological risk mapping, geohazard assessment, disaster prediction and early warning systems. Each of the proposed projects from the Philippine government has an important meaning for disaster management. It is expected to position these projects as well as other necessary actions in the above National Framework Plan for Comprehensive Disaster Risk Management from now on.

This Follow-on study is intended to build on the First study, presenting supplemental information examining in more detail some of the specific areas recommended therein, and provide directions for necessary actions for improving disaster management. Specifically, the study was designed to provide information that would allow the identification of key areas to address to reduce the levels of risk and vulnerability of the country.

1.2 Study Area

The study area of the Follow-on study covers the whole Philippines. As a general information, Table 1.1 shows the political regions and provinces of the Philippines, as well as the provincial and regional socio-economic conditions in the country. In relation to the Table 1.1, Figure 1.2 shows the per capita income by province and Figure 1.3 shows poverty incidence by province. These two figures are the bases for considering the relation between disasters and poverty in the Philippines.

Table 1.1 Regional and Provincial Socio-economic Conditions of the Philippines (page 1 of 2)

	Item No.	1	2	3	4	5	6	7	8	9	10	11
	Region / Province	Land Area	Population	Number of Families	No. of Munici-palities	No. of Baran-gays	GRDP	GRDP per Capita	Per Capita Income	Financial Resources Generated	Magnitude of Poor Families	Poverty Incidence
			Year 2000	Year 2000	Year 2002	Year 2002	Year 2002 at 2003 price level	Year 2002 at 2003 price level		Year 2001	Year 2000	Year 2000
		(km2)	(person)	(no.)	(no.)	(no.)	(Mil. Peso)	(Peso)	(Peso)	(Mil. Pesos)	(No.)	(%)
	Philippines	**300,000.0**	**76,504,077**	**15,269,655**	**1,506**	**41,869**	**4,022,694**	**52,581**	**19,676**	**59,778.6**	**4,338,780**	**28.4**
NCR	**National Capital Region**	**617.3**	**9,932,560**	**2,188,675**	**4**	**1,693**	**1,443,269**	**145,307**	**44,357**	**26,525.0**	**125,220**	**5.7**
CAR	**Codillera Administrative Region**	**19,392.9**	**1,365,412**	**275,075**	**76**	**1,172**	**91,790**	**67,225**	**17,563**	**1,299.6**	**85,427**	**40.4**
	Abra	4,198.2	209,491	39,452	27	303			18,707	235.9	19,235	48.8
	Apayao	4,351.2	97,129	17,120	7	131			14,599	162.3	4,461	26.1
	Benguet	2,826.6	582,515	127,195	13	269			20,735	285.8	17,992	14.1
	Ifugao	2,628.2	161,623	32,578	11	175			11,307	199.8	18,103	55.6
	Kalinga	3,231.3	174,023	30,898	8	150			15,008	221.9	11,996	38.8
	Mt. Province	2,157.4	140,631	27,832	10	144			15,122	193.9	13,640	49.0
Reg. I	**Ilocos Region**	**13,193.0**	**4,200,478**	**807,528**	**117**	**3,265**	**120,257**	**28,629**	**17,797**	**2,462.1**	**239,262**	**30.3**
	Ilocos Norte	3,504.3	514,241	107,045	22	557			22,864	340.0	19,466	18.2
	Ilocos Sur	2,596.0	594,206	115,626	32	768			20,061	517.3	35,367	30.6
	La Union	1,497.7	657,945	128,348	19	576			18,195	436.6	43,189	33.7
	Pangasinan	5,595.0	2,434,086	456,509	44	1,364			16,067	1,168.2	141,240	30.9
Reg. II	**Cagayan Valley**	**31,158.6**	**2,813,159**	**566,692**	**90**	**2,311**	**83,509**	**29,685**	**17,019**	**1,885.1**	**140,509**	**26.2**
	Batanes	219.0	16,467	3,338	6	29			26,669	102.4	249	7.5
	Cagayan	9,295.8	993,580	195,890	28	820			13,542	573.6	39,682	20.3
	Isabela	13,778.8	1,287,575	261,365	35	1,055			18,925	699.8	79,001	30.2
	Nueva Vizcaya	4,378.8	366,962	75,792	15	275			19,826	284.0	12,069	15.9
	Quirino	3,486.2	148,575	30,307	6	132			15,742	225.3	9,508	31.4
Reg. III	**Central Luzon**	**18,395.2**	**8,030,945**	**1,517,070**	**111**	**2,948**	**316,057**	**39,355**	**21,676**	**3,743.8**	**257,817**	**21.9**
	Bataan	1,373.0	557,659	110,190	11	237			29,648	505.8	10,958	9.9
	Bulacan	2,774.9	2,234,088	406,449	23	568			29,413	1,031.7	21,801	5.4
	Nueva Ecija	5,751.3	1,659,883	329,274	27	849			15,743	892.8	89,854	27.3
	Pampanga	2,045.0	1,882,730	337,449	20	537			20,691	523.5	48,461	14.4
	Tarlac	2,736.6	1,068,783	203,288	17	510			14,891	448.0	56,095	27.6
	Zambales	3,714.4	627,802	130,420	13	247			17,250	342.0	30,648	23.5
Reg. IV	**Southern Tagalog**	**49,325.8**	**11,793,655**	**2,274,665**	**211**	**5,617**	**569,196**	**48,263**	**21,878**	**6,678.8**	**417,327**	**30.8**
	Aurora	3,147.3	173,797	35,873	8	151			18,171	187.5	9,536	26.6
	Batangas	3,119.7	1,905,348	343,332	31	1,078			19,750	808.8	15,305	25.9
	Cavite	1,512.4	2,063,161	373,927	20	828			26,001	900.4	38,084	10.2
	Laguna	1,823.6	1,965,872	388,446	28	674			25,206	1,394.9	33,412	8.6
	Marinduque	952.6	217,392	42,844	6	218			13,545	179.9	19,379	45.2
	Occidental Mindoro	5,865.7	380,250	74,167	11	162			16,334	362.3	30,718	41.4
	Oriental Mindoro	4,238.4	681,818	132,229	14	426			15,821	346.5	56,962	43.1
	Palawan	17,030.8	755,412	144,874	23	432			19,336	866.9	40,351	27.9
	Quezon	8,926.0	1,679,030	341,948	40	1,242			17,773	746.8	116,734	34.1
	Rizal	1,175.8	1,707,218	343,925	13	187			27,171	676.4	27,555	8.0
	Romblon	1,533.5	264,357	53,100	17	219			12,332	208.4	29,291	55.2
Reg. V	**Bicol Region**	**18,130.5**	**4,686,669**	**1,096,920**	**107**	**3,471**	**105,632**	**22,539**	**12,864**	**2,121.1**	**537,704**	**50.9**
	Albay	2,565.8	1,090,907	207,051	15	720			13,404	447.8	82,046	39.6
	Camarines Norte	2,320.1	470,654	96,191	12	282			13,954	276.7	50,670	52.7
	Camarines Sur	5,481.6	1,551,549	296,136	35	1,063			13,681	525.6	126,116	42.6
	Catanduanes	1,492.2	215,356	42,243	11	315			17,310	202.4	18,874	44.7
	Masbate	4,151.8	707,668	334,105	20	550			9,031	350.3	209,851	62.8
	Sorsogon	2,119.0	650,535	121,194	14	541			11,919	318.3	50,147	41.4
Reg. VI	**Western Visayas**	**20,614.4**	**6,208,733**	**1,211,732**	**117**	**4,050**	**265,457**	**42,755**	**14,306**	**2,673.5**	**457,829**	**39.1**
	Aklan	1,821.4	451,314	86,466	17	327			13,134	273.4	31,386	36.3
	Antique	2,729.2	471,088	92,247	18	590			16,304	279.0	32,393	35.1
	Capiz	2,594.6	654,156	131,121	16	473			13,706	332.0	66,908	51.0
	Guimaras	604.6	141,450	26,091	5	98			16,072	141.3	5,900	22.6
	Iloilo	4,899.4	1,925,002	363,981	42	1,901			17,609	740.6	108,518	29.8
	Negros Occidental	7,965.2	2,565,723	511,826	19	661			11,723	907.2	212,724	41.6
Reg. VII	**Central Visayas**	**15,875.1**	**5,706,953**	**1,104,990**	**120**	**3,003**	**285,817**	**50,082**	**12,074**	**2,295.4**	**356,827**	**33.9**
	Bohol	4,821.0	1,139,130	210,182	47	1,109			11,022	698.4	99,321	47.3
	Cebu	5,331.1	3,356,137	652,478	47	1,203			12,730	813.8	187,359	28.7
	Negros Oriental	5,385.5	1,130,088	224,933	20	557			11,156	664.5	65,074	28.9
	Siquijor	337.5	81,598	17,397	6	134			12,501	118.7	5,073	29.2
Reg. VIII	**Eastern Visayas**	**23,328.5**	**3,610,355**	**736,809**	**139**	**4,390**	**93,442**	**25,882**	**12,554**	**2,038.0**	**278,487**	**38.4**
	Biliran	536.0	140,274	28,646	8	132			11,848	135.5	9,975	34.8
	Eastern Samar	4,640.7	375,822	74,137	23	597			10,138	262.6	35,067	47.3
	Leyte	6,515.1	1,592,336	338,320	41	1,641			13,267	701.4	122,070	36.1
	Northern Samar	3,692.9	500,639	94,413	24	569			12,640	321.2	38,409	40.7
	Samar	6,048.0	641,124	128,116	25	951			11,206	363.8	52,110	40.7
	Southern Leyte	1,895.8	360,160	73,177	18	500			14,474	253.5	20,856	28.5
Reg. IX	**Western Mindanao**	**19,180.7**	**3,091,208**	**603,728**	**73**	**2,068**	**88,887**	**28,755**	**10,478**	**1,040.9**	**231,078**	**39.1**
	Basilan	2,217.8	332,828	60,582	6	210			9,098	245.9	15,866	26.2
	Zamboanga del Norte	7,301.0	823,130	165,942	25	691			12,625	504.6	75,738	45.6
	Zamboanga del Sur	9,661.9	1,935,250	377,204	26	779			9,802	187.0	139,474	37.0
	Zamboanga Sibugay		-	-	16	388			-	103.4	-	-

Table 1.1 Regional and Provincial Socio-economic Conditions of the Philippines (page 2 of 2)

Reg. X	**Northern Mindanao**	16,191.8	2,747,435	535,736	63	1,514	146,373	53,276	13,340	1,411.3	176,210	34.2
	Bukidnon	10,477.5	1,060,265	202,184	20	464			14,658	578.6	65,036	32.2
	Camiguin	238.0	74,232	14,443	5	58			13,311	119.2	7,676	53.1
	Misamis Occidental	2,055.2	486,723	98,102	14	490			11,762	274.7	42,555	43.4
	Misamis Oriental	3,421.1	1,126,215	221,007	24	502			12,783	438.8	60,943	27.6
Reg. XI	**Southern Mindanao**	28,419.6	5,189,335	1,032,588	60	1,522	220,494	42,490	13,924	1,990.4	324,833	34.9
	Compostela Valley	4,479.8	580,244	-	11	235			-	328.4	-	-
	Davao	3,427.0	743,811	266,299	7	223			11,934	405.7	103,679	38.9
	Davao del Sur	6,666.9	1,905,917	371,326	14	517			13,002	329.2	67,504	18.2
	Davao Oriental	5,670.1	446,191	85,745	11	183			14,236	333.7	29,516	34.4
	Saranggani	3,747.0	410,622	82,561	7	140			10,840	270.8	39,638	48.0
	South Cotabato	4,428.8	1,102,550	226,657	10	224			17,882	322.6	84,496	37.3
Reg. XII	**Central Mindanao**	18,085.0	2,303,271	463,081	51	1,297	101,850	44,220	11,738	1,118.8	224,225	48.9
	Lanao del Norte	3,824.8	758,123	152,758	22	506			13,208	300.7	77,572	50.8
	North Cotabato	9,008.9	958,643	191,892	17	543			10,821	492.3	82,365	42.9
	Sultan Kudarat	5,251.3	586,505	118,431	12	248			11,337	325.8	64,288	54.3
Reg. XIII	**Caraga**	21,470.9	2,095,367	408,789	70	1,308	54,082	25,810	11,541	1,343.8	175,481	43.5
	Agusan del Norte	3,546.9	552,849	105,214	11	250			10,392	254.8	41,946	39.9
	Agusan del Sur	9,989.5	559,294	114,723	14	314			10,014	482.0	57,627	50.2
	Surigao del Norte	3,009.3	481,416	91,506	27	435			11,463	291.1	38,760	42.4
	Surigao del Sur	4,925.2	501,808	97,346	18	309			14,582	315.9	37,148	38.2
ARMM	**Autonomous Region in Muslim Mindanao**	25,276.7	2,707,098	394,255	97	2,240	36,582	13,513	9,911	1,151.0	254,167	57.2
	Lanao del Sur	12,051.9	800,162	100,072	38	1,155			10,606	405.5	66,464	55.0
	Maguindanao	7,547.2	964,951	145,985	22	472			11,864	346.3	97,293	55.1
	Sulu	2,251.0	619,668	99,416	18	410			5,960	232.2	62,872	63.2
	Tawi-Tawi	3,426.6	322,317	48,782	19	203			9,936	167.0	27,538	56.5
Others	**Officials in abroad**		2,851									

Data sources: 1. Data Item 1, 2, 6 and 7: 2003 Philippine Statistical Yearbook, NSCB; 2. Data Item 3, 4, 5, 8, 9, 10 and 11: The Philippine Countryside in Figures 2002 Edition, NSCB

Notes:

1. Financial Resources: includes local resources (tax and non-tax revenue), internal revenue allotment , grants and borrowings.
2. Tax Revenue: compulsory charges or levies imposed by government on goods, services, transactions, individuals, entities, and others, arising from the sovereign power of the state.
3. Non-Tax Revenue: revenues collected from sources other than compulsory tax levies. Includes those collected in exchange for direct services rendered by government agencies to the public, or those arising from the government's regulatory and investment activities.
4. Internal revenue allotment: the account created under PD144, as amended, representing the portion of total national government revenues which accrue to the local governments. This includes the local government's share in the specific tax on oil products authorized by PD436, as amended. This share has been revised under the Local Government Code of 1991 and its now terms as internal revenue allotment.
5. Poverty Incidence: proportion of families/population whose annual per capita income falls below the annual per capita poverty threshold of the total number of families/population.
6. Poverty Threshold: annual per capita income required or amount to be spent to satisfy nutritional requirements (2,000 Kcal) and other basic needs.

1.3 Members of the Study

This study was jointly implemented by the World Bank, NDCC headed by the OCD, and Study team comprised of members from Pacific Consultants International (PCI). Table 1.2 shows the members of the Study team.

Table 1.2 Members of the Study

World Bank Office Manila

Ms. Idah Z. Pswarayi-Riddihough	Lead Natural Resources Management Specialist

OCD

Colonel Elma C. Aldea	Administrator
Director Ronald I. Flores	Special Assistant to the SND/C, NDCC, Civil Defense Executive Officer, Chief Calamity Fund Management Unit
Mr. Edgardo J. Ollet	Chief, OCD Plans Division. Head, NDCC Secretariat
Mgen Melchor P. Rosales	

Study Team

Mr. Noboru Ikenishi	Team Leader / Volcanic Disaster Risk Management
Mr. Takashi Furukawa	Flood/ Typhoon Disaster Risk Management
Ms. Kanako Iuchi	Earthquake Risk Management/ Coordinator
Mr. Yoshihiko Uchikura	Hydrologist
Mr. Joel F. Cruz	GIS/Database Development

1.4 Basic Approach of the Study

The study proceeded separately for each type of disasters, since the necessary information and data varied per disaster type. However, the basic approach is common, as shown in Figure 1.4.

Disaster types for this study are as follows:

1. Flood and sediment disaster, including typhoon disaster,
2. Earthquake disaster
3. Volcanic disaster

Typhoons are one of the major causes of flood and sediment disaster. Hence, typhoon disasters caused by storm rainfall, strong wind and storm surge were comprehensively studied in the Study on Floods and Sediment Disaster.

In step 1, basic data at national level was collected. A sample area was selected and studied further to supplement the understanding of basic disaster mechanisms.

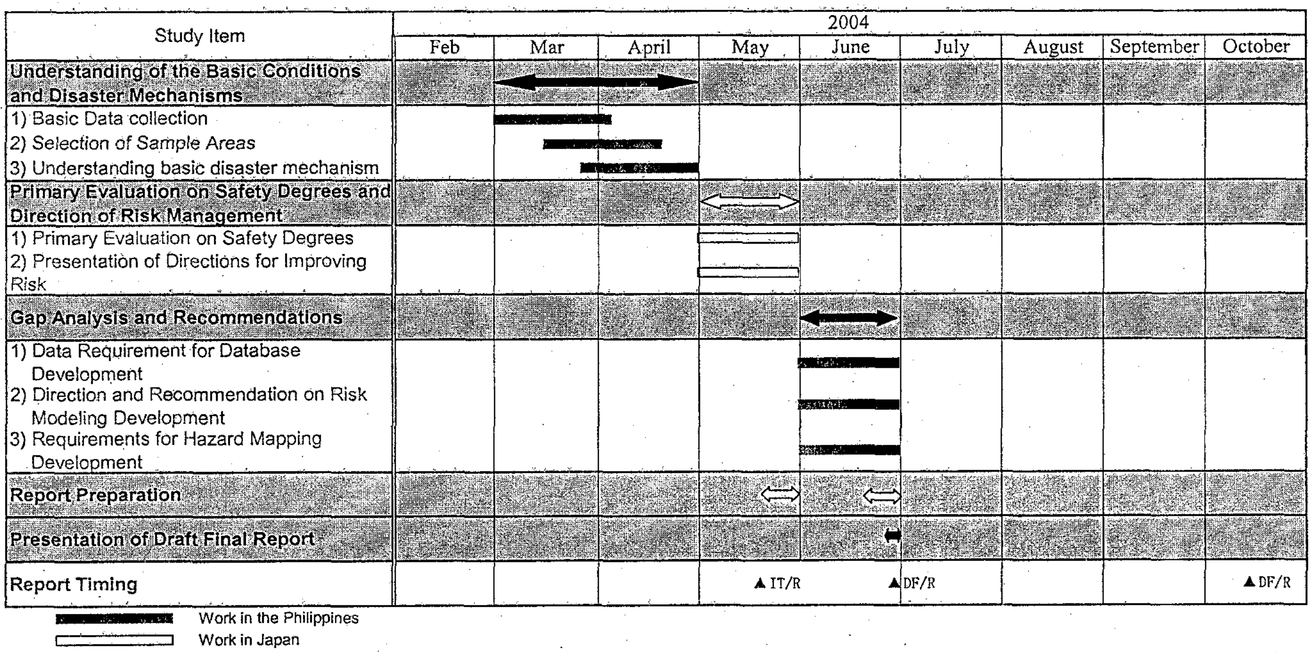
In step 2, primary evaluation on safety degrees and direction of risk management improvement were considered. These are described together with the findings of national level data and information, and selected sample areas.

Step 3, considered the gaps and recommendations of three components, the data requirements for database development, direction and recommendations on risk models

development, and requirements for hazard mapping. Conclusions and recommendations of individual disasters were integrated, where needed, for the comprehensive development of database, risk modeling, and hazard mapping.

1.5 Study Schedule

This study was implemented according to the overall schedule shown below.



Chapter 2. Overview of Natural Disasters and Capacity of Disaster Management in the Philippines

CHAPTER 2. OVERVIEW OF NATURAL DISASTERS AND CAPACITY OF DISASTER MANAGEMENT IN THE PHILIPPINES

2.1 Records of Natural Disasters

2.1.1 Composition of Natural Disasters

Natural disasters in the Philippines include floods, flashfloods, sediment (including debris flow, mud flow and lahar), landslide, storm surge, big waves, tornado, whirlwind/wind flow, earthquake, volcanic eruption, drought, and red tide. Among these, flood, flashflood, sediment and most of the landslides are caused by large rainfall from typhoons or depression or local storm rainfall. Storm surge is caused by typhoon, and big waves. Tornado and whirlwind are also related to typhoon or depression.

Table **2.1** shows the summary of damage of natural disasters between 1980 and 2003 and their damage ratios.

Table 2.1 Damage of Natural Disaster in the Philippines 1980-2003

Damage of Natural Disaster 1980-2003

Disaster Type	Casualties				Affected		Damaged Houses			Damaged Properties			
	Dead (pers.)	Injured (pers.)	Missing (pers.)	Total (pers.)	Families (no.)	Persons (pers.)	Totally (no.)	Partially (no.)	Total No. (no.)	Agricult. (Bil. P)	Infra. (Bil. P)	PVT (Bil. P)	Total (Bil. P)
Flooding including heavy rainfall	1,617	1,032	421	3,070	2,685,739	13,301,642	36,254	103,174	139,428	10.006	6.717	2.299	19.022
Flashflood	5,138	313	1,259	6,710	160,587	837,234	5,317	26,045	31,362	1.898	1.221	0.001	3.120
Sediment including debris flow, mud flow and Lahar	44	16	7	67	65,234	313,604	5,738	1,035	6,773	2.968	1.241	0.000	4.208
Landslide	571	396	45	1,012	7,586	37,288	981	1,161	2,142	0.202	0.206	0.004	0.411
Storm surge	4	127	0	131	4,747	26,037	119	264	383	0.105	0.174	0.576	0.856
Big waves	2	17	16	35	6,583	28,680	215	456	671	0.015	0.000	0.000	0.015
Tornado	56	441	33	530	6,312	29,414	823	574	1,397	4.626	2.814	0.948	8.388
Whirlwind/wind flow	0	11	0	11	573	3,256	23	21	44	0.000	0.000	0.001	0.001
Earthquake	1,385	3,337	329	5,051	261,929	1,444,024	27,069	84,391	111,460	6.314	17.660	10.960	34.934
Volcanic eruption	930	193	23	1,146	297,441	1,419,086	40,867	67,860	108,727	4.765	16.515	1.850	23.130
Drought	0	0	0	0	1,868,285	8,455,937	1,586	0	1,586	46.768	0.000	0.000	46.768
Red tide	24	216	0	240	130,313	647,219	0	0	0	0.622	0.000	0.000	0.622
Others	313	105	17	435	36,246	183,555	260	3	263	0.096	0.000	0.000	0.096
Grand Total	10,084	6,204	2,150	18,438	5,531,575	26,726,976	119,252	284,984	404,236	78.384	46.547	16.639	141.571

Data source: Major and Minor natural Disaster Incidents 1980-2003, NDCC

Note: Property damage is adjusted to 2003 price level by applying CPIrate=(CPI of respective year/CPI of 2003).

Damage % of Natural Disaster Damage 1980-2003

Disaster Type	Casualties				Affected		Damaged Houses			Damaged Properties			
	Dead (%)	Injured (%)	Missing (%)	Total (%)	Families (%)	Persons (%)	Totally (%)	Partially (%)	Total No. (%)	Agricult. (%)	Infra. (%)	PVT (%)	Total (%)
Flooding including heavy rainfall	16.0	16.6	19.6	16.7	48.6	49.8	30.4	36.2	34.5	12.8	14.4	13.8	13.4
Flashflood	51.0	5.0	58.6	36.4	2.9	3.1	4.5	9.1	7.8	2.4	2.6	0.0	2.2
Sediment including debris flow, mud flow and Lahar	0.4	0.3	0.3	0.4	1.2	1.2	4.8	0.4	1.7	3.8	2.7	0.0	3.0
Landslide	5.7	6.4	2.1	5.5	0.1	0.1	0.8	0.4	0.5	0.3	0.4	0.0	0.3
Storm surge	0.0	2.0	0.0	0.7	0.1	0.1	0.1	0.1	0.1	0.1	0.4	3.5	0.6
Big waves	0.0	0.3	0.7	0.2	0.1	0.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0
Tornado	0.6	7.1	1.5	2.9	0.1	0.1	0.7	0.2	0.3	5.9	6.0	5.7	5.9
Whirlwind/wind flow	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Earthquake	13.7	53.8	15.3	27.4	4.7	5.4	22.7	29.6	27.6	8.1	37.9	65.9	24.7
Volcanic eruption	9.2	3.1	1.1	6.2	5.4	5.3	34.3	23.8	26.9	6.1	35.5	11.1	16.3
Drought	0.0	0.0	0.0	0.0	33.8	31.6	1.3	0.0	0.4	59.7	0.0	0.0	33.0
Red tide	0.2	3.5	0.0	1.3	2.4	2.4	0.0	0.0	0.0	0.8	0.0	0.0	0.4
Others	3.1	1.7	0.8	2.4	0.7	0.7	0.2	0.0	0.1	0.1	0.0	0.0	0.1
Grand Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In the table above, it can be seen that typhoon related disasters such as floods, flashfloods and sediment have the worst percentage of casualties (about 60%), the second to worst being earthquake (27%), and the third is from volcanic eruption (16%). Property damage consists of damages to agriculture, infrastructure and private property. The worst property damage is due to drought (33%), the second to worst is due to earthquake (25%) and the third is typhoon related disasters such as floods, flashfloods and sediment (19%).

Although drought may have negative economic impacts resulting from property damages, this study will focus on the following major disasters which have significant casualties and overall degree of economic damage: typhoon; earthquake; and volcanic eruption.

2.1.2 Major Natural Disasters by Floods, Sediment, Earthquake and Volcanic Eruption

Descriptions of major historical natural disasters by floods, sediment and volcanic eruptions are summarized below.

(1) Floods, Sediment and Typhoon Disasters

Consolidated damage by floods, sediment and typhoon disasters are shown in NDCC's data of Destructive Typhoons 1970-2003. Major damages caused by destructive typhoons, floods, flashfloods, sediment and landslide disasters, in these 34 years are listed in Table 2.2. Unfortunately, it is difficult to segregate damages caused by each type of water-related disasters based on NDCC's data. Major sediment disasters including landslides are shown in Table 2.3.

Table 2.2 Historical Major Damage caused by Destructive Typhoons 1970-2003

Date	Incident	Affected Region	Casualties		Property Damage (Bil. Peso)	Remarks
			Dead (Person)	Total (Person)		
Oct.10-16, 1970	TY Sening	II, III, IV & VI	575	2,361	2.812	
Aug.31-beg. Sep, 1984	TY Nitang	IV, VI, VII, VIII, X & XI	900	3,199	17.843	
Nov.3-6, 1984	TY Undang	IV, V, VI & VII	895	3,693	1.541	
Nov.2-5, 1991	TY Uring	VI & VIII	5,101	6,649	1.045	Flashflood damage in Ormoc, Leyte Island is included.
Oct.30-Nov.4, 1995	TY Rosing	NCR, CAR, I, II, III, IV, V & VIII	936	5,404	10.829	
Note: Property damage is adjusted to 2003 price level by applying CPIrate=(CPI of 2003/CPI of respective year).						

Source: NDCC

Table 2.3 Major Sediment Disasters including Landslide

Year	Sediment Disasters including Landslide	Damage
1991	Lahar Disasters in Mt. Pinatubo Area -Debris flow or hyper-concentrated flow of sediment and water caused by heavy rainfall, and breaching of natural lakes.	Large lahars have been recorded in 3 times after eruption in 1991 with total casualties of 62 (including dead: 44), and total property damage of 4.209 Bil. Peso (2003 price).
2001 (last eruption)	Mud and Debris Flow Disasters in Mt. Mayon Area	Damage data is included in the damage data of Mt. Mayon eruption and difficult to segregate.
Nov 6 t0 9, 2001	Debris flow Disasters in Camiguin Island	Damage happed by debris flow including flashfloods caused by Typhoon Nanang (Nov. 6 to 9, 2001). Total casualties are 366 (including dead: 148).
December, 2003	Landslide including Mudflow and Debris flow Disasters in Panaon Island, Southern Leyte	Damage by landslide, mudflow and debris flow happed in December 2003, by local storm rainfall with total dead of 132 persons.

It can be concluded that among flood, sediment and typhoon disasters, the largest impacts are caused by typhoons. Destructive typhoons hit the Philippines approximately 6 times per year, and devastating ones, which leave property damage of more than 10 billion pesos (2003 price) at least once every 10 years.

(2) Major Earthquake Disasters

Based on the information supplied from the Office of Civil Defense (OCD), data including the amount of property damage is available from 1980. Table 2.4 shows the property damage caused by the destructive earthquakes between 1988 and 2003.

Table 2.4 Historical Major Damage caused by Destructive Earthquakes 1988-2003

Date	Incident	Affected Areas	Casualties				Property Damage (Bil peso)
			Dead (Person)	Injured (Person)	Missing (Person)	Total (Person)	
June 19, 1988	Earthquake Magnitude 6.4	Mindoro Occidental	N.A.	N.A.	N.A.	N.A.	2.680
July 16, 1990	Earthquake Magnitude 7.8	Luzon (Baguio City)	1,283	2,786	321	4,390	31.176
Nov 15, 1994	Earthquake Magnitude 7.1	Oriental Mindoro	83	430	8	521	0.881
April 21, 1995	Earthquake Magnitude 7.3	Leyte, Eastern Samar	N.A.	N.A.	N.A.	N.A.	0.043
Feb. 8, 1996	Earthquake Magnitude 6.8	Tagbilaran city	6	N.A.	N.A.	6	0.001
Jan. 12, 1998	Earthquake Magnitude -	-	N.A.	8	N.A.	8	0.000
Dec 12, 1999	Earthquake Magnitude 6.8	Reg. I & Metro Manila	5	40	N.A.	45	0.085
July 28, 2000	Earthquake Magnitude-	Batanes	N.A.	34	N.A.	34	0.054
May 6, 2002	Earthquake Magnitude 6.8	Mindanao	8	39	N.A.	47	0.020
Note: Property damage is adjusted to 2003 price level by applying CPIrate=(CPI of 2003/CPI of respective year).							

Source: Major and Minor Natural Disaster Incidents 1980-2003, NDCC

Table 2.5 shows the most destructive earthquakes, usually those with more than 100 deaths or 500 casualties, based on the available information. Seven devastating historical earthquakes were observed during the last 400 years. However, older data before 1863 did not provide quantitative numbers of casualties, and hence were not included.

Table 2.5 List of the Most Destructive Earthquakes in the History (Selected from 1599 to Present)

Date	Mg	Location	Casualties				Summary of damage observed
			Death	Injuries	Missing	Total	
1863/6/3	6.5	Manila	876+	387+		1,263+	1. Devastating damages to buildings, infrastructure 2. Ground openings with gasses 3. Tsunami 4. Aftershock
1918/8/15	8.3	Southern Cotabato	100			unknown	1. Houses destroyed 2. Landslide (50) 3. Tusnami (many, 18 ft)
1955/4/1	7.5	Lanao	291	713		1004	1. Lake Lanao, slipped into water 2. Infrastructure damage 3. Fissures, sand boils, landslides
1968/8/2	7.3	Casiguran	270	600		870	1. Large damages to buildings 2. Landslides 3. Fissures 4. Property damage several million dollars
1976/8/17	7.9	Moro Gulf	4,791	9,928	2,288	17,007	1. 40 aftershocks 2. Damages to buildings 3. Damages to bridges 4. Damages to Tsunami
1990/7/16	7.8	Cabana-tuan	1,283	2,786	321	4,390	1. 125km long Ground rupture 2. Collapse of man-made structures, liquefaction, lateral spreading and slope failures 3. Induced landslide caused severe disruption of road transport lifelines and closure of all four main road access routes to Baguio city
1994/11/14	7.1	Oriental Mindoro	83	430	8	521	1. Damage to bridges (some impassible) 2. Surface rupture 3. Tsunami

Source: Created from available data of the followings: 1. OCD; 2. Southeast Asia Association of Seismology and Earthquake Engineering, Volume IV, Philippines, 1985; 3. Destructive earthquakes in the Philippines from 1983 to 1995, Phivolcs,; and 4. PHIVOLCS web pages

In summary, 59 destructive earthquakes and 7 devastating earthquakes occurred in the past 400 years. This indicates that a devastating earthquake hits the country once every 60 years.

(3) Major Disasters by Volcanic Eruptions

There are 6 very active volcanoes in the country. Of these, the recent active volcanoes are Mt. Pinatubo and Mt. Mayon. Table 2.6 shows the recent damage caused by these volcanoes. Mt. Mayon has

been very active recently; however, it's past property damage is smaller compared to the Mt. Pinatubo eruption in 1991. Very roughly, it can be stated that there are violent volcanic eruptions once in 30 years.

Table 2.6 Historical Major Damage caused by Volcano Eruption 1991-2003

Date	Incidents	Affected Areas	Casualties				Property Damage (Bil Pesos)
			Dead (Person)	Injured (Person)	Missing (Person)	Total (Person)	
July 15, 1991	Mt. Pinatubo Eruption	Reg. III (5 provinces)	850	184	23	1,057	22.8502
Feb. 2, 1993	Mt. Mayon Eruption	N.A.	80	9	N.A.	89	0.13505
1999	Mayon Volcano Phreatic explosion (1 no.)	N.A.	N.A.	N.A.	N.A.	N.A.	0
Feb. 23, 2000	Mt. Mayon Eruption (1 no.)	N.A.	N.A.	N.A.	N.A.	N.A.	0.1008
July 06, 2001	Mt. Mayon Eruption (1 no.)	N.A.	N.A.	N.A.	N.A.	N.A.	0.05194
Note: Property damage is adjusted to 2003 price level by applying CPIrate=(CPI of 2003/CPI of respective year).							

Source: Major and Minor Natural Disaster Incidents 1980-2003, NDCC

2.2 Socio-economic Impacts of Natural Disasters

It is widely understood in the Philippines that disasters have hampered the efforts of socio-economic development, and have been one of the key factors contributing to poverty in the country. In disaster-prone provinces or regions, where the problem of disaster is more serious than other areas, disasters have severely impacted investments for development.

The areas (or provinces) with low income or high poverty are those often hit by floods, sediment, typhoon disasters (such as Cagayan, Agno, Bicol, Panay river basins and others) and volcanic disasters (such as Mt. Pinatubo, Mt.Mayon, Camiguin Island and others) and earthquake disasters (such as Mindoro island and south-western parts of Mindanao) (see Figure 1.2 and Figure 1.3).

As shown in Table 2.7, the events that caused property damage over 10 billion pesos in the last 20 years include 2 typhoons, 1 earthquake and 1 volcanic eruption. Each of these disasters caused about 1,000 deaths. Although these disasters did not occur yearly, it is obvious the impact to the national economy is very large.

Table 2.7 Disaster with Property Damage over 10 Billion Pesos (1980-present)

Event	Date	Property Damage (Bill. Pesos)	Casualties			
			Dead	Injured	Missing	Total
TY Nitang	Aug-Sept, 1984	17.843	900	N.D.	N.D.	2,361
TY Rosing	Oct.-Nov, 1995	10.829	936	N.D.	N.D.	5,404
Baguio Earthquake	7/16/1990	31.176	1,283	2,786	321	4,390
Mt. Pinatubo Eruption	7/15/1991	22.851	850	184	23	1,057

2.3 Overview of the Disaster Management Capacity in the Philippines

The disaster management system of the Philippines needs to be improved enormously from both medium and long-term viewpoints because there is critical insufficiency in every area including human resources, technology, equipment, and funding. In order to cope with the requirements of disaster management, it is essential to take an integrated approach, including establishment of regulations, improvement of institutional systems, acquisition of budgets, promotion of training for professional staff, and introduction of equipment.

The disaster management organization consists of NDCC at the top with RDCC, MDCC, BDCC, and others below it. The organization in each administrative district from national to regional level is there to perform emergency response and restoration activities in the event of disaster. However, the emergency response capacity of MDCC and BDCC is considered to be inadequate, particularly in getting a clear picture of the extent of the disaster conditions, and passing on of this information to relevant agencies in the upper levels, in a timely manner.

In the case of regions near the Capital area and large cities, the problems related to the collection and transfer of disaster information and emergency response seems to be comparatively low. However, in regions or islands where infrastructure for communication and transportation are not yet well established, present conditions pose serious problems and prevent them from being able to both comprehend the disaster conditions and provide emergency response.

Floods, sediments and landslides are disasters basically related to typhoons and rainfall. With regards to these types of disaster, there are limitations in collecting enough information about the rainfall conditions and forecasting the effects for the area.

Consequently, these limitations hamper necessary evacuation activities of people in the region and operations of disaster risk management. However, it is essential to strengthen the functioning of the system for collection and transfer of information of weather conditions that is well-structured on a national basis.

In addition, with regards to data collection for disaster management for rivers, it is necessary to strengthen the functioning of monitoring of the water level and flow volume. Concerning preparedness for

earthquake and volcanic activities, it is necessary to strengthen the monitoring system covering the whole nation.

Enhancing awareness of people living in the high potential area of natural disasters and capacity development of MDCC and BDCC staff, who are in charge of disaster management, is also essential. For the improvement of regional disaster management capacity, middle and long-term measures are required. It is also necessary to enhance regional economic power to invest the necessary funds in the establishment of regional disaster mitigation measures. In view of these points, an integrated regional development plan including both natural disaster management and economic development should first be prepared.

Chapter 3. Study on Floods, Sediment and Typhoon Disaster

CHAPTER 3. STUDY ON FLOODS, SEDIMENT AND TYPHOON DISASTER

3.1 Meteorological Conditions in the Philippines

3.1.1 Climate Types and Monthly Rainfall

The climate of the Philippines is characterized as one having a relatively high temperature (mean annual temperature: 26.6 °C), high humidity (average 70-85 %), and high annual rainfall. Climate in the Philippines is mainly influenced by the northeast monsoon, southwest monsoon, tropical typhoon, Inter Tropical Convergence Zone (ITCZ) and topography.

There are four distinct climate types (Types 1 to 4, described below) in the country, classified in terms of the rainfall distribution. Table 3.1 shows the climate types and monthly rainfall patterns at several cities in the Philippines.

(1) Type I: Two pronounced seasons; dry from November to April, wet during the rest of the year. The western side of the country characterized by this climate type is largely influenced by the southeast monsoon and there is generally a maximum rain period from June to September that is caused by the tropical typhoons occurring especially during this period.

(2) Type II: No dry season with a very pronounced maximum rainfall from November to January. The eastern side of the country characterized by this climate type is generally along or very near to the eastern coast that is open to the northeast monsoon.

(3) Type III: Seasons not very pronounced, being relatively dry from November to April and wet during the rest of the year. This type is intermediate between Type I and II, but resembles Type I more closely. Areas characterized by this climate are partly shielded from the influence of the southwest monsoon but influenced by the rainfall caused by tropical typhoon.

(4) Type IV: Rainfall more or less evenly distributed throughout the year. This type is also intermediate between Type I and II, but resembles Type II more closely. Areas characterized by this climate are partly shielded from the influence of the northeast monsoon.

Mean annual rainfall in the Philippines varies between 1,000 and 4,000 mm with an average of about 2,360 mm/year. Under these climate conditions, heavy rainfall results from typhoons, pressure depressions and local cumulonimbus.

3.1.2 Typhoons

Generally between March / April and November / December every year, about 30 typhoons are born in the northwestern Pacific Ocean and move in a northwestern direction. Of this number, about 20 of them hit the Philippines. Typhoons bring heavy rainfall and strong winds, which cause damages by floods, flashfloods, sediment (including landslide), storm surge and strong wind.

Based on the damage caused by typhoons, about 30 % of the typhoons are considered destructive. Figure 3.2 shows the paths of destructive typhoons from 1970 to 2002. Many of the destructive typhoons hit the northern part of Mindanao, Samar and Leyte first, and then went up in a northwestern direction passing Visayas, Mindoro and Luzon. Only a few typhoons passed through Mindanao except for the northern area. Mindanao (except the northeastern part) is almost a typhoon free area.

From May to October, the typhoon paths are generally over Luzon islands. The west side of the Luzon is influenced by the southwest monsoon during this season, and it is likely to get more rainfall if the typhoon comes. On the other hand, the typhoon paths are generally over Visayas and Northern Mindanao from December to March. The east side of this area is influenced by the northeast monsoon during this season, and it is likely to get more rainfall if the typhoon comes.

Figure 3.3 shows characteristics of destructive typhoons, in terms of the lowest pressure, maximum wind and the maximum 24-hour rainfall, between 1990 and 2002 as an example. The lowest pressure ranges between 970-990 hps, the maximum wind speed ranges between 20-50 m/s, and the maximum 24-hour rainfall ranges between 200-400 mm.

3.2 River Basins in the Philippines

In the Philippines, 421 rivers are identified as principal river basins with catchment areas raging from 41 km^2 to 25,649 km^2 (source: National Water Resources Board (NWRB), "Principal River Basins of the Philippines", 1976). Among the principal river basins, 20 river basins are identified as major river basins, which have in general, a catchment area of more than 1,400 km^2 , with the exception of the Laoag River Basin (source: JICA, "Master Plan Study on Water Resources Management in the Republic of the Philippines, Final Report", 1998). These river basins are divided into 12 water resources regions. The major river basins and the water resources regions are shown in Figure 3.4 and the major river basins are also given in Table 3.1.

Table 3.1 **Major River Basins in the Philippines**

Major River Basin	Island	Catchment Area (km^2)	Major River Basin	Island	Catchment Area (km^2)
Laoag	Luzon	1,353	Jalaur	Panay	1,503
Abra	Luzon	5,125	Ilog-Hilabangan	Negros	1,945
Cagayan	Luzon	25,649	Agusan	Mindanao	10,921
Abulog	Luzon	3,372	Tagoloan	Mindanao	1,704
Agno	Luzon	5,952	Cagayan (Mindanao)	Mindanao	1,521
Pampanga	Luzon	9,759	Tagum-Libuganon	Mindanao	3,064
Pasig-Laguna Bay	Luzon	4,678	Davao	Mindanao	1,623
Bicol	Luzon	3,771	Buayan-Malungun	Mindanao	1,434
Amnay-Patric	Mindoro	993	Agus	Mindanao	1,890
Panay	Panay	1,843	Mindanao	Mindanao	23,169

Almost all of the major river basins have a problem with floods, and for some, an additional problem with sediments. Examples of such areas are Laoag, Agno and Pampanga basins. The issue of floods (including flashfloods) and sediment (including landslide) also affect many principal river basins.

3.3 Historical Damages by Floods, Sediment and Typhoon Disasters

3.3.1 Floods and Sediment Damages

(1) General

Flood Disaster

Floods (including flashfloods) are the result of an overflow of water from rivers with large discharges caused by heavy rainfall in the river basins. Floods and flashfloods are caused by typhoons, tropical depressions, and local storm rainfall. Areas such as alluvial plains along the rivers including agricultural lands, villages, towns and cities get inundated by the floods. Furthermore, due to insufficient drainage systems, drainage problems often happen in urban areas, which is also one of the flooding problems in the Philippines.

Sediment Disaster

In addition to the above, there are river basins with sediment problems from large sediment flows, debris flows and mud flows. These are also caused by heavy rainfall in the river basins resulting from typhoons, tropical depressions and local storm rainfall with large amounts of sediment production in the river basins and existence of large amounts of unstable sediments along the rivers often accompanied with flashfloods. Furthermore, landslides from mountain slopes and hills also occur in the Philippines. These are generally caused by weak resistance on the slopes due to heavy rainfall or earthquakes.

(2) Typhoon Damages

In many cases, floods (including flashfloods) and sediment (including landslide) are caused by typhoons especially in the Northeastern Mindanao area of the Visayas (Regions VI to VIII), Mindoro and all over Luzon. Generally, in Mindanao, floods (including flashfloods) occur due to heavy rains from a tropical depression, or just local heavy rains. Furthermore, typhoons sometimes cause storm surges in some of the coastal areas in the Philippines, and cause destructive damages to villages along the coast. However, the phenomenon and conditions of damage from storm surges is not well known due to the difficulty of accessing the damaged sites, as well as lack of observation networks. The strong winds associated with typhoons also damage houses, buildings and electric lines. However, it is difficult to disaggregate damage caused by wind to that from water, sediment and or flush floods damage, as the NDCC damage data is aggregated under "floods".

3.3.2 Frequency of Destructive Typhoons / Flood Damages

Table 3.2(1) shows a summary of provincial damages by destructive typhoons based on 12 year data from NDCC between 1991 and 2003 (1998 data is missing), which is the base data for the analyses shown in Figures 3.5 to 3.8. Since many disasters including floods and sediment have happened after 1991, it was assumed that these 13 years after 1991 would be a good sample period to study the profile of the provincial damages. Most of the damages are caused by floods from destructive typhoons. (Relating to the damage data, we found that sometimes there are discrepancies between the country, region and province data. In such cases, the data format is also not uniform, which makes it difficult to develop a database. In order to minimize data discrepancies, it is recommended that data is sent from the province to region and country at the same time and using a uniform format).

Figure 3.5 (1) shows the frequency of destructive typhoon disasters by province from 1991 to 2003. The frequency is higher in the area of northeastern Mindanao, Visayas, Mindoro and Luzon, which coincides with the typhoon paths. Frequency of typhoons in these areas (in other words safety degree) ranges between 0.5 to more than 2 times/year, which is equal to a range of a 2-year return period to a 0.5-year return period. The frequency of occurrence in Mindanao (except the northeastern part) is relatively low with a range of 0-0.5 times/year (more than 2-year return period) on average. Since typhoons cause floods in many cases, these can be assumed at almost the same frequency or safety degree as typhoons.

Table 3.2(1) Destructive Typhoon Damages by Provinces based on 12 Year Data between 1991 and 2003

Province	Region	Affected Times	Casualties				Affected		Damaged Houses			Damaged Properties			
			Dead (pers.)	Injured (pers.)	Missing (pers.)	Total (pers.)	Families (no.)	Persons (pers.)	Totally (no.)	Partially (no.)	Total No. (no.)	Agricult. (Mil. P)	Infra. (Mil. P)	PVT (Mil. P)	Total (Mil. P)
Philippine		**838**	**8,484**	**7,612**	**2,224**	**18,320**	**5,866,641**	**29,845,671**	**547,691**	**1,668,092**	**2,215,783**	**51,233.575**	**26,376.791**	**2,212.709**	**80,485.265**
NCR	NCR	34	63	40	9	112	186,964	1,035,063	1,342	14,860	16,202		87.078		87.078
Abra	CAR	14	23	28	16	67	38,874	199,858	2,092	8,730	10,822	302.974	1,108.195	342.582	1,753.752
Apayao	CAR	17	4	16		20	16,698	88,621	354	3,617	3,971	75.502	134.346		209.848
Benguet	CAR	23	173	196	26	395	26,182	117,275	1,087	2,277	3,364	177.667	1,455.648	97.789	1,731.104
Ifugao	CAR	13	32	6		38	15,111	78,932	1,693	9,758	11,451	192.818	245.056	6.936	444.810
Kalinga	CAR	17	15	17	10	42	31,796	148,636	2,271	11,724	13,995	309.137	307.598	8.017	624.752
Mt. Province	CAR	16	33	11		44	712	4,390	1,238	588	1,826	209.090	1,031.255	7.309	1,247.654
Ilocos Norte	Reg. I	24	15	38	13	66	104,133	364,685	3,100	22,675	25,775	445.266	745.612	0.594	1,191.474
Ilocos Sur	Reg. I	21	49	20	11	80	87,878	436,649	7,935	17,543	25,478	987.144	1,044.976	147.909	2,180.771
La Union	Reg. I	22	27	35	11	73	74,097	341,120	2,447	13,418	15,865	435.436	887.220	83.831	1,407.587
Pangasinan	Reg. I	21	100	107	35	242	567,525	3,166,343	3,631	19,555	23,186	5,135.233	1,144.401		6,347.486
Batanes	Reg. II	12					27,651	159,444				32.604	30.895	110.302	182.579
Cagayan	Reg. II	18	55	22	15	92	244,084	1,210,750	5,335	51,306	56,641	2,899.725	1,051.543	21.083	3,972.351
Isabela	Reg. II	13	108	228	14	350	353,951	1,704,282	41,890	106,971	148,861	3,576.954	262.259	0.033	3,839.246
Nueva Vizcaya	Reg. II	15	36	31	23	90	15,258	71,684	763	3,809	4,572	1,222.145	520.313	7.702	1,750.160
Quirino	Reg. II	12	10	17	1	28	33,911	153,111	955	1,269	2,224	438.727	71.182	0.001	509.910
Bataan	Reg. III	24	13	6	5	24	174,164	1,016,352	1,654	6,215	7,869	170.028	179.533	0.028	400.085
Bulacan	Reg. III	21	37	1	9	47	220,217	1,180,833	155	549	704	808.907	69.486		912.990
Nueva Ecija	Reg. III	21	34	2	4	40	168,309	872,639	471	2,057	2,528	934.289	532.163	11.916	1,543.295
Pampanga	Reg. III	30	85	8	1	94	542,059	2,650,554	1,829	2,539	4,368	1,116.902	123.107		1,429.592
Tarlac	Reg. III	20	15			15	162,810	853,286	1,414	2,999	4,413	784.865	1,085.624		1,962.507
Zambales	Reg. III	26	34	35	22	91	77,889	394,554	411	3,114	3,525	112.225	298.110	0.553	428.652
Aurora	Reg. IV	7	2			2	25,956	124,299	2,579	10,589	13,168	370.183	275.385		645.568
Batangas	Reg. IV	11	19	8	7	34	9,483	44,847	622	2,811	3,433	325.474	48.465	5.130	379.069
Cavite	Reg. IV	13	12	550	97	659	92,973	452,680	8,257	15,333	23,590	238.814	97.936	126.812	463.562
Laguna	Reg. IV	10	49	281	16	346	103,731	497,165	13,622	26,659	40,281	917.527	94.486	255.799	1,267.811
Marinduque	Reg. IV	5	21	16	6	43	27,713	118,664	1,082	11,201	12,283	754.923	925.503	19.950	1,700.375
Occidental Mindoro	Reg. IV	7	4		1	5	4,133	18,514	243	541	784	26.455	50.265	14.800	91.520
Oriental Mindoro	Reg. IV	9	78	12	5	95	117,724	574,262	32,202	21,695	53,897	1,443.882	946.868	44.558	2,435.307
Palawan	Reg. IV	8	78	18	50	146	17,546	105,728	510	5,574	6,084	68.428	3.922	4.240	76.590
Quezon	Reg. IV	10	324	598	95	1,017	225,885	934,953	50,492	165,886	216,378	7,339.865	407.677	18.383	7,765.925
Rizal	Reg. IV	19	33	19	38	90	76,475	396,847	8,172	38,964	47,136	471.670	1,464.501	61.657	2,001.020
Romblon	Reg. IV	7	12	14		26	12,393	29,477	1,356	154,232	155,588	96.928	224.836	65.604	387.367
Albay	Reg. V	15	99	56	28	183	109,303	575,853	19,339	80,726	100,065	201.550	397.225	17.232	616.007
Camarines Norte	Reg. V	11	332	886	57	1,275	131,994	643,874	50,647	79,282	129,929	2,968.797	402.421	50.170	3,421.388
Camarines Sur	Reg. V	7	407	2,332	34	2,773	300,548	1,522,311	106,799	207,352	314,151	2,173.227	846.240	158.516	3,177.983
Catanduanes	Reg. V	9	58	42	14	114	49,613	289,478	26,248	31,086	57,334	731.010	463.006	11.100	1,205.116
Masbate	Reg. V	8	8	10	14	32	9,305	48,051	1,020	8,872	9,892	682.918	230.657	43.744	957.319
Sorsogon	Reg. V	11	25	61	3	89	42,520	214,417	4,371	33,089	37,460	627.486	189.978	94.441	911.904
Aklan	Reg. VI	14	3	4	3	10	160,802	831,028	319	3,695	4,014	281.687	172.859		454.547
Antique	Reg. VI	12	6		3	9	5,866	32,077	902	2,017	2,919	182.197	374.797		562.474
Capiz	Reg. VI	12	42	15	6	63	63,085	354,192	782	4,359	5,141	1,453.638	151.023	7.565	1,612.225
Guimaras	Reg. VI	8	4	2		6	1,902	10,395	181	1,109	1,290	58.068	59.047		117.115
Iloilo	Reg. VI	15	91	42	16	149	225,055	1,188,502	26,931	73,656	100,587	2,686.772	471.447	0.416	3,279.227
Negros Occidental	Reg. VI	21	269	241	59	569	179,312	1,031,393	33,035	71,966	105,001	1,161.429	913.348	2.220	2,082.067

Table 3.2 (2) Destructive Typhoon Damages by Provinces based on 12 Year Data between 1991 and 2003

Province	Region	Affected Times	Casualties				Affected		Damaged Houses			Damaged Properties			
			Dead (pers.)	Injured (pers.)	Missing (pers.)	Total (pers.)	Families (no.)	Persons (pers.)	Totally (no.)	Partially (no.)	Total No. (no.)	Agricult. (Mil. P)[2]	Infra. (Mil. P)	PVT (Mil. P)	Total (Mil. P)
Bohol	Reg. VII	10	63	7	7	77	11,413	59,912	7,435	3,486	10,921	227.422	451.759	42.951	722.131
Cebu	Reg. VII	12	91	57	41	189	82,378	401,628	9,316	49,900	59,216	307.806	237.489	38.198	583.493
Negros Oriental	Reg. VII	8	11	4	4	19	1,641	7,944	218	418	636	126.033	21.961	0.887	148.881
Siquijor	Reg. VII	2							2		2	1.346	5.855		7.201
Biliran	Reg. VIII	8		1	2	3	21,816	114,909	567	6,496	7,063	108.951	97.258	1.117	207.325
Eastern Samar	Reg. VIII	6	3	8		11	19,363	116,106	3,499	15,854	19,353	75.864	85.029		160.893
Leyte	Reg. VIII	20	4,984	502	1,244	6,730	246,085	1,170,093	33,040	153,874	186,914	1,607.884	1,464.948	14.535	3,087.366
Northern Samar	Reg. VIII	9	24	568	51	643	65,996	335,118	12,243	24,935	37,178	186.944	352.249	246.831	786.024
Samar	Reg. VIII	8	8		1	9	12,310	66,301	61	9,570	9,631	282.385	19.230		301.615
Southern Leyte	Reg. VIII	9	24	2	4	30	2,557	11,281	557	2,120	2,677	139.604	133.491	2.226	275.321
Basilan	Reg. IX														
Zamboanga del Norte	Reg. IX	2	3	5		8	238	1,236	16	40	56	21.750	5.300		27.050
Zamboanga del Sur	Reg. IX	4	42	101		143	3,342	18,041	241	492	733	237.642	0.109	5.800	243.551
Bukidnon	Reg. X	2	18	7		25			5		5	3.145			3.145
Camiguin	Reg. X	4	148	146	72	366	9,022	53,427	253	568	821	46.763	172.192	0.287	219.242
Misamis Occidental	Reg. X	2	1			1						3.700	0.888	0.145	4.733
Misamis Oriental	Reg. X	4		1		1	1,869	10,174	36	72	108	38.189	59.330		97.519
Compostela Valley	Reg. XI														
Davao	Reg. XI	2	23		1	24	36,377	171,905	220	114	334	141.887	125.425		267.312
Davao del Sur	Reg. XI	2		4		4		1,186	14	52	66	434.750	128.177		562.927
Davao Oriental	Reg. XI	7	16		3	19	4,232	25,295	24	30	54	37.277	39.791	1.673	78.741
Saranggani	Reg. XI	2						236	34	25	59			0.407	0.407
South Cotabato	Reg. XI	1										0.033			0.033
Lanao del Norte	Reg. XII														
North Cotabato	Reg. XII	2										217.464			217.464
Sultan Kudarat	Reg. XII	2					484	860				41.225			41.225
Agusan del Norte	Reg. XIII	5	15	6	3	24	45,196	276,859	493	8,826	9,319	226.910	282.587		509.496
Agusan del Sur	Reg. XIII	1	2	2	2	6	10,423	52,115	63	4	67	31.402	38.467		69.869
Surigao del Norte	Reg. XIII	9	22	116	6	144	70,680	372,175	5,820	21,052	26,872	392.221	542.211	0.080	934.512
Surigao del Sur	Reg. XIII	7	46	4	6	56	55,629	280,802	1,756	13,897	15,653	555.812	485.554	8.652	1,050.018
Lanao del Sur	ARMM	2					2,000	10,000				63.911			63.911
Maguindanao	ARMM	1										35.701			35.701
Sulu	ARMM														
Tawi-Tawi	ARMM	2	3			3						8.990			8.990

Notes:
1) Available damage data of NDCC are 12 year data of 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1999, 2000, 2001, 2002 and 2003.
2) Property damage is re-calculated based on 2003 price level by allping rates of CPI of each year.

(1) **Frequency of Flash Flood Damage**

Figure 3.5(2) shows the frequency of flashflood disaster. The frequencies of flashfloods are generally much lower than that of floods. The frequencies of flashflood range only between 0 to 0.5 times per year (more than 2-year return period) for the whole country on average. Flashfloods also occur in Mindanao, probably due to tropical depressions or local storm rainfall, and not only in the flood prone areas such as Visayas, Mindoro and Luzon.

(2) **Frequency of Sediment and Landslide Damage**

Figure 3.5(3) shows the frequency of sediment/landslide disaster. These frequencies are also much lower than those of floods, and range only between 0 to 0.5 times per year (more than 2-year return period). Recorded areas of landslides are evenly spread over the country.

(3) **Damage by Floods and Sediment Disasters**

Depending on the topography and land use of river basins and meteo-hydrological conditions, the patterns of floods differ from basin to basin. River basins with flat topography suffer from vast floods with long durations (for example: Cagayan, Agno, Pampanga, Bicol, Panay and Mindanao river basins). River basins with steep topography suffer from flashfloods and sediment discharge in many cases (for example: Laoag river basin), as do middle to small rivers like the rivers in Mt.Pinatubo area, Camiguin island, and Ormoc City).

Furthermore, debris flow and mud flow together with flashfloods occur in the upstream basins and can be seen in the rivers such as the rivers in Mt.Pinatubo area, Camiguin Island and Southern Leyte (Panaon Island).

The severity of damages depends on the magnitude and pattern of the flood (including flashflood) and sediment (including landslide), population distribution and landuse such as agricultural land. Considering this, severity of damages by destructive typhoons which include consolidated damages of floods and sediment disasters are analyzed in terms of affected population and property damage. The extent of the impact is easily gauged by the number of casualties (dead, injured and missing), as well as property damage: agricultural damage, infrastructural damage and private property damage, which relates to the damages to assets.

Affected Persons:

Figure 3.6 shows annual average affected persons by destructive typhoons, by province. This is assumed to be almost at the same levels as the affected persons of floods and sediment (including landslide). The highest group of affected persons includes the northeastern Luzon where Cagayan river basin is located, central Luzon where the Agno and surrounding river basins and the Pampanga river basin are located, and southern Luzon where Bicol river basin is located. Generally speaking, the number of affected persons is large in the provinces with large populations living in the typhoon path, such as the provinces in Luzon, Iloilo in Panay, and Negros Occidental. Affected persons in Leyte belong to the 2nd highest

group due to the large flashflood that happened in November 1991 at Ormoc City, where about 5,100 persons died.

Property Damage and Per-Capita Property Damage:

Figure 3.7 shows the annual property damages from 1991 to 2003, and Figure 3.8 shows per-capita annual property damage. In terms of property and per-capita property damage, Luzon is in the middle to higher group (more than 50 million pesos/year), especially in the areas of the Cagayan, Agno and Bicol river basins which have suffered severe property damage (both of total and per-capita). Other islands, especially Oriental Mindoro, Northeastern and southern Panay, Leyte and northeastern Mindanao (Surigao Norte and Sur) have suffered severe property damage (total and per-capita).

Relation between Property Damage and Poverty:

It cannot be always said that the area with high frequency, or many affected persons, or large amount of property damage by flood, sediment and typhoon disasters have high relation to poverty. However, clear relationships between the property damage (shown in Figures 3.7 and 3.8) and condition of poverty (shown in Figures 1.2 and 1.3) can be seen for the Cagayan and Bicol River Basins, Oriental Mindoro, Panay river basin in Northeastern Panay, Leyte and Northeastern Mindanao (Surigao Norte and Sur). Among these, Cagayan River Basin, Bicol River Basin, Leyte and Northeastern Mindanao have a characteristically high frequency of destructive typhoons and many affected persons as well as large amounts of property damage (total and per-capita). Panay River Basin and Oriental Mindoro have characteristically large amounts of property damage (total and per-capita). It can be concluded that floods, sediment and typhoon disasters are among the key reasons for poverty in these areas.

3.3.3 Storm Surge Damage

Storm surge is the abnormally high sea level caused by low pressure of tropical cyclones/typhoons, and the impacts are affected by direction and topography of the coast. It is often associated with very high waves. When storm surge occurs, it usually causes significant damage to the affected towns and villages along the coasts with a resultant high number of deaths. In the Philippines, although the frequency of occurrence of storm surges is lower than floods, it has been recorded as occurring. However, as the damaged places are usually located in remote areas, almost no observation facilities such as tidal gauges exist in and around the damaged places, hence the pattern and conditions following storm surges, including its damage is not yet well known yet. Figure 3.9 shows the recorded places of storm surge from 1897 to 2002, but looking at this data, it seems that a good number of storm surge occurrences are missing, mainly due to the difficulty in investigating and data collecting. Since the storm surge damage is very serious, especially in poor villages depending on

fishery, it is recommended to investigate and study the phenomenon of storm surge and its associated damages from now on.

Table 3.3 Recorded Storm Surges 1897-2002

Date	Tropical Cyclone	Place of Max. Sea Water Level		Max. Sea Water Level above MSL (m)
		Province/Area	Place	
Oct. 12, 1897	TY Samar & Leyte	Samar	Hernani	7.3
Oct. 13, 1908	TY Aparri	Cebu	Consolacion	9.1
Oct. 11-15, 1970	TY Sening	Luzon	West coast	3.6
Jan. 25-31, 1975	TY Auring	Surigao Sur	Tandag	2.4
Jan. 25-31, 1975	TY Anding	Aurora	Sabang	4.8
July 11-16, 1983	TY Bebeng	Sorsogon	Bulabog	3.4
Aug. 31-Sep. 4, 1984	TY Nitang	Cebu	San Fernando	3.3
Aug. 10-14, 1987	TY Herming	Oriental Mindoro	Naiyan	2.6
Nov. 23-27, 1987	TY Sisang	Albay	Tiwi	
Dec. 1, 1990		Cebu	Bgy. Mataas	3.3
Nov. 1-3, 1995	TY Rosing	Lopez	Pansol	2.3
Dec. 1995	TY Naning	Dact	Bagasbas	2.6
Sep. 1998	TS Gading	Pangasinan	Dagupan	0.9
Oct. 1998	TY Loleng	Calauag	Kagtalaba	3.4
July 2-5, 2001	TY Feria	Ilocos	Santa	3.3
Nov. 6-10, 2001	TY Nanang	Cebu and Bohol		
Mar. 19-22, 2002	TY Caloy	Cebu	Talisay	2.7

MSL: *Mean sea level*
Source: PAGASA

3.4 Existing Countermeasures and Plans against Floods, Sediment and Typhoon Disasters

3.4.1 Existing Flood / Sediment Control Plans and Structural Measures

The Department of Public Works and Highways (DPWH) is responsible for implementing flood and sediment control structures (including landslides). Substantial structural measures against floods and sediment in the Philippines have been provided, but only for some of the major river basins. Other rivers have only minor mitigation measures such as bank protection and dikes for a limited reach. Table 3.4 shows the list of the existing plans and structural measures mainly for the major river basins. Figure 3.10 shows the location of the river basins with existing major flood control or sediment control projects of DPWH. Although it takes time and money, it is necessary to continue and increase the number of river basins with substantial flood control or sediment control measures.

Table 3.4 Major Flood / Sediment Control Projects of DPWH

River	Project	Framework Plan	Master Plan (M/P)	Feasibility Study (F/S)	Implementation
1. Major Rivers					
Laoag	Flood control Sediment control	GOP & OECF (1982)*	JICA (1997)	JICA (1997)	GOP & JBIC (from 2001, D/D 2003)
Abra		-	-	-	-
Cagayan	Flood control Water resources develp.	GOP & OECF (1982)*	JICA (1987)	JICA (2002)	-
Abulog		-	-	-	-
Agno	Flood control	GOP & OECF (1982)*	JICA (1991)	JICA (1991)	GOP & JBIC (OECF) (from 1995)
Pampanga	Flood control	GOP & OECF (1982)*		JICA (1982)	GOP & OECF (1990-2003)
Pasig-Laguna Bay	Flood control Drainage improvement	GOP (1954)	JICA (1990)	JICA (1990)	GOP (1970s) GOP & JBIC (OECF) (from 1973 for several projects)
Bicol	Flood control	GOP & OECF (1982)*	WB (water shed management project on-going)	BRDBDP (1983)	BRDBDP (D/D, 1992) GOP (1973-1991, partially)
Amnay-Patric	Flood control Sediment control Water resources develop.	GOP & OECF (1982)*		DPWH (Pre-F/S, 1984)	-
Panay	Flood control Water resources develop.	GOP & OECF (1982)*	JICA (1985)	JETRO (2002)	-
Jalaur	Flood control	GOP & OECF (1982)*	-	-	-
Ilog-Hilabangan	Flood control	GOP & OECF (1982)*	JICA (1991)	-	-
Agusan	Flood control	GOP & OECF (1982)*	-	-	GOP & OECF (1985, 1988-1999)
Tagoloan	Flood control	GOP & OECF (1982)*	-	-	-
Cagayan (Mindanao)	Flood control Environmental improve.	-	LGU (1999)	-	-
Tagum-Libuganon	Flood control Irrigation develop.	-	-	NIA & DPWH	NIA (completed) DPWH (on-going)
Davao	Drainage improvement	-	Davao City (1998)	Davao City (1998)	-
Buayan-Malungun		-	-	-	-
Agus		-	-	-	-
Mindanao	Flood control Watershed management	GOP & OECF (1982)*	-	-	-
2. Other Rivers					
Pinatubo Pasig-Potrero Sacobia-Bamban West side rivers	Lahar control		JICA (1978) - JICA (2003)	- JICA (1995) JICA (2003)	JBIC (from 2000) OECF (1997) -
Mayon Volcano	Mud flow control		JICA (1981 & 83)	JICA (2000)	Italia (Community level pilot project: 1989-1992) DPWH (after 1983)
Ormoc City FC	Flashflood control		JICA (1995)	JICA (1995)	GOJ Grant (1998-2001)
Iloilo City FC	Flood control		JICA (1995)	JICA (1995)	GOP & JBIC (D/D 2001-2002)

Note: * DPWH, Nationwide Flood Control Plan and River Dredging Program.
Source: JICA; "Water & Floods", 2003

3.4.2 Existing Flood Control / Multipurpose Dams

There are 36 large dams with a dam height of more than 15 m in the Philippines. These dams are mainly for hydropower, irrigation and water supply, while some have flood control functions. Among the 36 large dams, 7 dams are called major dams with a dam height of more than 100 m as shown in the following table. Together with the existing flood control facilities and flood forecasting and warning systems (mentioned in 3.4.3), it is expected to more effectively utilize the existing dams for flood control.

Table 3.5Major Large Dams (with Height > 100 m) in the Philippines

Dam	Agency	Purpose	Province	River Basin	Catch -ment Area (km2)	Dam Type	Dam Height (m)	Gross Storage (mil. m3)	Active storage (mil. m3)
Angat	NIA / NPC	Hydropower Water supply Irrigation Flood control	Bulakan	Angat	568	Rockfill	131	1,075	850
Magat	NIA / NPC	Hydropower Water supply Irrigation Flood control	Isabela	Cagayan	4,143	Rockfill / Concrete Gravity	114	1,254	969
Pantabangan	NIA / NPC	Hydropower Water supply Irrigation Flood control	Nueva Ecija	Pampanga	853	Earthfill	107	2,310	1,973
Ambuklao	NPC	Hydropower	Benguet	Agno	612	Rockfill	129	327	258
Binga	NPC	Hydropower	Benguet	Agno	854	Rockfill	107	91	33
San Roque	NIA / NPC	Hydropower Water supply Irrigation Flood control	Pangasinan	Agno	1,235	Rockfill	200	850	530
Pulangi IV	NPC	Hydropower	Bukidnon	Pulangi	3,633	Concrete Gravity	115	287	-

Data sources:
1) JICA; "water & Floods", 2003
2) JICA; "Master Plan Study on Water Resources Management , Final Report, Vol. IV Data Book", 1998

3.4.3 Existing Flood Forecasting and Warning Systems as Non-structural Measures

Figure 3.11 shows the existing flood forecasting and warning systems (FFWSs) in the Philippines. Flood forecasting and warning is one of the mandates of Philippine Atmospheric, Geophysical and Astronominal Services Administration (PAGASA). PAGASA has flood forecasting and warning systems for 4 river basins: Cagayan, Agno, Pampanga and Bicol, which are all located in Luzon. Relating to the FFWSs of Cagayan, Agno and Pampanga river basins, there are 4 Flood Forecasting and Warning Systems for dam Operation (FFWSDO), which are operated by the National Power Corporation (NPC) and National Irrigation Administration (NIA). They also connect to PAGASA's FFWSs. Although these systems are in place, because of maintenance problems, some of the automatic water level gauges and warning stations are not working.

DPWH had a FFWS called Effective Flood Control Operating System (EFCOS) in the Pasig-Laguna de Bay River Basin (Pasig-Marikina River Basin) in Metro Manila. EFCOS has been transferred to Metropolitan Manila Development Authority (MMDA) from DPWH. It is in good condition and it is utilized for operating Mangahan Floodway to divert floodwater of the Marikina River (upper tributary of the Pasig River) to Laguna Lake for mitigating or preventing floods of the Pasig River in the center part of Metro Manila. The observed data is sent to PAGASA .

Although the area with high frequency of flood, sediment and typhoon disasters is wide, the area of coverage by the existing FFWSs is very limited. It is necessary to increase the coverage by FFWSs as well as maintain the existing systems.

Furthermore, although PAGASA gives typhoon signals, based on wind speed, through media and networks of disaster coordinating committees (DCCs), this information is sometimes not enough to make a judgment for conducting a warning and/or evacuation by DCCs at the local government unit (LGU) level, nor at the barangay level. To increase the accuracy, information such as how heavy the rainfall is, the rise in water level in the rivers and the flood discharge is required. The purpose of the above five existing FFWSs includes informing people through DCCs or LGUs about the possibility of floods. However, the coverage of the existing FFWSs is limited in the country, and it requires more time and money to increase FFWSs in the country. To improve availability of real-time information on rainfall and water level for DCCs at LGU level and barangay disaster coordinating councils (BDCCs), it is recommended, that as a provisional measure, observations on the rainfall and water level for select key gauging stations by municipality in cooperation with PAGASA and DPWH be carried out.

3.4.4 Forest Coverage

The Department of Environment and Natural Resources (DENR) together with National Mapping and Resources Information Authority (NAMRIA) are conducting a study on forest cover in the Philippines based on satellite images. The study will make available information on the area and percentage of forest cover

in the Philippines. Present estimates show that as of end June 2004, overall forest coverage in the Philippines is only about 18 % of its land area. This percentage of forest coverage is very small compared to Japan, for example, which has a similar topography, flood and sediment problems including typhoons, but still has about 70% of forest coverage.

It is generally noted that deforestation in the Philippines has resulted in increased vulnerability of the country to major risks from floods and sediment hazards. Although DENR has conducted afforestation programs in the country, the areas are limited. Besides, to make the reforestation efforts more meaningful, structural measures and flood forecasting and warning systems need to be provided – structural and non-structural measures need to complement each other. Furthermore, it is important that afforestation programs are implemented with people's participation to increase the potential for economic benefits.

3.5 Mechanism of Floods, Sediment and Typhoon Disasters, Safety Degrees (Risks) and Problem Areas

Floods (including flashfloods) are caused by both physical and non-physical factors. Physical factors include the small discharge capacity of river channels, which often causes overflow of the rivers, and insufficient structural measures such as river improvement. Furthermore, the physical reasons also include limited natural water storage capacity of river basins due to deforestation, which makes rainfall runoff hydrograph sharper with increased peak discharge and reduced duration. Non-physical reasons include improper settlement of houses and landuse in flood prone areas, insufficient information such as rainfall and water level to inform people of the potential danger of floods, while also giving information on evacuation activities before and during the floods. In the urban areas, drainage problems include decreased discharge capacity of drainage channels due to illegal structures and garbage disposal in the drainage channels.

Sediment disasters (including landslides) are also caused by both physical and non-physical factors. Physical factors include large productions of sediment due to weak slope resistance against landslides, large amounts of sediment discharge in the form of sediment flows, debris flows and mud flows, as well as small sediment carrying capacity of river channels due to siltation. The physical reasons also include insufficient structural measures against sediments. Non-physical reasons include improper landuse in the mountains such as deforestation and uniform plantation of coconut trees, etc., improper settlements in hazard prone areas of sediment, insufficient information such as rainfall and water level, and insufficient forecasting and warning systems.

In addition to the physical and non-physical factors causing floods and sediment disasters, insufficient capacity of disaster management systems result in the relevant institutions paying sufficient attention to low safety conditions against floods, sediment and typhoon disasters.

The following sub-sections describe the mechanisms of floods and sediment disasters including capacity of disaster management based on the analyses given in sub-sections of 3.3 and 3.4, and sample surveys as well as questionnaire surveys conducted in this study.

3.5.1 Sample Survey (Southern Leyte and Capiz)

To understand past occurrences of disasters and problems of disaster management, and assess the capacity to deal with them more objectively, sample surveys were conducted by the Study team in Southern Leyte and Capiz Provinces. These surveys were supported by NDCC and respective Regional Disaster Coordinating Councils (RDCCs of Region VIII and Region VI) and Provincial Disaster Coordinating Councils (PDCC of Southern Leyte Province and PDCC of Capiz Province). Southern Leyte suffered very severe landslide damage with debris flow and mud flow in December 2003 in Panaon Island, which is located at the southern most part of the province. Capiz Province has often suffered from floods with very wide and deep inundation (inundation area of about 320 km^2 and 1.5 m to 4 m maximum depth) with prolonged duration (2 to 10 days). Such events have severely affected people and have been constraints for socio-economic development including agriculture. The largest flood of Capiz in these 20 years happened in December 2000.

(1) Southern Leyte Province

Figure 3.12 shows the conditions of damage of Panaon Island in December 2003. There were two barangays, which were severely damaged by landslide with mudflow (Barangay Punta: 105 dead and 103 houses destroyed) and debris flow (Barangay Pinotan: 5 dead and 496 houses destroyed). Among them, Barangay Punta had many dead, because the village people escaped to one of the houses (evacuation center) just after the first small landslide happened, which after a second large landslide happened, caused a massive mud flow which rushed towards the evacuation center where there were many people. Furthermore, when people of Barangay Punta started evacuating, the only road to the nearby municipality of San Francisco was already impassable due to the landslide and overflow of small rivers between the two places, and the only choice for people was to evacuate within their barangay. Escape by boats to sea was also not possible due to high waves along the seashore, worsening the situation. The impassable road also made it difficult for the rescue teams to get access to the damaged site, which delayed rescue operations. In Barangay Lutao, flashfloods with a landslide occurred and caused severe damages because many houses were located in a hazard prone area within the small valley.

There was no real-time rainfall data from PAGASA and almost no information about the local heavy rainfall in these remote areas to the PDCC located in the capital city Maasin and surrounding municipalities due to lack of communication facilities such as radio. The communication problems and lack of real-time rainfall information could not make it possible for the PDCC and MDCC to support the BDCCs in providing warning and evacuation.

Through site investigation and discussions with PDCC members and the RDCC of Region VIII, the problems identified related to disaster management in this area are summarized in the table below.

Table 3.6 Problems of Disaster Risk Management in Southern Leyte Province

Problems	Contents
1. MITIGATION 1) No Mitigation Measures against Floods, Landslide and Debris/Mud flow	• No structural measures even for priority areas. • No forecasting measures. • Uniform coconut plantation with weak resistance against landslide. • No investigation on potential hazard areas and people live in the hazardous areas.
2) Late Evacuation Actions	• No real-time rainfall data available. • Insufficient guidance to people for early evacuation. • Lack of communication facilities in remote areas such as radio communication. • Final decision of evacuation is highly depended on BDCCs and very weak support from MDCCs and PDCC due to lack of information of disaster possibility and communication. • People's ignorance of early warning. • Impassable road due to flooding and landslide. • Evacuation by boats was impossible due to high waves (no jetties).
3) Improper Evacuation Places	• Unsafe evacuation places: the major evacuation house of Barangay Punta was destroyed by landslide with mudflow.
2. RESPONSE 1) Took Long Time until Reaching the Rescue Team	• Lack of rescue equipment (heavy equipment and basic equipment such as shovels and ropes). • Only one road, but it was not passable due to landslides and flooding. • Lack of communication facilities (no radio communication). • Lack of first aid medicines and sanitary facilities.
3. REHABILITATION 1) Insufficient and slow rehabilitation	• Lack of budget. • Bad accessibility to the site (rehabilitation for the national road along western coast has been finished, but that for the provincial road along eastern coast has been done only partially) due to institutional problem. • Difficulty of land acquisition for relocation (but finally, relocation sites for Punta was acquired and houses are being built).

Note: Evacuation including warning is considered to be overlapping mitigation, preparedness and emergency response.

<u>Conditions of Disaster Management Capacity in Southern Leyte Province and Directions for Improvement:</u>

Considering the conditions of disaster management and problems relating to the sediment disaster in Panaon Island directions for improvement are proposed as follows:

a. Increase reforestation efforts to strengthen the protection of the area, presently only under coconut plantations, which provide weak protection against slope erosion. This may need to be combined with structural measures. In all, cooperation with communities is indispensable.

b. Control settlements to avoid sediment and flood disaster risks, particularly as many people live inside the hazard prone areas, such as along the small steep streams. Although, some of the areas such as Barangay Lutao in Municipality Liloan were designated as high risk areas by the Mines and Geosciences Bureau (MGB) Region VIII and Municipality of Liloan after the 2000 Disaster, there are many other similar areas which must be investigated for their potential disaster risks.

c. As the implementation of these structural and non-structural measures, as well as preparedness measures relate to various agencies, such as DPWH, DENR, DoH, Local Government Units (LGUs) and others, coordination among the agencies, as well as the institution of an integrated implementation approach of the various measures is needed. This is also because disaster management has mainly focused on emergency response in a very ad hoc manner, and has not really focused on the integrated mitigation measures and preparedness measures. Furthermore, there is no coordinating authority for managing the integrated approach. Therefore, it is necessary to improve disaster management systems, in such a way that integrated mitigation measures and preparedness measures are possible.

d. The recommendation above, to improve coordination among the various stakeholders is also applicable to the implementation of rehabilitation programs. For example, the national road along western coast in Panaon Island has been rehabilitated, but the provincial road along eastern coast is still in a damaged condition due to the budget constraints (by March 2004). These variances in the rehabilitation, unfortunately contribute to continued vulnerability to future hazards of the concerned areas.

e. As for the warning for early evacuation and emergency response, Barangay Disaster Coordinating Councils (BDCCs), which have the responsibility for community level disaster management should be strengthened in capacity given their high responsibility, particularly, in terms of warning the communities and guiding people to safe havens. For BDCCs in remote areas, such as was the case of Barangay Punta and Pinotan, early warning systems are crucial, for an early evacuation.

f. Furthermore, the capacity of Municipal Disaster Coordinating Councils (MDCCs) and PDCCs to supporting the BDCCs is presently insufficient mainly due to the limited number of skilled staff, lack of communication facilities, lack of information on rainfall in and around the damaged areas, and impassable access roads.

g. Considering these conditions, it is important to establish support systems for evacuation and emergency response to BDCCs from MDCCs and PDCCs including capacity building of the staff of these DCCs. Furthermore, communication networks, provision of real-time data on disaster phenomenon such as rainfall, and improvement of access (roads and from the sea) must be improved.

(2) Capiz Province

Figure 3.13 shows the flooding condition of the December 2000 Flood in the Panay River Basin. About 320 km2 was inundated from a catchment area of 2,181 km2, and approximately 222,000 people were affected (including 19 dead) and property worth approximately 530 million pesos (in 2000 prices) was damaged. As there are almost no flood control facilities in the basin, at the strong request of LGUs and DPWH, a feasibility study on flood control was conducted by Japan External Trade Organization (JETRO) in 2001-2002. A priority flood control project was formulated, which is composed of river improvement actions,

a floodway in the downstream reaches, and flood forecasting and warning system covering the whole Panay River Basin.

This study team conducted site investigation and discussions with the PDCC members in Capiz Province and the RDCC Region VI mainly on the condition and problems of evacuation and response. Through the survey, it became known that although warnings and evacuation guidance were provided to people from the PDCC, MDCCs and BDCCs several times before or during floods, many people did not follow the warnings and stayed in their homes until the houses became totally or partially submerged. Based on the questionnaire survey on floods in the JETRO F/S, it was clear that about 54 % of the people in the inundated area stayed in their houses, simply moving to higher places in the house, including the roofs!. The PDCC and MDCCs sent dump tracks and boats to rescue people in the inundated areas. Furthermore, many people could not escape because the roads were also submerged.

Many of the evacuation centers (mainly schools), were also inundated, and people had to stay on the 1st floor of the schools, where space is very limited per person. Facilities and materials such as blankets, toilets, water, electricity and medicines were also insufficient. Furthermore, inundated municipalities tried to evacuate people to the evacuation centers within its municipality, but there were little network evacuation systems to permit the neighboring municipalities to help the affected municipalities. Findings on the problems of disaster management in Capiz Province are summarized in the table below.

Table 3.7 Problems of Disaster Risk Management of Capiz Province

Problems	Contents
1. MITIGATION No Mitigation Measures against Floods	• No structural measures and no forecasting measures. • No flood hazard map. • High rainfall runoff and siltation by deforestation.
Late Evacuation Actions	• No real-time rainfall and water level data available. • Insufficient guidance to people for early evacuation. • Insufficient communication facilities in remote areas (no radio communication). • People's ignorance of warnings for early evacuation. • Impassable roads to evacuation centers by flooding.
Improper Evacuation Places	• Inundated evacuation centers in low-lying areas and some of them are also inundated. • There is a problem of lacking network evacuation systems to support the severely damaged municipalities by surrounding municipalities without inundation.
2. RESPONSE Insufficient Rescue Activity	• Insufficient radio communication facilities in remote areas. • Insufficient facilities for affected people (food, water, medicine, toilet and blanket etc.). • Insufficient equipment for rescue (rubber boats, etc).
Note: Evacuation including warning is considered to be overlapping mitigation, preparedness and emergency response.	

<u>Conditions of Disaster Management Capacity in Capiz Province and Directions for Improvement:</u>

a. The Panay River Basin has very limited forest coverage, estimated at about 8 % of the basin area, which is recognized as causing problems of heavy siltation in the river channel and worsening of the

flooding condition of the basin. Although DENR has implemented afforestation programs, the total areas covered are still very limited.

b. This area has traditionally piloti type houses, which are appropriate for inundation conditions as they result in lesser property damage. However, there is now a tendency to increase the number of houses with floors on the ground level, even in the potential inundation areas, which increases the flooding risk damage.

c. In order to control or mitigate floods and flood damage in the Panay River Basin, structural measures such as river improvement and non-structural measures such as flood forecasting and warning systems are indispensable. In addition to these measures, afforestation and conservation of the river basin is important to implement with the participation of communities. Furthermore, water proofing such as constructing piloti type houses in areas with a potential to be inundated should necessarily be maintained and promoted in case of constructing new houses.

d. To reduce the impact of floods in the Panay River Basin and/or Capiz Province a well-balanced implementation of structural measures and non-structural measures is necessary. However, as like in other areas in the country, coordination between various concerned agencies for implementing these mitigation measures, such as DPWH, DENR and LGUs, is relatively weak. Therefore, it is recommended that the coordinating unit, such as the PDCC be strengthened to better coordinate concerned agencies for implementing mitigation measures within an integrated approach.

e. As for evacuation, support from the PDCC and MDCCs to BDCCs is rather well done, but sometimes it is insufficient, especially for the BDCCs in remote areas due to lack of communication facilities, impassable access, and lack of real-time information on heavy rainfall and flood water levels. To conduct early evacuation, even more support from the PDCC and the MDCCs to the BDCCs is necessary. For this purpose, improvement of communication facilities and access roads, providing real-time information about rainfall and flood water level are necessary. With regard to the improvement of the above support, capacity building for the staff of the PDCC, MDCCs and BDCCs must necessarily also be considered.

f. In addition to the above, network supporting systems from the surrounding municipalities and barangays outside of the affected areas is necessary. Through this kind of support system, it is possible to rapidly evacuate affected people to safer places in the surrounding municipalities or barangays.

3.5.2 Questionnaire Survey

To determine the condition and problems of disaster risk management, questionnaires were prepared and sent to the PDCCs. 12 of these questionnaires were filled-up directly by the Study team through discussions

with the 12 PDCCs (refer to Chapter 8). Based on the questionnaire survey on the condition of disaster management in the provinces, the following information and opinions were recorded:

(1) Constraints

a. Insufficient discharge capacity of rivers and inadequate structural measures.
b. Insufficient communication between PDCC, MDCCs and BDCCs due to lack of equipment, such as radios especially in remote areas.
c. Lack of afforestation programs.
d. Lack of hazard maps.
e. People refuse to follow warnings and evacuation instructions because they worry about leaving their property, as well as fear of living in uncomfortable conditions in evacuation centers.
f. Insufficient capacity for disaster management of PDCCs, MDCCs and BDCCs.
g. Insufficient rescue teams and equipment.

(2) Opinions for Necessary Measures for Improving Disaster Management

a. Provide and improve structural measures.
b. Implement and promote afforestation.
c. Prepare hazard and evacuation maps.
d. Develop real-time flood forecasting systems.
e. Improve communication facilities.
f. Improve evacuation centers with facilities.
g. Improve capacity building for PDCC, MDCC and BDCC members.
h. Increase community level training for disaster management.
i. Strengthen rescue teams and improving rescue equipment.
j. Establish permanent office for disaster risk management.
k. Make the national calamity fund more flexible, to include mitigation and rehabilitation.

Based on the questionnaire survey, it can be deduced that the PDCCs recognize the problems, including insufficient capacity of the rivers, insufficient structural measures and non-structural measures such as afforestation and land use including settlement management in hazard prone areas. Furthermore, PDCCs also recognize the insufficient capacity of PDCCs, MDCCs and BDCCs for disaster management, and the need to build their capacity.

3.5.3 Mechanism of Flood and Sediment Disasters

Flood and sediment mechanisms (including landslides) are summarized in Table 3.8(1) and Table 3.8(2).

Table 3.8 (1) Mechanism of Flood Disaster

Item	Description
1. Sharp Rainfall Runoff	1) Sharp rainfall runoff with higher peak discharge due to deforestation.
2. Insufficient Discharge Capacity of Rivers	1) Insufficient discharge capacity of river channels, which cause frequent overflows. 2) Siltation of river channels decreases discharge capacity of river channels.
3. Insufficient Mitigation Measures against Floods	1) Insufficient or almost no structural measures against floods in many river basins. 2) Settlement of people in flood prone areas, and almost no controls. 3) Insufficient observation stations for rainfall and water level, and almost no real-time information on heavy rainfall and flood water level to PDCCs, MDCCs and BDCCs before and during disasters, which delayed the decision for early evacuation. 4) Insufficient communication networks such as radio communication with the remote flood prone areas, which makes difficult for PDCCs and MDCCs to collect information about the conditions of potential flooding areas, and guidance to BDCCs for evacuation.
4. Insufficient Guidance to People for Early Evacuation	1) People don't heed warnings for evacuation probably for looking after their properties. 2) Final evacuation decision highly depends on BDCCs, thus there was weak support for deciding evacuation by MDCCs and PDCC for the BDCCs, which caused late evacuation of people, and people could only escape to the nearby evacuation centers within flood potential areas.
5. Insufficient Evacuation Networks under Supports of Surrounding Areas	1) People had to escape to the evacuation centers in their barangays or municipalities, which are also inundated or within the flood potential areas. This caused dangerous and uncomfortable situation in the evacuation centers, and become one of the reasons of people ignored warnings. 2) Wide evacuation networks with surrounding barangays or municipalities outside of damaged areas are insufficient.
6. Access Road Problems	1) Access roads to the flooded or damaged places or to evacuation centers were not passable due to flooding, which caused difficulty for early evacuation to safer places and delay of arrival of rescue team. 2) There are almost no alternative routes to and from the damaged sites.
7. Insufficient Rescue Equipment	1) Insufficient rescue equipment (shovels, ropes, rubber boats, trucks, etc.) delayed the rescue works. 2) Due to insufficient first aid equipment and medicines, severely injured persons could not be saved well.

Table 3.8 (2) Mechanism of Sediment (Including Landslide) Disaster

Item	Description
1. Weak Resistance of Slopes against Erosion	1) Weak resistance of slopes of mountains and hills against erosion due to deforestation, which makes higher possibility of erosion and landslide, and produces sediments.
2. Deposition of Unstable Sediment	1) Deposition of unstable sediments along the rivers and foot of slopes, which have been caused by past sediment discharge and landslides.
3. Insufficient Discharge Capacity of Rivers	1) Insufficient discharge capacity of river channels for water and sediment. 2) Siltation of river channels decreases discharge capacity for water and sediment.
4. Insufficient Mitigation Measures against Sediment / Landslide	1) Insufficient or almost no structural measures against sediment / landslide. 2) Settlement of people in hazard potential areas of sediment / landslide, and almost no controls. 3) Insufficient observation stations for rainfall and water level, and almost no real-time information on heavy rainfall and river water level to PDCCs, MDCCs and BDCCs before and during disasters, which delayed the decision for early evacuation. 4) Insufficient communication networks such as radio communication with the remote areas, which caused difficulty for PDCCs and MDCCs to collect information about the conditions of potential hazard areas of sediment / landslide, and delayed guidance to BDCCs for evacuation.
5. Insufficient Guidance to People for Early Evacuation	Same as Table 3.8 (1) 4.
6. Insufficient Evacuation Networks under Supports of Surrounding Areas	1) People had to escape to the evacuation centers in their barangays or municipalities, which are also within the hazard potential areas of sediment / landslide. This caused dangerous situation for the evacuation centers. 2) Wide evacuation networks with surrounding barangays or municipalities outside of damaged areas are insufficient.
7. Access Road Problems	1) Access roads to the sediment / landslide damaged places or to evacuation centers are not passable due to sediment / landslide, which caused difficulty for early evacuation to safer places and delayed arriving rescue team. 2) There are almost no alternative routes to and from the damaged sites.
8. Insufficient Rescue Equipment	Same as Table 3.8 (1) 7.

3.5.4 Disaster Management Capacity for Floods, Sediment and Typhoon Disasters

Disaster management capacity also relates to the damage condition of disasters. Based on the field surveys, of floods and sediment disasters in the country and the questionnaire survey, conditions and problems of disaster management capacity for floods, sediment and typhoon disasters and their directions for improvement are described as follows:

(1) Mitigation measures for floods and sediment disasters are composed of structural measures such as river improvement and sediment control facilities, and non-structural measures such as flood or sediment warning and evacuation systems, landuse management and conservation of river basins including afforestation are needed. Depending on the kinds of mitigation measures, there are various responsible agencies such as DPWH, DENR , LGUs and others. The current situation is that each agency implements mitigation measures under its responsibility with or without insufficient coordination between other concerned agencies. This lack of coordination, including budgetary difficulties, is one of the reasons causing unbalanced implementation of mitigation measures between structural measures and non-structural measures.

(2) There is a need to support the BDCCs with better communication systems, early warning and evacuation systems through the MDCCs and/or the PDCCs, , which is generally weak. In addition, training for the staff of DCCs is needed to build capacity to better judge timing and actions for warning and evacuation as needed.

(3) Relating to the above support, network supporting systems between DCCs needs to be promoted, so that safer places for the affected people can be assured with better cooperation of the surrounding municipalities and barangays.

3.5.5 Problem Areas of Floods and Sediment Disasters

Considering the frequency of floods and sediment / landslide disasters and severity of damages in terms of provincial affected persons and property damage (total and per-capita), problem areas of floods and sediment (including landslide) disasters are tentatively identified as shown in Figure 3.14 and listed in Table 3.9 below.

Table 3.9 Problem Areas of Floods, Sediment Disasters (Tentative)

Problem Area	River Basins	Existing Major Control / Mitigation Measures	
		Structural Measures	Non-structural Measures (Flood Forecasting and Warning System)
Northeastern Luzon	1) Cagayan	None	Exists
Northwestern Luzon	1) Laoag 2) Abra	None (D/D finished) None	None None
Central Luzon	1) Agno and surrounding river basins 2) Eastern rivers of Mt.Pinatubo 3) Western rivers of Mt.Pinatubo 4) Pampanga	Exists and under const. Exists and under const. Partially exists Exists	Exists None Exists
Metro Manila	1) Pasig-Laguna Bay	Exists	Exists
Bicol and Surroundings	1) Bicol and other rivers	Partially exists	Exists
Southern Luzon and Eastern Mindoro	1) Rivers in Eastern Mindoro 2) Rivers in Southern Luzon	None None	None None
South and Northeastern Panay and Western Negros	1) Panay 2) Jalaur 3) River basins in and around Iloilo City 4) Ilog-Hilabangan and others	None None None (D/D finished) Partially exists	None None None None
Leyte and Northeastern Mindanao	1) River basins in Leyte and Southern Leyte 2) River basins in northeastern Minidanao	Ormoc City: exists Other areas: none None	None None

3.6 Directions for Improving Floods, Sediment and Typhoon Disaster Risk Management

Considering the conditions of floods, sediment and typhoon disasters based on the secondary damage data of NDCC and other information from concerned agencies, and the sample field and questionnaire surveys, general directions for improving floods, sediment and typhoon disasters risk management are proposed in this sub-section. However, area-wise, concrete improvement directions will be possible if they are based on primary

data and information, which can be collected from the respective areas by site investigation and discussion with concerned agencies and people in the areas. Following is a brief discussion of the improvements proposed:

3.6.1 Providing Mitigation Measures

(1) Structural measures for substantial flood and sediment control have gradually been provided by DPWH on a basin by basin approach, and mainly for the major river basins. It is also necessary to provide structural measures in the other river basins. It is advisable to consider priority for implementing structural measures among the river basins in the above problem areas.

(2) To reduce peak rainfall runoff and strengthen resistance against soil and slope erosion of river basins, afforestation with various kinds of trees needs to be promoted for the river basins in the above problem areas.

(3) It is necessary to investigate hazard-potential areas and prepare hazard maps (or risk maps) (scale 1/50,000 and 1/10,000 etc.), and control land use including houses in hazard prone areas.

(4) Information on rainfall and water level is indispensable for planning mitigation measures as well as warning and early evacuation. Therefore, it is necessary to strengthen rainfall and water level observation networks, and make available real-time rainfall and water level data for DCCs. It is also advisable to consider priority for strengthening the rainfall and water level observation networks among the river basins in the above problem areas. Furthermore, in order to utilize the observed data as real-time data for the concerned LGUs and DCCs, it is also advisable to consider observations at key stations by the concerned LGUs (municipalities etc.) under cooperation of PAGASA and DPWH.

(5) General directions for the major structural and non-structural measures to be considered for the problem areas are proposed as follows:

Table 3.10 Proposed General Directions for Mitigation Measures for Problem Areas

Problem Area	Structural Measures	Non-structural Measures	River Basin
Northeastern Luzon	• Construct flood control structures including river improvement.	• Watershed management including afforestation. • Landuse control. • Improvement of existing flood forecasting and warning system (FFWS).	• Cagayan
Northwestern Luzon	• Construct flood and sediment control structures.	• Watershed management including afforestation. • Flood plain management. • Install FFWSs.	• Laoag • Abra • Others
Central Luzon	• Continue or implement flood and sediment control structures.	• Improve existing FFWSs. • Afforestation. • Landuse control.	• Agno • Pampanga • Rivers around Mt. Pinatubo
Metro Manila	• Improve existing flood control and drainage structures and facilities.	• Control informal settlers along rivers, flood control structures and drainage channels, and their maintenance. • Maintain existing FFWS.	• Pasig-Laguna de Bay (Pasig-Marikina) • Others

Problem Area	Structural Measures	Non-structural Measures	River Basin
Bicol and Surroundings	• River improvement. • Polders for key towns. • Utilization of existing lakes for flood storage.	• Watershed management including afforestation. • Improve existing FFWS.	• Bicol
	• Sediment control facilities.	• Install sediment warning system.	• Rivers around Mt. Mayon
Southern Luzon and Eastern Mindoro	• Flood control structures such as river improvement.	• Watershed management including afforestation. • Install FFWSs.	• Rivers in Eastern Mindoro • Rivers in Southern Luzon.
South and Northeastern Panay and Western Negros	• Flood control structures such as river improvement	• Install FFWSs • Watershed management including afforestation.	• Panay • Jalaur • Rivers in Iloilo City • Ilog-Hilabangan and others
Leyte and Northeastern Mindanao	• Landslide control structures. • Flood and sediment control structures.	• Install FFWSs. • Watershed management including afforestation with various kings of trees. • Landuse and settlement control in disaster risk areas.	• Rivers in Leyte and Northeastern Mindanao

3.6.2 Promote Early Evacuation

(1) Improve evacuation centers and stock them appropriately with supplies such as blankets, toilets, water, electricity, food and medicine. It is advisable to start developing inventory data of evacuation centers as the basis for formulating evacuation and improvement plans.

(2) Educate people to better understand and conduct early evacuation.

(3) Improve communication networks of PDCC-MDCCs-BDCCs including radio communication with barangays in hazard potential areas, and strengthen support from PDCC and MDCCs to BDCC's for deciding early evacuation. It is advisable to start developing inventory data of communication networks as the basis for formulating improvement plans.

3.6.3 Establish Supporting Networks for Evacuation

(1) Establish networks for supporting evacuation by surrounding municipalities and barangays. Using the networks, affected people that need to escape can be assisted rapidly .

(2) To establish networks for supporting evacuation, it is advisable to start investigating the existing conditions of evacuation by river basin or area, and develop a database for the evacuation conditions as a basis for formulating improvement plans.

3.6.4 Improve Access Roads and Acquire Alternative Accesses

(1) Improve access roads, so that they are not destroyed or submerged by floods or sediment, and ensure access to disaster areas and evacuation centers.

(2) If it is difficult to access the disaster struck areas by roads, alternative access to the sites or to evacuation centers needs to be established (example: from sea or river by boats).

(3) To improve access conditions, it is advisable to start investigating the existing conditions and problems of access by river basins or area as a basis for formulating improvement plans.

3.6.5 Strengthen Rescue Activities

(1) Improve communication networks to and from PDCC-MDCCs-BDCCs for immediate start of rescue actions.

(2) Strengthen rescue teams, including provision of training.

(3) Improve rescue equipment and store first aid facilities to carry out early and effective rescue.

(4) To formulate improvement plans for rescue activities, it is advisable to start investigating the existing conditions and problems of rescue activities including rescue teams, equipment and facilities.

3.6.6 Improve Disaster Management Capacity (refer to Sub-section 3.5.4)

(1) For a comprehensive risk reduction strategy, it is important to formulate integrated management systems for disaster management, covering mitigation, preparedness, response and rehabilitation with the coordination of concerned agencies including funding arrangements.

(2) Strengthen support to BDCCs from PDCCs, MDCCs,and CDCCs for disaster management including early warning and evacuation judgment and actions.

(3) Conduct capacity building of the staff concerned with disaster management activities.

3.6.7 Formulate a Framework and Master Plans for Disaster Risk Management

(1) Considering the above items 1) to 6), formulate a framework for improving disaster risk management (covering floods, sediment, typhoons, earthquake and volcanic disasters), which includes preparation of a mitigation plan; strengthening preparedness, response and rehabilitation activities. In the Framework, various kinds of menus for improving disaster risk management, to be implemented by the Government, province, city, municipality and people, as well as by financial and technical assistance from donor agencies and countries should be presented,.

(2) Based on the Framework, formulate master plans for disaster risk management basin by basin including the concerned provinces.

Chapter 4. Study on Earthquake Disaster

CHAPTER 4. STUDY ON EARTHQUAKE DISASTER

4.1 Geographical Condition of the Philippines

4.1.1 Geographical Location of the Philippines

The Philippines are located in an earthquake prone area, commonly known as the Pacific ring of fire. The country lies between two major tectonic plates, and also has many active faults within its land area. Figure 4.1 shows the Philippine Archipelago with its bounding trenches, subduction zones and active faults.

According to PHIVOLCS, the northwestward moving Pacific Plate is presently pushing the Philippine Sea Plate beneath the eastern side of Philippine archipelago at the rate of about 7 cm per year. The oceanic parts of the slower-moving Eurasian Plate are being subducted along the western side of Luzon and Mindoro at the rate of 3 cm per year. The northeastward component of the Eurasian Plate motion is now sustaining the active collision of the continental block of Palawan with Mindoro and of the northern sections of the Zamboanga Peninsula with western Mindanao. These plate interactions, displacements along the Philippine Fault Zone which decouple the northwestward motion of the Pacific with the southeastward motion of the Eurasian Plate, and movements along other active faults are the reasons for the present-day high seismicity of the Philippines.

4.1.2 Active Faults

Figure 4.2 shows the distribution of active faults with active trenches. One of the most significant active faults in the Philippines is the Philippine fault zone (PFZ) and its splays. Strong earthquakes in historical times were caused by movement of these faults. PFZ extends 1,600 km from Luzon through eastern Visayas to eastern Mindanao. Digdig fault (induced 16 July 1990 Luzon earthquake), Lupao Fault, and San Manuel Fault are the major splays of the PFZ. Other significant active faults within the Philippines are the following:

(1) Aglubang river fault, located in northeast portion of Mindoro Island which induced the November 15, 1994 earthquake. This earthquake brought many casualties through a resultant Tsunami.

(2) The Valley fault system (VFS) located 5 km east of the Metro Manila that runs north to south. This fault is assumed to have at least ruptured three times within the last 1400 years. Since it is located very close to the Metropolitan Manila, where all the economical, social, and cultural assets are assembled, the impact of a potential future eruption could cause damage that would be very destructive to the nation.

(3) Tablas fault is located on the eastern shore of the Tablas Island, and the 7.9 Magnitude of the December 1621 Panay Earthquake may have been generated by the movement of this fault.

(4) Casiguran Fault is located on the eastern edge of northern Luzon. This fault caused the August 2nd 1968 earthquake that affected building structures in the area, and also collapsed one building in Metro Manila, causing a total of 270 deaths. It also induced the Magnitude 7.3 earthquake of April 7, 1970.

(5) Other less studied faults are represented by the Mindanao fault, and Lubang fault. The former fault is a northwest trending structure located in a western portion of Mindanao, and the latter fault is a west trending structure north of Mindoro.

4.2 Geological Condition, Population and Urbanization

4.2.1 Population Increase and its Distribution of the Philippines

Figure 4.3 shows the population changes and average annual rates of increase of the Philippines, through years 1799 to 2000. Details are shown in Table 4.1. The figure shows that population growth boomed from 1960 to 1990 with a high average annual rate increase of nearly 3%. The annual rate increase has lowered recently; however, it is still high, averaging around 2.3%. The population is still considered to be increasing at the same rates and the National Statistical Coordination Board (NSCB) has estimated that the national population will be around 92 million, in year 2010 based on a projection of an annual increase of 1.87% a year.

Table 4.1 Population of the Philippines Census years 1799 to 2000

Census Years 1799 to 2000	Population	Average annual rate of increase (%)	Source of data
1799	1,502,574	-	Fr. Buzeta
1800	1,561,251	3.91	Fr. Zuniga
1812	1,933,331	1.8	Cedulas
1819	2,106,230	1.23	Cedulas
1829	2,593,287	2.1	Church
1840	3,096,031	1.62	Local officials
1850	3,857,424	2.22	Fr. Buzeta
1858	4,290,381	1.34	Bowring
1870	4,712,006	0.78	Guia de Manila
1877	5,567,685	2.41	Census
1887	5,984,727	0.72	Census
1896	6,261,339	0.5	Prof. Plehn's estimate based on census records.
1903	7,635,426	2.87	Census
1918	10,314,310	2.03	Census
1939	16,000,303	2.11	Census
1948	19,234,182	2.07	Census
1960	27,087,685	2.89	Census
1970	36,684,486	3.08	Census
1975	42,070,660	2.78	Census
1980	48,098,460	2.71	Census
1990	60,703,206	2.35	Census
1995	68,616,536	2.32	Census
2000	76,498,735	2.36	Census

Note: Population from 1799 to 1896 excludes non-Christians.
a - Includes the household population, homeless population, Filipinos in Philippine Embassies/Consulates and missions abroad and institutional population who are found living in institutional living quarters such as penal institutions, orphanages, hospitals, military camps, etc. at the time of the census taking.
Source: National Statistics Office/ through NSCB web page

Figure 4.4 shows the population density and its transition for the past 20 years. These figures present the overall growth in density throughout the Philippines, especially along the north-south corridor of the country, the so- called the S-zone. The population in the metropolitan areas, such as Metropolitan Manila, Metropolitan Cebu, and Davao has experienced especially high population increases.

4.2.2 Capital Cities in the Philippines

(1) Urbanization of the Philippines

The Philippines is one of the fastest urbanizing countries in the world, with an estimated average annual urban growth rate of 5.14% between 1960 and 1995. In 1999, the Philippines was estimated to have an urban population of 38.6 million (52% of the total population, still estimated to increase to 61% by 2010).

Most urban population growth is taking place in low density peri-urban areas. These areas are just outside of the capital city Metro Manila, in Cavite and Laguna Provinces, and in major secondary

cities. There are three dominant urban centers in the Philippines: namely, Metro Manila, Metro Cebu, and Davao, whose populations are more than 1 million each.

The population of these three regions: Capital Region (NCR; Region VII (Central Visayas, including Metropolitan Cebu); and XI (Davao Region, including Davao) total approximately 21 million, or about 27% of the total population. GRDP of these three regions is 1,949,580 million pesos, sharing approximately half of the GDP of the Philippines.

Table 4.2 Population and GRDP of NCR, Region VII, and XI

Region	Population (Year 2000)	%	GRDP (Year 2002 at 2003 price level (Mil. Peso))	%
NCR	9,932,560	13.0	1,443,269	35.9
VII	5,706,953	7.5	285,817	7.1
XI	5,189,335	6.8	220,494	5.5
Sub-total	***20,828,848***	***27.2***	***1,949,580***	***48.5***
Others	55,675,229	72.8	2,073,114	51.5
Total	**76,504,077**	**100.0**	4,022,694	**100.0**

Source: Created from NSO data

(2) Other Highly Urban Areas

Other highly urbanized areas, with their capital cities are shown in Figure 4.5. There are a total of 32 cities and municipalities in the Philippines, based on NSO data, which defines a city or municipality as one that is highly urban, having a population of more than 200,000 or has an annual income of more than 50 million pesos.

4.2.3 Population Density Distribution and Active Fault locations

Figure 4.6 shows active faults and trenches overlaid on population density of 2000 per barangay. The figure shows that the active fault is spread along the north-south corridor, along highly inhabited areas. Secondly, there are active faults along the highly urbanized areas. The NCR, could be greatly affected by the rupture of the Valley Fault System, and also by other faults of the PFZ located in the outer skirts of the metropolitan capital. Metro Cebu is located along Cebu Lineament, and other faults located near the metropolitan area that could cause devastating damage to the region in the vent of a fault rupture. Davao is also located in an area where many faults surround the city. Expected economic and social losses, should the faults to rupture, could be very large.

4.2.4 Distribution of Houses by Construction Materials

The census in the Philippines is officially held every 10 years, and includes a survey of the building construction materials of both outer walls and the roof[1]. Table 4.3 shows the number of occupied housing units by construction material, resulting from a 2000 census. The table shows that the four dominant construction

[1] Other important information included in Census are the year building, and floor area of the housing unit.

materials of the outer walls in the country are as follows: (i) concrete/ brick/ stone about 31%; (ii) wood 23%; (iii) bamboo/ sawali/ cogon/ nipa 23%; and (iv) half concrete/ brick/ stone and half wood 19%. Houses with construction materials made of concrete/ brick/ stone, and half concrete/ brick/ stone and half wood are mainly in the urban areas, while houses made of bamboo/ sawali/ cogon/ nipa are distributed in the rural areas. Wood houses can be seen in the urban and rural areas, yet more distributions are seen in the rural areas.

The "Earthquake Impact Reduction Study for Metropolitan Manila (MMEIRS), 2002-2004", sponsored by JICA, has developed a building damage function for Metropolitan Manila to estimate possible damage in the area, in the event of a disaster. The damage function was developed based on statistical information of the building damage and their structure during the 16 July 1990 Luzon earthquake. For an earthquake with an intensity of 10 on the MMI scale, the damage ratio of buildings made of wood is approximately 40%, for half concrete/ brick/ stone and half wood is 30%, while that for concrete/ brick/ stone is 27%. In addition, the damage ratio is also affected by the construction years of the structures. These values indicate that there is a great potential for significant building damage to the structures distributed throughout the Philippines.

The MMEIRS project focused on the buildings that are commonly distributed in Metro Manila. Therefore, the other typical building structures of the Philippines, the bamboo/ sawali/ cogon/ nipa, are not included. According to the July 16, 1990 Luzon earthquake statistics, damages to these buildings were visible; therefore, it could also be assumed that the damages to such types of buildings can be expected.

It is recognized worldwide from the evidence of past disasters, that many countries in seismic areas, particularly in developing countries, possess many highly vulnerable structures that may collapse under extreme seismic forces. The effects and consequences of earthquakes are varied, but a key issue is the relationship of earthquakes to unsafe structures.[2]

[2] AT RISK, Natural hazards, people's vulnerability, and disasters, Piers Blaikie, Terry Cannon, Ian Davis, and Ben Wisner, London and New York: p 168-169

Table 4.3 Number of Occupied Housing Units by Outer Wall and Roof Construction Material: 2000

Construction Materials of the Outer Walls	Total Number of Occupied Housing Units	%	Construction Materials of the Roof							
			Galvanized Iron/ Aluminum	Tile/ Concrete/ Clay Tile	Half Galvanized Iron/ Half-Concrete	Wood	Cogon/ Nipa/ Anahaw	Makeshift Salvaged/ Improvised Materials	Asbestos/ Others	Not Reported
Total	14,891,127	100.0	10,066,730	138,050	689,226	306,121	3,315,374	107,786	57,300	210,540
Concrete/ brick/stone	4,587,978	30.8	4,323,530	100,987	67,627	10,657	73,176	2,934	9,067	-
Wood	3,381,339	22.7	2,263,524	10,670	70,193	227,549	786,637	12,031	10,735	-
Half concrete/ brick/ stone and half wood	2,816,272	18.9	2,146,675	17,607	483,460	23,369	137,000	3,995	4,166	-
Galvanized iron/ aluminum	144,234	1.0	118,741	1,307	13,389	3,827	6,159	539	272	-
Bamboo/ sawali/ cogon/ nipa	3,399,180	22.8	1,044,744	5	43,592	35,625	2,238,453	15,775	20,852	134
Asbestos	8,823	0.1	5,623	1,321	493	262	-	-	1,121	3
Glass	4,895	0.0	3,594	669	260	121	-	-	249	2
Makeshift/ salvaged/ improvised materials	181,769	1.2	66,216	15	3,030	1,212	38,497	70,817	1,884	98
Others/not reported	352,293	2.4	85,186	4,536	6,466	2,948	33,167	1,129	8,634	210,227
No walls	14,344	0.1	8,897	933	716	551	2,285	566	320	76

Source: National Statistic Office (NSCB web page)

4.3 Characteristics of Earthquakes

4.3.1 Available Earthquake Information

Historical records of seismic activity for the Philippines consists initially of written accounts mostly by foreign missionaries dating back from 1599 to 1865 and later from a more reliable database derived from instrumental monitoring conducted by the Manila Observatory (1865 to 1901), which was later on reorganized as the Philippine Weather Bureau (1901 to 1942), and subsequently renamed as the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) (1948-1985). The Seismology unit of PAGASA became the forerunner of the Seismology division of the present Philippine Institute of Volcanology and Seismology (PHIVOLCS) (1986 to present)[3].

In general, earthquakes that occurred before the instrumental seismic observation started are called "historical earthquakes". The catalogue of historical earthquakes is indispensable data to the study of seismic activities in the area. Earthquakes recorded by instrumental seismic observations that started in the early 20th century to decide parameters on the events and magnitude of the events are called "instrumental earthquakes".

[3] Destructive Earthquakes in the Philippines from 1983 to 1995, compiled by Janette S. Manahan and Melchor P. Lasala, PHIVOLCS, DOST: introduction

PHIVOLCS recently developed an earthquake catalogue based on the data of other organizations and their original observation through the monitoring system developed throughout the nation.

4.3.2 Earthquake Damages

Spatial distribution of seismicity: Earthquake frequency of occurrence

Figure 4.7 shows the spatial distribution of seismicity in the Philippine region from 1608 to 1999. This shows that the seismic activity of this country is so high, such that places without any seismic activities are rare.

4.3.3 Destructive earthquakes in History

(1) Destructive Earthquake Database

A historical destructive earthquake database was developed for this study to examine the characteristics and mechanisms of earthquake damage based on an understanding of the direct damage, notable secondary effect, and the direct cause of the casualties.

The Southeast Asia Association of Seismology and Earthquake Engineering (SEASEE), Series on Seismology describes a "destructive" earthquake as 'that which renders buildings unfit for use'. Some reports give very long narratives of earthquake effects, whereas others are described simply as 'destructive'. Both explanations are included in the catalogue, because it is very difficult to understand which are "genuine destructive events" or just "seemingly destructive events". Recent data (1983 to present), however, is based on a moderate to large magnitude earthquake with shallow depth that has caused significant to heavy damages to manmade structures and has brought injuries and death to people, according to PHIVOLCS paper.

The following are the sources of this database:

a. Southeast Asia Association of Seismology and Earthquake Engineering (SEASEE), Series on Seismology, Volume IV, Philippines. Part E Catalogue of Destructive Earthquakes in the Philippines 1589-1983 pp 549-741
b. "Destructive Earthquakes in the Philippines from 1983 to 1995", PHIVOLCS
c. "List of Destructive Earthquakes in the Philippines", PHIVOLCS web page
d. "Major and Minor Natural Disaster Incidents 1980-2003", NDCC

SEASEE also describes that the information includes data that was taken from catalogues of Significant Philippine Earthquake for different time periods, newspaper reports, various earthquake bulletins and special reports on destructive earthquakes: for example, UNESCO reports and EERI reconnaissance reports. Therefore, the catalogue is compiled with scientific data and of written documents. Other sources listed above are also compiled in a similar manner.

The database is designed to include as much information as possible on the following:

a. **Date:** Date of the earthquake
b. **Location:** Longitude and Latitude
c. **Surface Magnitude:** Size of the Surface Magnitude (Ms)
d. **Intensity:** Modified Melicalli Intensity scale applied for the earthquakes 1599 to 1985, Applied Rossi-Forel Intensity scale applied for earthquakes 1985 to 2003
e. **Causalities:** Numbers dead, injured, missing
f. **Damages:** The direct damage observed
g. **Notable secondary phenomenon:** Notable secondary phenomenon observed
h. **Direct cause of casualties:** The cause for death and injury

A total of 59 earthquakes were selected for further studies, which have minimum information on the location and the written description of the damages observed.

(2) Return period of the destructive earthquakes

Roughly, average occurrence of destructive earthquakes nationwide is every 6.8 years. There are 7 of these destructive earthquakes in the last 400 years, with large damages defined as those with deaths of 100 and casualties of 500 people or more. These devastating earthquakes occurred at 57.7 years return period.

(3) Destructive Earthquake Locations

Figure 4.8 shows destructive earthquake locations. The labeled earthquakes are the seven devastating earthquakes that caused deaths of more than 100 or injuries of 500. The label and size of magnitude show that the size of magnitude does not always proportionally relate to the size of damage.

4.4 Existing Countermeasures and Plans against Earthquake Disasters

4.4.1 Structural measures

(1) Existing Seismological and Volcanological Stations in the Philippines

As shown in Figure 4.9, PHIVOLCS maintains 64 seismological stations of which 34 are manned and 30 un-manned. PHIVOLCS also maintains volcano monitoring stations: 6 volcano observatories with at least 3-sensor seismic radio-telemetry, 2 volcanoes with 1 sensor seismic radio-telemetry and 2 volcanoes with nearby manned seismic stations. The ultimate goal of PHIVOLCS is to increase the numbers of seismological stations to 100, a number that is still not enough to manage earthquake data effectively.

(2) Database of Historical Record of Earthquake

Historical data accumulated in PHIVOLCS basically came from two resources: one is historical records of earthquakes kept since 1608; the other is instrumental earthquake records since 1907. Although

earthquake catalog data is available, the database on damages has not yet been effectively constructed. The Office of Civil Defense (OCD) is the agency responsible for accumulating these data; however, the casualties, damages, and estimated loss caused by the earthquake have not yet been stored in an efficient manner.

4.4.2 Non-structural measures

(1) *Hazard Maps and Dissemination Activities*

PHIVOLCS's principal mandate is to assist the country avert disasters and mitigate damage from geotectonic processes. Under this mission, PHIVOLCS has prepared earthquake hazard maps on a national scale for PGA, earthquake induced landslide (Figure 4.10), liquefaction (Figure 4.11), active faults and a map showing the tsunami prone shorelines in the Philippines. MGB also produced geo-hazard maps, including flood, landslide, and tsunami. However, there are duplications when MGB includes earthquake and volcano hazard maps, such as PGA maps to their products. There once was confusion among the public, caused by the discrepancy between Pinatubo hazard maps produced by PHIVOLCS and MGB separately. Such overlaps need to be prevented, to avoid public confusion.

For future hazard map development for earthquakes, PHIVOLCS will follow the procedure of hazard map development studied by USGS/USAID in 1994 (ERP project). Areas of focus for hazard maps as the next stage are summarized in Table 4.4.

Tsunami hazard assessment is also planned.

Table 4.4 Areas of Focus for Regional Hazard Map Development

Region	Cities
Northern Luzon	Laoag
	Baguio
	Vigan
	Dagupan
Luzon Economic Zone	CALABALUZON
	Subic
	Clark
Bicol	Legaspi
	Alabay
Visayas	Panay
	Leyte
	Bohol
Mindanao	Davao
	Cagayan de Oro
	Butan
	Surigao

(2) Public Awareness and Involvement

PHIVOLCS has three major activities for public awareness and involvement, mainly targeting barangays. These are funded by international donors and the Philippine government. Details are described in Table 4.5. They are planning to continue expanding these activities, budget permitting.

Table 4.5 List of Public Awareness and Involvement Projects

Program	Fund	Description of the Program	Targeted Area
Crustal Stress community Awareness Network: CSCAN	UNDP	Networking of the information at the local level to monitor and prepare for natural disasters. Workshops, risk mapping, etc Targeting Local officials, barangay officers	Aparri, Santa, Ilagan, Baler, Infanta, Lingayen, Quezon city, Marikina City, Batangas, Sorsogon
CBDM towards mobilizing women	gov't fund (gender+dev't fund)	Started in 1995, vulnerability and capability analysis for women, utilizing the community women leaders, and members for disaster management involvement in volcanoes and earthquakes	Taal (Tagaytay)(95), Kanlaon (96), Hibok-hibok(97), Quezon city (98), Kanlaon (Panay)(99-00), Hibok-hibok(01), Employee (02/03), Bulusan (Bicol) (04)
Volunteer volcano observers training	Gov't funded (93-97)	Networking of the information at the local level to monitor and prepare for volcanoes through distribution of the checklist and training of its usage to the community members.	Taal, Kanlaon, Hibok-hibok, Mayon, McKinley, Sursogon

Source: Based on the hearing from PHIVOLCS

4.5 Mechanism of Earthquakes, Safety Degrees (Risks) and Problematic Areas

4.5.1 Primary Analysis of Earthquake Damages from Database

(1) Direct damages

There are mainly three major direct damages observed from the information available. These relate to ground damage, building damage, and infrastructure related damages. Simplifying the type of damages, ground damages generally create fissures, sand boils, and ground subsidence, according to the data. For building damages, these are categorized in one of three types: many destroyed totally, some destroyed - partially damaged, or no significant damage. Infrastructure related damage started to be seen after around 1940. The infrastructure related damages are classified into three types: pipeline/ water supplies, railway/road/bridges, and communication.

Table 4.6 shows the summary of notable direct damage, from the 59 earthquakes.

Table 4.6 Summary of Direct Damages

Type of damages	Number
Ground damages	
Fissures	30
Sand boils	4
Ground Subsidence	5
Building Damages	
Many destroyed totally	25
Some destroyed/ partial damages	23
No big damage	4
Infrastructure Damages	
Pipeline/ water supplies	4
Railway/ roads/ bridges	9
Communication devices	3

Note: Summary of direct damages may duplicate in one earthquake
Source: Developed from the destructive earthquake database, Study team

Figures 4.12, 4.13, and 4.14 show the distribution of epicenters of earthquakes that caused ground, building, and infrastructure related damages.

(2) Destructive earthquakes with notable secondary phenomena/ damages

Studying the available information, it can be concluded that there are mainly four types of phenomena that are induced by an earthquake: namely, tsunami, landslide, liquefaction, and aftershocks. For some phenomena, large damages resulted. It should be noted that the secondary phenomena for tsunami and landslide is notable throughout the Philippine history of destructive earthquakes. Figures 4.15, 4.16, 4.17, and 4.18 show the distribution of destructive earthquakes that caused secondary damage.

Table 4.7 Summary of Notable Secondary Phenomenon/ Damages

Type of damages	Number
Tsunami	15
Landslide	17
Liquefaction	5
Aftershocks	14

Note: Notable secondary phenomenon may duplicate in one earthquake
Source: Developed from the destructive earthquake database, Study team

(3) Direct cause of casualties and its impact

Table 4.8 shows the number of direct cause of casualties. This is derived from the 59 sample earthquakes selected for this study. It is clear that the direct cause of casualties is mostly from building collapse, although tsunamis and landslides cannot be ignored. Damage from the aftershocks is also significant.

Table 4.8 Summary of Direct Cause of Casualties

Type of damages	Number
Building Collapse	37
Tsunami	9
Landslide	7
Aftershock	9
Others (Heart attack, electric shock)	2
None or not clarified	14

Note: Direct causes of casualties may be multiple in one earthquake
Source: Developed from the destructive earthquake database, Study team

Table 4.9 shows the seven destructive earthquakes with large casualties where there were more than 100 deaths or casualties more than 500. The 17 August 1976, Moro Gulf earthquake caused many deaths and missing persons from the resultant tsunami. According to the surveys during the event, the tsunami was responsible for 85% of deaths, 65% of injuries, and 95% of those missing[4]. It is said that the earthquake was the largest tsunamigenic earthquake to have occurred in Mindanao in the last two decades, in terms of destruction of property and loss of lives. The 14 November 1994 earthquake in Oriental Mindoro was also tsunamigenic. The tsunami accounted for the majority of casualties and brought significant damage on the northern shoreline communities of Mindoro. Approximately 63% of deaths were caused by the tsunami. It can be concluded that if a tsunami is generated, the casualties will be large. The recent experience in Indonesia, December 26, 2004 more significantly illustrates this point. Other effects of the earthquake can equally be illustrated by that which occurred in 1918 in Southern Cotabato, which resulted in major direct causes of casualties from land slides and tsunamis. Historical data indicates that more than 100 people were killed by the landslides. Landslides could cause a number of casualties in a limited area where the phenomenon occurs.

[4] http://www.phivolcs.dost.gov.ph/Earthquake/1976MoroGulfEQ/moro76.html

Table 4.9 List of Destructive Earthquakes with Large Casualties

Date	Ms	Intensity	Location of large damage	Casualties				Direct cause of casualties			
				Death	Injuries	Missing	Total	Building Collapse	Tsunami (wave of lake incl.)	Land slide	After shock
1863/6/3	6.5	10	Manila	876+	387+	n.a.	1,263+	x	x		
1918/8/15	8.3	10	S. Cotabato	100		n.a.	unknown		x	x	
1955/4/1	7.5	10	Lanao	291	713	n.a.	1,004	x	x		
1968/8/2	7.3	9	Casiguran	270	600	n.a.	870	x			
1976/8/17	7.9	10	Moro Gulf	4,791	9,928	2,288	17,007	x	x		
1990/7/16	7.8	8	Cabanatuan	1,283	2,786	321	4,390	x		x	x
1994/11/14	7.1	7	Oriental Mindoro	83	430	8	521	x	x		

Note: Shadowed represents the major cause of death.

Figure 4.19 shows the direct causes of casualties in destructive earthquakes and their impact. The epicenter, illustrated by the label, shows the 7 devastating earthquakes. This figure also describes that the building collapse and/or tsunamis are a major cause of large casualties.

(4) Fire Spreading Possibilities

Although the catalogue of historical earthquakes did not show much damage from fire, recent records of world earthquakes indicate that even modern cities are vulnerable. An example, is Kobe, in Japan, which was struck by an earthquake in 1995 with the result that approximately 6,200 buildings burnt, despite the occurrence being very early in the morning. The fire was caused by a broken electricity line, and it spread out through the urban structure – many linked buildings, of which most were flammable.

According to the Bureau of Fire Protection (BFP) through the MMEIRS study, fire outbreaks in Metropolitan Manila are large, approximately 4,000 outbreaks per year. 40% of the cause is electrical related, due to the leakage of inadequate wiring or lack of fail-safe devices. Fire outbreaks usually spread through densely constructed wooden houses. Referring to Table 4.3 shown in the previous section, houses with wood, half concrete/brick/stone and half wood, and bamboo/sawali/cogon/nipa comprise approximately 64% of the total buildings in the Philippines.

Gas distribution systems using underground pipelines are not common in the Philippines, because households in the Philippines use the cylinder type LPG, which are oftentimes unstably placed inside the house. In this state, there is a high possibility of the cylinders rolling over and catching fire in an earthquake.

The MMEIRS study concluded that fire damage comprises a large portion to the total damages expected. Calculation in the study shows that the fire spreading will cause 9% of total casualties and 36% of total heavily damaged buildings. Therefore, fire is another important issue to consider.

(5) Earthquake damage mechanism in the Philippines -1

In conclusion, Figure 4.20 explains mechanisms of earthquake occurrence in the Philippines, to better clarify the analytical process carried out. When the earthquake occurs, the ground ruptures, and buildings and infrastructure will be damaged by the ground shaking as the direct damage. Tsunami, landslide, liquefaction, and fire may develop within a small time lag. Largest and most frequent damages to be expected are the building damage; however, if tsunami or fire develops, it will also be a big threat that can cause both casualties and property damages.

4.5.2 Detailed analysis on sample areas

Background

Interview and questionnaire surveys were conducted to identify the existing situation of the PDCCs. The survey was carried out following two tracks: 1) through the key informant survey on the 12 selected disaster prone areas, recorded by the consultants; and 2) through questionnaires disseminated through the NDCC.

As for the earthquake, 3 areas (namely Baguio, Antique, and Mindoro Oriental) were selected for the key informant survey. These areas suffered the devastating damages during the July 16, 1990 earthquake, November 14, 1994 earthquake, and June 14, 1990 earthquake respectively.

Of the 17 remaining questionnaires, 8 of the provinces sampled, had recently experienced earthquakes.

4.5.3 Findings

(1) Areas with large earthquake damage have introduced strategies to mitigate property damage. For example, Baguio city revised building design standards, and integrated the building height and environmental development controls. They have allowed only a maximum of 6-storeys within the CBDand a maximum of 12 floors within industrial zones. Mindoro Oriental is also enforcing a strict policy, requiring buildings to be earthquake proof, and in addition, is restricting building heights to a maximum of 3 storeys. Also, land use restriction for buildings near the faults and coastlines.

(2) The constraints for continuous earthquake disaster management activities are the lack of human resources and enforcement of restrictions.

(3) Training for PDCC/ MDCC/ and BDCC personnel is additionally highly demanded preparatory measure by the PDCCs. However, PDCCs are not capable of implementing this training because of lack of funds. Identification of risk areas is another topic of concern for the areas that experienced earthquakes.

(4) Not many mitigation measures for earthquakes have been taken up. However, the areas that experienced earthquakes are at least making an effort to enforce land use control and construction safer buildings.

(5) Important concerns by the PDCC/ MDCC for continuous earthquake management are to establish permanent "disaster management structures". Commonly, disaster management involves extensive volunteering, resulting in some officers being over-burdened by the additional work. A permanent response and management structure developed through legislative actions, like that in Albay is desirable. The Albay disaster management unit is permanent, with an allocated budget, such that, it is not depended on calamity fund releases.

4.6 Disaster Management Capacity for Earthquake

In the Philippines, the Philippine Institute of Volcanology and Seismology (PHIVOLCS), attached to the Department of Science and Technology (DOST), is the established national research institution and responsible for the observation of volcanic activity and earthquakes. This institution conducts observations of earthquakes and volcanic activities all over the nation and it possesses a nationwide seismograph network. Recently, through technical cooperation with the Japan International Development Agency (JIDA), PHIVOLCS has been expanding this nationwide monitoring system for volcanic activity by introducing more seismographs. If an earthquake is observed, PHIVOLCS is obligated to report the location of the epicenter and its intensity to DOST and Office of President.

Also for volcanic activities, PHIVOLCS is obligated to conduct the same kind of observations as for earthquakes, and to report to relevant agencies when it detects unusual conditions.

With the current equipment, it takes more than ten minutes to calculate the epicenter and its intensity; with further technical improvements it will be possible to conduct this calculation within a few minutes. PHIVOLCS has the basic intention to strengthen information collection and dissemination capability based on regular observations of earthquake and volcanic activities including tsunami warning.

In the event of an earthquake disaster, BDCC and MDCC staff in the disaster stricken areas, as well as experts from relevant public agencies are obligated to collect appropriate information on disaster conditions and report them to relevant upper level agencies. However, past experience shows that for large-scale disasters, staff and experts in charge at district/municipality level tend to have serious difficulties in checking the damage conditions in the area and responding to the emergency. This is mainly due to accessibility difficulties regarding damage information collection and transfer.

In general, a survey on the actual conditions of damage is conducted using aerial photography of the disaster area, using detailed topographic maps as basic data. Based on the data and site surveys, the amount of damage is estimated and a restoration plan is prepared. However, in the Philippines, detailed procedures for damage survey are not adequately sophisticated, and presently, the MDCC and BDCC experts only visit the damaged area to inspect and visually estimate the amount of damage. This damage information is transferred to

upper organizations such as RDCC, PDCC to NDCC after the necessary discussions by municipality administrations.

Another problem is that feedback is not given on the report contents. In addition, detailed data and materials such as contour maps, etc are not well enough prepared to support feedback.

In case of a large-scale disaster, it is impossible for the government itself, without assistance from foreign countries, to conduct and complete emergency rescue operations and restoration activities.

For the preparation of detailed damage assessment and cost estimation for reconstruction related to large-scale natural disasters, such as Mt. Pinatubo eruption, as an example, the international society greatly supported the Philippine government both technically and financially.

4.7 Strategy Development Directions for Earthquake Impact Mitigation in the Philippines

4.7.1 Direction of Measures to take for the Mitigation of Earthquake Impact

Based on the clarified mechanism in Figure 4.20, there are three types of damages that may cause large casualties, and there are four types of damages that may cause large property damages. Building damage will cause large casualties, tsunami, the largest casualties; fire spread may also cause large casualties - depending on the urban structure. In addition to these three damages that may cause large casualties, liquefaction is another cause that may produce large property damage. Other causes of casualties and property damages are landslides, infrastructure/lifeline damages from ground shaking. These types of damages are the focal items for the earthquake disaster mitigation measures.

Table 4.10 shows the direction of measures to take for the mitigation of earthquake impact. There are 6 types of disasters that need impact mitigating measures; the priorities are on the ones with large casualties and property damages, as described in Figure 4.20. According to the size of the impacts, building damages due to ground shaking have the utmost urgency to take some measures; tsunami, and fire, next, and infrastructure damage due to ground shaking landslide, liquefaction, and ground rupture follow. In addition to these mitigation measures to take, there is need for research of earthquakes. Identifying the location of the most active faults will contribute to the preparedness of the region.

Table 4.10 Direction of Measures to take for the Mitigation of Earthquake Impact

Key Issues	Characteristics of Damage	Measures for Mitigation
Building Collapse	- There is no time to be warned/ predicted for the earthquake (No time for preparation) - Vulnerable buildings, that are old or structurally weak collapse first - Majority crushed to death within an hour	**Building collapse mitigation** - Prevention of building collapse (Research and dissemination) - Area Strengthening on buildings and disaster management. * These measures shall be taken from highly urban areas
Tsunami	- There are few minute or longer to escape from the seashore, if tsunami is warned or its impact understood. - Wide area along the seashore will be affected, depending on the size of the wave.	**Tsunami damage mitigation** - Hazard map development (Two levels) - Warning and monitoring system - Evacuation measures (Warning system and awareness)
Fire	- People lose lives under the crushed house, if they cannot escape from burning buildings	**Fire damage mitigation** - Area Development to enhance Fire proofing - Community empowerment on rescue operation and awareness of fire outbreak prevention
Liquefaction	- Buildings and properties in the liquefaction area will be damaged or affected.	**Liquefaction induced property damage mitigation** - Develop hazard map on liquefaction potential - Minimal land use control - Measures for newly constructing buildings
Landslide	- Landslide occurs where the slope are steep; Geophysical condition is not good. - Higher vulnerability with heavy rain/ rainy season	**Landslide damage mitigation** - Hazard mapping (Steep areas) - Land use regulation on the hazardous areas
Infrastructure/ lifelines	- Infrastructure/ lifeline damage will mostly affect the emergency response process	**Infrastructure damage mitigation** - Strengthening on infrastructures and lifelines that is important to emergency response - Securing emergency road network
Aftershock	- Additional corruption of buildings - There is time to escape from the vulnerable buildings	**Preventing additional casualties from aftershock** - Assessment of important public buildings - Evacuation of unsafe buildings
Active fault	- In addition to all measures that could be taken beforehand, some faults should be identified as threatening	**Research on earthquake** - Research on locating the active faults - Evaluate activities of faults located near the metropolitan/ large cities

4.7.2 Building Collapse Mitigation Measures

Building collapse mitigation measures, although very difficult, will be among the most effective measures to take to reduce the number of casualties and property damage. The proposed strategy for this measure is the study of methodologies for strengthening the four dominant building types distributed in the Philippines. Along with the study results, the methodologies will need to be disseminated to the public. These will be effective especially if implemented in the populated areas. Some studies on financial support systems for retrofitting or constructing earthquake resistant buildings may need to be considered.

This strategy may be implemented through area re-development procedures or subdivision development procedures as well. Moreover, since slum and illegal settlement areas are estimated to have the concentration of building collapses, these areas may be strengthened through the programs of NHA, such as social housing policy.

4.7.3 Tsunami Damage Mitigation Measures

As described earlier, tsunamis could produce tremendous damages to the area, if they occur in a populated coastal area. Historical Philippine earthquake damage data shows that the largest number of casualties were due to tsunamis. To prevent such a high number of casualties, focus will need to be on the evacuation of people living in the tsunami vulnerable area. This mitigation measure will be developed in two steps: first by creating a hazard map to better understand the vulnerable areas, and then conducting public awareness with the developed hazard map. The public living in the vulnerable areas need to understand that they are at risk, and an earthquake could produce tsunamis that will affect many people.

Strengthening of monitoring systems on the tide level observation is additionally recommended as a mid term goal.

4.7.4 Fire Damage Mitigation

Fire spreading in populated areas is another threat to the modern cities. Although historical data did not show much damage from fire, recent world earthquakes have shown that densely populated areas with wooden houses have suffered large fire damage. In addition to area development to enhance fire proofing, community empowerment for rescue operations and increasing awareness on fire outbreak prevention is recommended.

Together with these community operations, fire suppression efforts are very important. Locating hydrants and water tanks within the high flammable areas is recommended. In some areas, existing hydrants are not maintained well and are thus out of service. These not so well-maintained resources need to be taken into consideration for full usage.

The promotion of fireproof districts through the introduction of urban fireproof development is another recommendation. The idea is to develop many plots in urban areas that introduce networks of firebreaks. Axis of firebreaks will be composed of some geographical features, such as rivers, wide roads, and parks; supporting firebreaks will be fire resistant buildings, open spaces, and plants. Parks can be utilized for evacuation purposes, and location of the water resources will be noted. Such methods shall be introduced to highly flammable areas.

4.7.5 Mitigation of Earthquake induced Landslide

Earthquake induced landslides basically occur in steep areas with soft soil conditions, and have a higher possibility of occurring if associated with rain. Reducing vulnerability can only be achieved through land use regulation in the hazardous areas. For the development of regulations, hazard maps for landslides are indispensable.

4.7.6 Measures for Liquefaction Potential Areas

Although liquefaction will generally not cause large casualties, its impact on building and property damage is large. To avoid and or reduce the effects from liquefaction, construction of buildings and property development in vulnerable areas is most effective. To identify such conditions, hazard maps identifying potential areas for liquefaction are necessary. Large scale hazard maps are useful to understand the detailed conditions. Minimal land use control and/or structural measures are recommended for the identified liquefaction potential areas.

4.7.7 Infrastructure/ Lifeline Damage Mitigation

Infrastructure and lifeline damage will directly cause casualties and property losses, and it will also weaken the emergency response and recovery. As for the emergency response, securing the emergency road network is very important within the region. Securing public facilities that will function as an emergency response center is another important factor for smooth emergency response. Also, reducing the lifeline damage will strengthen capabilities for emergency response and smooth recovery as well.

4.7.8 Additional Loss Prevention from Aftershock

Analysis of the historical earthquake damage shows that there is potentially also a large loss from aftershocks. To prevent additional losses, public facilities, which are used as disaster management centers or evacuation centers, need to be assessed for safety for immediate occupancy. The public needs to understand that there are possibilities of aftershocks capable of producing additional large damages. The public needs to be informed about aftershocks and damage possibilities through public education programs.

4.7.9 Research on Earthquake

In addition to implementing possible measures to mitigate earthquake damage, research on earthquakes needs to be continued. If faults throughout the nation could be located as the ones to pay most attention to, preparedness will be more efficient. There are mainly two directions for research: 1) research on locating the active faults nation-wide; 2) as well as the evaluation of activities of faults located near metropolitan/ large cities.

Chapter 5. Study on Volcanic Disaster

CHAPTER 5. STUDY ON VOLCANIC DISASTER

5.1 Background

Geologically, the Philippine islands were formed by active tectonic movement. Subduction by the China Sea Plate and the Philippine Sea Plate from eastern and western sides generated a complex of skeleton islands.

Many fault lines and volcanoes are distributed all over the country. Geological activities such as earthquake, volcanic eruption and fluvial processes including erosion and sedimentation formed the present landforms of the Philippines.

At present, 22 active volcanoes are identified in the country. Famous active volcanoes are Mayon, Taal, Canlaon, Hibok-hibok and Pinatubo. Past eruptions of these volcanoes have resulted in pyroclastic flow, lava flow, together with volcanic gas and ash falls that have caused direct damages to buildings and local people living around the volcanoes. Moreover, after the eruption, mud flows known as "lahar" occurred along the main river channel and large amounts of mud were transported to downstream areas of the rivers as part of the sedimentation processes. These mud flows buried agricultural land, villages, roads and forests. Their effects are long lasting.

Necessary information on potential volcanic hazards should be prepared and disseminated to relevant LGUs, barangays and communities using proper measures in order to reduce/mitigate volcanic hazards.

5.2 Distribution of Volcanoes in the Philippines

According to the definition by PHIVOLCS, the research institute for earthquake and volcanoes in the Philippines, a volcano is designated as active if it has erupted within past 10,000 years, is geomorphologically young as suggested by low degree of erosion and dissection, presence of young vent features and may lack or have very little vegetation cover. In total, 22 volcanoes are classified to be in this category. These are distributed in the northern, central and southern part of Luzon, Negros, and Mindanao Island. PHIVOLCS also identified 27 potentially active volcanoes.

Locations of these active and potentially active volcanoes are shown in Figure 5.1 and the names are listed in Table 5.1 and Table 5.2. Figure 5.2 shows the number of active and inactive volcanoes per province.

In addition to these volcanoes, another 281 inactive volcanoes are identified in the Philippines.

Table 5.1 List of Active Volcanoes

No	Name	No. of Historical Eruptions	Date of Last Eruption/ Known Activity	Location
1	Babuyan Claro	4	1917	Babuyan Island
2	Banahaw	3	1843	Laguna-Quezon Province
3	Biliran	1	1939	Biliran Island
4	Bud Dajo	2	1897	Jolo Island, Sulu
5	Bulusan	15	1994-1995	Sorsogon
6	Cagua	2	1907	Cagayan
7	Camiguin de Babuyanes	1	1857	Bayuban Island Group
8	Canlaon	25	1996	Negros Oriental
9	Didicas	6	1978	Bayuban Island Group
10	Hibok-hibok	5	1948-1953	Camiguin Island
11	Iraya	1	1454	Batan Island, Batanes
12	Iriga	2	1642	Camarines Sur
13	Leonard	10	1800 years ago by Carbon 14	Davao
14	Makaturing	10	1882	Lanao del Sur
15	Matutum	1	1911	South Cotabato
16	Mayon	47	2001	Albay
17	Musuan (Calayo)	2	1867	Bukidnon
18	Parker	1	1640	South Cotabato
19	Pinatubo	3	1991	Zambales-Tarlac-Pampanga
20	Ragang	8	1916	Lanao del Sur-Cotabato
21	Smith	5	1924	Babuyan Island
22	Taal	33	1977	Batangas

Source: PHIVOLCS

Table 5.2 List of Potentially Active Volcanoes

No.	Name	Location
1	Apo	Davao
2	Balut	Davao
3	Cabalian	Southern Leyte
4	Cancajang	Leyte
5	Corregidor	Bataan
6	Cuernos De Negros	Negros Oriental
7	Dakut	Sulu
8	Gorra	Sulu
9	Isarog	Camarines Sur
10	Kalatungan	Bukidnon
11	Labo	Camarines Sur
12	Lapac	Sulu
13	Malinao	Albay
14	Malindig(Marlanga)	Marinduque
15	Mandalagan	Negros Oriental
16	Maripipi	Leyte
17	Mariveles	Bataan
18	Natib	Bataan
19	Negron	Zambales
20	Parang	Sulu
21	Parangan	Sulu
22	Pitogo	Sulu
23	San Cristobal	Laguna-Quezon
24	Silay	Negros Oriental
25	Sinumaan	Sulu
26	Tukay	Sulu
27	Tumatangas	Sulu

Source: PHIVOLCS

5.3 Volcanic Disasters

5.3.1 Type of Volcanic Disasters

Typical phenomena associated with volcanic eruptions are pyroclastic flow, lava flow, fall of ash, gravels and scoria. Continuous ejection of sulfuric gas will also cause damage to people, plants and animals. These volcanic activities cause large disasters in the surrounding area of volcano. Depending on the type and the magnitude of the eruption, damage by pyroclastc flow is the most frequent and the severest, because of the speed at which the pyroclastic flow moves down the mountain slope - an estimated speed of 50 m/sec. Ash falls also extensively affect the area around the volcano. Thick layer of ash destroys houses and agricultural products.

Lava flow causes direct damages to houses and infrastructures; however, the speed of lava flow is always slow and human casualties will be limited.

After a large eruption of a volcano, huge volumes of volcanic materials such as ash, scoria and gravel will be deposited on the mountain slope and surrounding areas. These deposits cause secondary damage, especially in the rainy season, when these volcanic materials are washed away in the form of mud flow called lahar. Lahar may flow down along the river channel burying valleys, forests, agricultural land, settlement area, roads and bridges. A severe lahar disaster was caused in Mt.Pinatubo area after the huge eruptions in 1991. Mt. Hibok Hibok in 2001 also suffered from very severe lahar disasters due to heavy rainfall.

5.3.2 History of Volcanic Disasters

Six very active volcanoes out of 22 listed as active are designated based on recent eruptions. These very active volcanoes are Pinatubo, Taal, Mayon, Bulusan, Canlaon and Hibok Hibok. Historical data on these volcanoes are shown in the Table 5.3 and based on this table, the history of volcanic eruptions and hazards are briefly described.

Table 5.3 History of Six very Active Volcanoes

Name	Elevation (m)	Base (km) Area (km2)	No. of Historical Eruptions	Date of Last Eruption	Largest Eruption	Population (No. of Barangay)	Type of Volcano
Pinatubo	1,745m	N.A.	3	1991	1991 June Total 932 death	N.A.	Compound volcanoes
Mayon	2,462m	250km^2 62.8km	47 (Since 1616)	2001	1814 Feb. 1 Total 1200 death	N.A.	Strato
Taal	311m	23km^2	33 (Since 1572)	1977	1911 Total 1334 death	5,000 Volcano Island	Tuff cone
Bulusan	1,559m	400km^2	15 (1852, earliest record)	1994-1995	N.A.	60 Barangays 6 Municipalities (within 4 to 10 km)	Composite
Canlaon	2,345m	30km	25 (1866, earliest record)	1996	N.A.	N.A.	Strato
Hibok-Hibok	1,500m	290km^2	5	1948-1953	1952 500 death	68,000	Composite

5.3.3 Pinatubo

Mt.Pinatubo is located along the border area of Zambales, Tarlac and Pampanga Provinces. Historically, three eruptions were recorded by PHIVOLCS. However, two eruptions before 1991 were identified based on the interpretation of geological, geomorphological characteristics and dating of carbon 14.

In April 1991, minor shakes and steam eruptions were observed by a nun who was working as a volunteer for mountain people in Mt.Pinatubo. This information was relayed to PHIVOLCS the next day. An international monitoring team was formed which involved USGS with the coordination by PHIVOLCS. Many seismographs were setup on the foot slope area of Mt.Pinatubo. At this time, no pre-volcanic activities were observed.

In early June 1991, volcanic earthquakes were observed frequently and these occurrences strongly suggested a near term eruption. Based on the recommendation by PHIVOLCS, the government asked the local people who are living within 10 km radius from the summit to evacuate as soon as possible.

On June 11, 1991, the infamous and largest eruption of Mt. Pinatubo took place. A huge cloud of volcanic eruption reached more than 20,000 meters above sea level and ash fall was observed in extensive areas of western central Luzon. Manila international airport was closed for one week because of ash fall.

Mt.Pinatubo was 1,745 meters in height before the eruption, but after the eruption, the height of the mountain top dropped to about 1,400 meters after the upper part was totally broken off by the strong eruption. The shape of the mountain was drastically changed and a huge crater was formed. Broken parts of the mountain body and volcanic materials were deposited on the mountain slope area and also in the surrounding area.

The rainy season was starting at the same time in the Philippines and heavy rain fall in the mountain area washed away the newly made volcanic deposits in a form of mud flow called lahar. In the eastern part of Mt.Pinatubo, especially in the Province of Tarlac and Pampanga, rivers were totally buried by sediment and this caused inundation. Roads and bridges, productive agricultural land and urban areas were also buried. Thickness of these sediments in some parts was measured at more than 5 meters. The weight of the lahar and water caused such a heavy load on houses that many collapsed.

As a result of these disasters, 77,000 hectares of farm lands were buried and 250,000 families had to abandon their homes, and 112,000 houses were totally or partially destroyed. Including public infrastructure damage, total loss was estimated at 10.6 billion Pesos (US$ 366 million).

Reconstruction and rehabilitation works for people in the affected area started immediately after the eruption. Construction of river dykes and sabo-dams for controlling lahars have been continuing up to the present.

This fact indicates that the rehabilitation of large-scale volcanic disaster needs a long time to implement and has a huge cost involved.

5.3.4 Mayon

Mayon volcano is located in Albay Province in southern Luzon island. Legazpi city is the largest urban center in the area. The height of the mountain is 2,462 meters above sea level. Mayon is a world famous active volcano for having an almost perfect cone shape.

Volcanic activity is very active and is recorded to have erupted 47 times since 1616. The type of eruption of Mt.Mayon is classified into three categories, the first being the Vulcan type, which has made up the majority of the eruptions – at least 80%. The second type is the Stromboli type, which accounts for up to 19% of the eruptions. The third type, the Plinian type has only been recorded once in 1814, and has been, ironically, the most destructive.

These type of volcanic eruptions with accompanying lava flow, ash fall and pyroclastic flow always cause sizable damage to the surrounding area. A recent record of eruption and damage is summarized in the following table.

Table 5.4 Recent Record of Eruption and Damage of Mayon Volcano

Year	Eruption Type	Damage	Death/Affected Population
1968	Vulcan	Pyroclastic flow Lahar	6/?
1978	Stromboli	No Pyroclastic flow Lahar	40/8,000～15,000
1984	Vulcan	Pyroclastic flow Lahar	0/16,000～73,000
1993	Vulcan	Pyroclastic flow	70/60,000

Volcanic eruptions are difficult to predict. For the 1814 eruption of Mt. Mayon, pre-eruptive phenomena such as volcanic earthquake or minor smoke ejection were observed only one day before the eruption, showing the degree of difficulty in predicting an eruption. As a result, a total of 1,200 persons were killed and many villages were destroyed. To control the impact of eruptions, some lahar control projects were started by constructing sabo-dam and flood control facility in the 1980s. In addition, PHIVOLCS continually monitors Mayon and has prepared a volcanic hazard map.

5.3.5 Taal

Taal volcano, located in Batangas province in southern Luzon island, is also world famous because it is one of the lowest volcanoes. The highest point of this volcano is 311 meters above sea level. In the central part of the lake, the Volcanic Island covering 23 km^2 was formed. Many craters are found at the bottom of the lake and the island. In total, 33 eruptions have been recorded since 1572. Volcanic activity is very high and many destructive eruptions have occurred. In 1754, a very strong eruption occurred. This eruption totally devastated the towns of Sala, Lipa, Tanauan and Taal. Another large eruption which caused 1,334 deaths and destroyed surrounding towns of the Taal Lake occurred in 1911. Ash fall from this eruption was observed even in Manila and covered an area of 2,000 km^2. According to recent records, eruptions have occurred in 1965, 1969, 1976, and 1977.

More than 5000 people inhabit in the Volcanic Island, which is in an eruption danger zone. The type of destructive eruptions that have happened here are the phreatic or phreatomagmatic types. In the event an eruption happens, damages will be high and evacuation will likely take a long time due to the lack of a transportation system. PHIVOLCS has installed a volcanic monitoring system on the Island.

5.3.6 Bulusan

Mt. Bulsan is located in the Bicol peninsula and it has a height of 1,559 meters. This mountain is located within the Ilosin Cardera which has an 11 km diameter and was formed 40,000 years ago. In total, 15 eruptions were recorded since 1852. Type of eruption is mainly Vulcan. In 1978, 1980 to 1983, 1994 and 1995 minor pheratic eruptions occurred. Damages were not reported.

According to PHIVOLCS, 60 barangays are located within the volcano hazard zone.

5.3.7 Canlaon

Mt.Canlaon is located on the northern part of the Negros island. Mountain height is observed to be 2,345 meters above sea level. In total, 21 eruptions were recorded since 1866. The main eruption type is classified as pheratic. Recent eruptions were recorded in 1978 and 1985. Both eruptions were not large.

5.3.8 Hibok-Hibok

Hibok-Hibok was formed on Camiguin island and is located 15 km north of Misamis Oriental, Mindanao. Mountain height is around 1,500 meters above sea level. In total, 5 eruptions were recorded since 1871. This volcano erupted intensely between 1948 and 1951. The most destructive eruption occurred in December 1951. Huge pyroclastic flow flowed down the north-eastern coast. More than 500 persons were killed by this pyroclastic flow. After these eruptions, the volcanic activity seemed to cease. In November 2001, the Camiguin island suffered from heavy rain storm brought by Typhoon Nanan. Volcanic deposits were washed away as mud flow or debris flow. Almost the entire island was damaged by this storm. In total, 220 persons were killed or lost within the island. Loose volcanic deposits are easily eroded and washed away by heavy rainfall. In order to manage and control loose volcanic deposits, knowledge of mud flow protection and watershed management should be introduced including construction of structural measures. Also, comprehensive disaster management systems, including timely evacuation through community led activities should be prepared.

5.4 Monitoring System of Active Volcanoes

Before the eruption of Mt.Pinatubo, a monitoring system for the volcano was installed in limited areas such as Taal. Systematic installation of monitoring systems for active volcanoes began recently. PHIVOLCS is installing earthquake detecting seismographs in the very active volcanoes. This seismograph installation is totally networked with the earthquake monitoring network covering the whole territory of the Philippines. Monitored data will be sent to PHIVOLCS by online or manually through the existing telecommunication lines.

The necessity of volcanic monitoring was realized by the Pinatubo case. Based on monitored data, PHIVOLCS and Government could dispatch evacuation orders to local municipalities before an eruption. Because of this early warning and evacuation, direct death by eruption was limited compared with the magnitude of the eruption. Existing monitoring systems will be extended to cover the main active volcanoes and further to important potentially active volcanoes in the future.

5.5 Mechanism of Volcanic Hazards and Problematic Areas

Volcanic hazards consist of two aspects: direct and indirect (Figure 5.3). Direct hazard is caused by the eruption itself. Each volcano has its own characteristics of eruption, such as interval, type and magnitude of eruption. According to the PHIVOLCS, the following six volcanic eruption types are identified in the Philippines:

a. Strombolian
b. Vulcanian
c. Pelean
d. Pheratomagmatic
e. Phreatic
f. Plinian.

During an eruption, volcanic activity usually changes from one type to another, but most volcanoes have characteristic habits of eruption. In the case of Pinatubo, the eruption type is Plinian which is characterized by great violence with voluminous explosive ejections of pumice and ash. Due to this destructive eruption, Pinatubo caused huge damages in the surrounding provinces.

In the case of Taal Volcano, the eruption type is known Phreatomagmatic which is characterized by the simultaneous ejection of fresh magmatic materials and steam produced by the contact of groundwater with the ascending magma. During the violent eruption of the Taal Volcano in 1911, many towns and villages were destroyed.

The eruptions of Mayon Volcano are classified as being Vulcanian type and they are sometimes destructive. Lava flows, huge cauliflower clouds, and pyroclastic flows were observed. Pyroclastic flows sometimes cause intensive damages along the course of the down flow. In the case of the eruption of 1993, farmers working on the mountain slopes were caught by the sudden occurrence of pyroclastic flow and 80 persons were killed. It is very difficult to predict the location and time of the eruption, especially for pyroclastic flows.

The mechanism of volcanic hazards is basically dependent on the magnitude and type of the eruptions as mentioned above. In order to understand these volcanic characteristics of eruption, detailed research on

volcanic geology, geomorphology and petology should be promoted. Based on detailed research on each volcano, history of eruptions including magnitude could be clarified. Accumulation of such scientific knowledge on volcanoes is the key to prevent future volcanic disasters.

Secondary or indirect damages by volcanoes are in the form of mud flow or debris flow called lahar. This phenomenon is always associated with heavy rainfall. Especially in the rainy season, loose volcanic ejecta or deposits on the slopes are severely eroded by heavy rainfall and transported to the down stream area in the form of lahar. Mt.Pinatubo, Mt.Mayon and Mt.Hibok-Hibok suffered from severe lahar damage.

5.6 Volcanic Hazards and Poverty

Problematic areas by volcanic hazard can be relatively limited to the surrounding areas of active or potentially active volcanoes. These problematic areas are shown in Figure 5.4 as a general concept.

Most part of the national territory of the Philippines has volcanoes. Slope areas with more than 18% are classified as forest land where free development is restricted. However, due to increased population numbers, some people have settled in these areas. In addition, mountain people with traditional customs live in volcanic areas, sometimes classified as Ancestral Domains. In the case of Mt. Pinatubo eruptions, a number of people of the Aeta tribe were seriously injured. Similarly, on Mindanao Island, many mountain people live around large-scale volcanoes such as Mt. Apo and Mt. Parker. In fact, their living standards are far below the poverty standard determined by the government. It is necessary to examine disaster management problems, including measures for evacuation and protection in case of eruptions, from a national viewpoint.

It is also vital to prepare measures for illegal inhabitants living in wooded regions. In the same way as mountain people, their living standards are statistically lower than the poverty standard. The government promotes preservative use of slope areas through programs such as tree planting. Presently, due to lack of basic information such as large scale topographic maps and existing land-use maps in forest land, it is difficult to prepare a disaster management plan including resource management.

In case of Taal Volcano, more than 5,000 people are living in the surrounding area near the volcano in disregard of hazard warnings issued by the government of a possibility of volcanic eruption. This large-scale habitation is also a crucial problem in terms of disaster management.

The inhabitants desire stable basic living conditions, however, this behavior is generating an additional number of vulnerable people and property. To prepare a disaster management plan, will require that measures for improvement of regional economic standards be considered as an integral part of the process – and also be promoted.

5.7 Disaster Management Capacity for Volcanoes

PHIVOLCS is obligated to report hazard information related to the occurrence of volcano disaster to relevant agencies in the same manner as that for earthquake disaster. So far, in the volcano eruptions of Mayon, Taal, Pinatubo, and others, PHIVOLCS has provided fundamental information related to disaster management such as information on the degree of danger and advice for evacuation.

In some of these cases, disaster management is effectively conducted while in others it is not. In the case of the volcanic eruptions of Mayon, the occurrence of an unpredictable pyroclastic flow caused injuries to farmers working on its mountain slopes. On the other hand, in the volcano eruption of Pinatubo in 1991, direct damage such as casualties were minimized by early warning.

It is possible to minimize human casualties through timely evacuation, based on monitoring data analysis related to seismographs, geophysical phenomena and visual observations of volcanoes. Therefore, it is important to conduct basic studies and research of future volcanic eruptions. In addition, it is essential to establish a well-structured system in which information on a danger can be promptly and timely transferred to regional MDCC and BDCC.

5.8 Directions for Improving Volcanic Disaster Management

Development of preliminary warning systems of volcanic eruptions is essential. In the case of the Mt. Pinatubo eruption, there was enough time to dispatch an evacuation order to the local people. Mt. Pinatubo erupted 70 days later after the first catch of pre-eruption phenomena.

During this period, the monitoring team was able to fully discuss the change of volcanic activities and made necessary recommendations to relevant agencies. Even so, nobody predicted the huge eruption which is recorded as one of the most violent eruptions in 20th century in the world.

The necessity of volcanic monitoring and early warning systems were in this case realized in the Philippines. Because of the early warning carried out and efficient evacuation of people, direct death by this type of eruption is limited to less than 100. Enhancement of monitoring system of volcanoes should be accelerated.

The preparation of an evacuation plan is also important. For the case of Taal Volcano, although PHIVOLCS has prepared guidelines for emergency management called "Operation TAAL", such evacuation plans should be reviewed and prepared for the people living on the Volcanic Island.

In Mayon, a volcanic hazard map has been prepared and a danger area zoning has been delineated by PHIVOLCS. This Hazard Map is disseminated to local disaster management agencies. Even so, local farmers still sometimes cultivate crops within the danger zone because of the rich soils of volcanic slopes.

To summarize, the following measures are necessary: (1) develop an early warning and evacuation system based on the monitored data on volcanic eruptions; (2) prepare detailed hazard maps; and (3) raise community awareness of volcanic disaster mechanisms and impact.

Chapter 6. Direction for Improving Disaster Management Data, Hazard Maps and Risk Models

CHAPTER 6. DIRECTION FOR IMPROVING DISASTER MANAGEMENT DATA, HAZARD MAPS AND RISK MODELS

6.1 General

The primary need for the promotion and establishment of disaster risk management is to understand the basic conditions of the country in relation to natural disasters. To do this requires a well-structured information system dealing with the distribution of regional characteristics and natural, social and economic conditions, among others, that serve as influential factors contributing to disaster.

The Philippines currently has insufficient maps and data that clearly show the social and economic conditions of the country as well as national conditions of (natural) resources and environments, which has become a crucial constraint in the promotion of national resources management, economic development and disaster management.

For instance, there is a topographic map with the scale of 1:50,000 covering the whole of the Philippines. It was compiled by the U.S. Army Map Services in the early 1950s, and has not, for the most part, been updated. Hence, it does not reflect changes in infrastructure, construction and land use. Therefore, it is not sufficient to base the preparation of regional development and resources management plans.

In considering future regional development and management of (natural) resources and environments, it is important to have a good understanding of the regional conditions related to disasters. For this purpose, it is necessary to collect and analyze information on natural disasters that have occurred in the past. This should include the preparation of hazard maps of vulnerable areas frequently hit by disasters.

Given how prone the Philippines is to disasters, it is important that the country has modern weather observation techniques which would make it possible to accurately trace and forecast that paths of typhoons and/or locations of heavy rain areas and hence provide early warning that would save lives and reduce economic damage. Data collected should be translated into usable information, including the preparation of risk models for natural disasters, both at the regional and national levels.

6.2 Floods, Sediments and Typhoon Disaster

6.2.1 Directions for Improving Data on Floods, Sediment and Typhoon Disasters

(1) Topographic Maps

Topographic maps are generally published by NAMRIA. Due to budget constraints and other issues, the present state of maps in the country is such that those available are generally outdated, and are of a resolution at which its too difficult to prepare hazard maps due to lack of detail. On the other hand, vulnerabilities in many areas have changed due to land use changes which are not represented in the maps, and therefore land use planning is still to a large extent being based on information that is no longer

relevant. Good hazard mapping requires maps with a scale of 1/10,000, although, a scale of 1/50,000 can also be used.

Presently, the maps are being updated one by one, which will take a significant time to complete the task. Given the fiscal constraints, and the severity of disasters in the country, it would be recommended that part of the criteria to select the priority of maps to update be the potential severity of the disaster.

(2) Aerial Photographs

Aerial photographs are the basis for producing topographic maps, and in addition give the necessary information to analyze potential hazard areas. Figure 7.2 shows the coverage and year of aerial photographs existing in the Philippines. The coverage is about one third of the country. Furthermore, as many of the photos were taken before 1990, much of the forest cover and land use in river basins has likely changed since then. These aerial photos will need to be updated for better accuracy.

(3) Rainfall

Meteorological observations including rainfall are mainly conducted by PAGASA. Other agencies such as NIA and NPC also have their own rainfall stations, which are used for their own purposes such as irrigation and power generation. Figure 6.1 shows the existing meteorological stations network of PAGASA. The duration of observations for each station is listed in Appendix 2. Almost all of the stations, except those stations for flood forecasting and warning systems (FFWSs), are operated manually. Therefore, except for the FFWSs stations, real-time data is not available before and during floods, and in the case of sediment and typhoon disasters, this is true for almost all of the meteorological stations. Generally, the observed data are sent periodically to PAGASA headquarters - only after the disaster.

There are only 187 meteorological stations in the country to capture the phenomenon of rainfall in river basins in general. This means that the average coverage of one station is too wide or about 1,600 km^2/station. Considering the size of river basins in the country, it is recommended that the number of rainfall stations be increased to more accurately capture the trends. Although the coverage of one rainfall station should ideally be about 50 km2, it is not necessary to stick to this size of coverage. For installing rainfall stations, it is necessary to identify the places that would yield the data that best guides warning systems and planning for better mitigation activities. This may require stations in the upper, middle and lower basins. Furthermore, since rainfall information is vital for LGUs and DCCs for forecasting floods, sediment and landslide, and for warning people for evacuation, one idea is to conduct observations by the concerned LGUs (municipalities, etc.) under cooperation from PAGASA.

(4) Water Level

The water level of rivers is measured by DPWH Regional Offices, and the data is sent to BRS of DPWH. However, some water stations are operated by PAGASA. The duration of the observation of the water level stations is shown in Appendix 3. Almost all of the stations are operated manually, and real-time

data is not available except for the stations of EFCOS System of MMDA and FFWSs of PAGASA. Data are periodically sent to BRS of DPWH from Regional Offices of DPWH usually after the disaster event.

There are only 255 water level stations in the country, and coverage of one station is about 1,180 km^2. Considering the size of catchment areas of river basins in the country, the coverage is too large to correctly identify floods in the river basins. It is necessary to install new water level gauging stations, so that floods are identified in the upstream, midstream and downstream reaches of each river basin. Furthermore, since information on the water level is vital for forecasting floods and sediment discharge, warning people for evacuation the concerned LGUs (municipalities etc.) under cooperation from DPWH could themselves conduct the observations.

(5) Data for Damageable Values

Asset data is indispensable for estimating damage. The following table shows the required data for assessing damage with their data sources. There has been no integrated asset database for s that includes damage values until now. Therefore, it is necessary to develop an integrated database on assets including damage values.

Table 6.1 Asset Data for Assessing Damage

Data Item	Data Source	
	Quantity by Types	Unit Value
1. Data for Direct Damage		
a. Residential building	- NSO and NSCB data - LGU's data - Site survey - Aerial photographs	- City and municipality assessor
b. Manufacturing establishment	- do -	- NSO and NSCB data
c. Wholesale and retail trading establishment	- do -	- NSO and NSCB data
d. Educational facility	- do -	
e. Medical facility	- do -	
f. Agricultural production - Crop - Livestock - Fishpond	- NSO and NSCB data - DA data - LGU's data - Landuse maps, aerial photographs and satellite images - Site survey	- NSO and NSCB data - DA data - NIA data
2. Infrastructure	- NSO and NSCB data - LGU'sdata - Topographic maps and aerial photographs - Site survey	- Proportion to direct damage (usually about 20 to 40%)
3. Data for Indirect Damage		
a. Opportunity loss and emergency expenditure	-	- Proportion to direct damage (usually about 10%)

6.2.2 Directions for Preparing Hazard Maps

(1) Hazard Map Needs

Hazard maps show potential hazard areas for inundation, sediment flow and landslides, as well as evacuation places and routes. Hazard maps are the basic information for implementing non-structural measures such as landuse management, including management of settlements in hazard prone areas. As was evident from the two sample surveys (Southern Leyte Province and Capiz Province) and the answers to the questionnaire from PDCCs, the need for hazard maps at the PDCC level is high. This will likely be the situation at the RDCC, MDCC and BDCC levels. Actually, many municipalities and cities have prepared very preliminary level hazard maps relating to their municipality or city development plans, but they are not based on the topographic maps of NAMRIA such as topographic maps with a scale of 1/50,000 or 1/10,000. Therefore, these preliminary hazard maps are not applicable for managing landuse (including settlement) in hazard potential areas. In order to prepare applicable hazard maps, it is necessary to be based on topographic maps of NAMRIA with scale of 1/50,000, 1/10,000 or larger, or to be based on recent aerial photographs (mosaic photos with scale such as 1/25,000, 10,000, etc.) instead of topographic maps.

(2) Other Existing Hazard Maps

Relating to the existing flood and sediment control studies by JICA and others, hazard maps or inundation maps were prepared. Some of the examples are listed below.

Table 6.2 **Existing Hazard Maps or Inundation Maps (Some Examples)**

River Basin	Prepared by	Base Map	Method
Cagayan	JICA (2002)	- 1/50,000 topographic maps - Digital elevation data of aerial photographs (2000)	- Flood survey. - Flood hydrograph estimation by storage function method. - Two-dimensional non-uniform calculation by mesh (1 km x 1 km).
Agno	JICA (1991)	- 1/50,000 topographic maps	- Flood survey - Flood runoff estimation and flood routine by storage function method. - Sequential two-dimensional pond model by mesh (2 km x 2 km) for inundation simulation.
Pasig-Laguna de Bay	JICA (1990)	- 1/10,000 topographic maps	- Flood survey - Flood runoff estimation by storage function method. - One-dimensional non-uniform calculation for water level estimation.
Panay	JICA (1985) JETRO (2002)	- 1/50,000 topographic maps - 1/10,000 topographic maps for low-lying areas along the rivers	- Flood survey (JICA & JETRO) - Runoff estimation by storage function method (JICA) - One-dimensional non-uniform calculation for water level estimation (JICA). - Sequential two-dimensional pond model by mesh (1 km x 1 km) for inundation simulation (JICA) - One-dimensional unsteady flow model for water level estimation (JETRO).
Pinatubo West	JICA 2003	- 1/10,000 topographic maps (digital)	- Rainfall runoff model (unit hydrograph) - One-dimensional sediment transport model - Two-dimensional mudflow model

(3) Directions for Preparing Hazard Maps

Directions for preparing hazard maps for floods and sediment (including landslide) are as follows:

<u>For Hazard Map for Floods:</u>

a. Prepare topographic maps as base maps at a scale of 1/50,000 or 1/10,000 covering the inundation areas.

b. Conduct flood surveys on the major floods such as maximum floods, second largest flood, and average floods in recent years (example about 10 years, depending on the records of floods in each river basin) and conduct questionnaire surveys in the inundation areas on flood depth, duration, evacuation places, damage, etc. Based on the results of the flood survey, plot the survey results on the above base maps and draw inundation areas with maximum water depth and duration of inundation. The map should also include evacuation routes and places.

c. Relating to the hazard maps, conditions of evacuation, response and rehabilitation conditions and problems should be studied.

d. Conduct hydrological and hydraulic simulations on the recent maximum floods or probable floods and draw the results on the base maps (simulated maximum water depth and duration of inundation of probable floods).

e. Inundation map prepared in the second bullet above can be a basic type of hazard map for floods.

Hazard Map for Sediment/Landslide:

a. Prepare topographic maps as base maps with scale of 1/50,000 or preferably 1/10,000 and, if possible, prepare aerial photographs covering the sediment and landslide potential areas.
b. Study erosion and landslide areas in the upper catchment as sediment production sources.
c. Study unstable sediment along the rivers.
d. Study landslide potential areas by geologists and sediment experts.
e. Study sediment flow patterns, including landslides disaster potential areas and surrounding areas by the major sediment disasters in recent years (maximum, medium and average size of disasters if possible during recent 10 years or so) by questionnaire to people and site reconnaissance (including geological investigation). Based on the survey, draw affected places with area and depth of erosion and sediment deposition on the base maps.
f. Simulation of sediment flow and deposition by a two-dimensional sediment flow model (however, it is not usually applied).
g. Include evacuation centers and evacuation routes on the above maps.
h. Usually, items in the first four bullets above will be the hazard maps for sediment and landslide disasters for the base cases.

6.2.3 Existing Loss Estimation Practices on Floods, Sediment and Typhoon Disasters

Existing loss estimation on floods, sediment and typhoon disasters is conducted: 1) during or just after the disasters; or 2) through separate studies on a certain flood or sediment control projects. The following describes current practices on damage estimation on floods, sediment and typhoon disasters.

(1) Loss Estimation During and After Floods, Sediment and Typhoon Disasters

Normal procedure is as follows.

a. Infrastructure Damage
   1. DPWH Regional Office (with District Office) investigates the sites of disaster.
   2. Interview with LGU units concerned.
   3. Estimate infrastructure loss based on quantity of damaged infrastructure.
   4. DPWH Regional Office sends the loss estimation to DPWH Central Office.
   5. DPWH Central Office sends the estimation to NDCC.
b. Agricultural Damage
   1. Department of Agriculture (DA) Regional Office investigates the sites of disaster.
   2. Interview with LGU units concerned.
   3. Estimate agricultural loss based on quantity of damaged crops etc.
   4. DA Regional Office sends the loss estimation to DA Central Office.
   5. DA Central Office sends the estimation to NDCC.

c. Health Damage

1. Department of Health (DoH) Regional Office investigates the sites of disaster.
2. Interview with LGU units concerned.
3. Estimate health loss.
4. DoH Regional Office sends the loss estimation to DA Central Office.
5. DoH Central Office sends the estimation to NDCC.

d. Other Damage to be estimated by Engineering Offices of LGUs

1. Report from BDCC to MDCC / CDCC
2. Report from MDCC / CDCC to PDCC
3. Report from PDCC to RDCC
4. Report from RDCC to NDCC

As it is necessary to report the damage quickly, the estimations above are conducted very roughly without detailed investigation on quantity and cost of damages. Furthermore, as there is normally no area-wide database on assets in and around the damaged areas, accuracy of the damage estimation is generally low.

Timing of reporting is as follows:

Initial Report:	Hours after event.
Progress Report:	As new development happen.
Final Report:	2 to 3 weeks after disaster based on compilation of NDCC
Archive	Final estimates are recorded in the database.

The NDCC/OCD Operation Center has 24 persons and operates 24 hours. Among the staff, some persons have IT background, but there is no person with domain background such as economics, environment, science, etc, limiting the efficiency for evaluating reported damage and utilizing the damage data for future improvement of disaster management.

Recommendations:

a. To increase accuracy of information, it is recommended to develop a database on assets (area-wide database) in and around the potential damaged areas by floods, sediment and typhoon disasters.

b. As the reporting format on damage is sometimes not uniform, it is recommended to use a uniform format for damage reporting.

c. It is advisable that a technical working group in the NDCC / OCD Operation Center is formed to analyze and evaluate damage caused by disasters, and the results are utilized for the improvement of disaster management.

(2) Loss Estimation through Separate Studies on Certain Flood or Sediment Control Projects

Loss estimation is normally based on river basins, using information from: 1) field surveys including questionnaires to people on damages; 2) estimations of losses based on the historical damages; and 3) estimations of losses by probable events (floods and sediment) by using models. This procedure is the same as the river basin model described in the following sub-section 6.2.4.

6.2.4 Directions for Preparing Catastrophic Risk Models

(1) Risk Model for Floods

a. River Basin Model

A river basin model is the most basic model of risk models. Figure 6.3 (1) shows the concept of a river basin model, which is usually applied by flood control studies in the Philippines. Generally, the river basin model is developed following the steps below:

<u>Step 1 Flood and Flood Damage Estimation based on Flood Survey</u>

- Can be done without mathematical simulation.

i. Survey of Major Floods in Recent Years (max, medium and average sizes)

- Survey of flood depth and duration, damage, and conditions of evacuation, response and rehabilitation.
- Survey by site investigation, flood mark survey and interview to people.
- Collect information from LGUs and others
- Produce flood hazard maps including flooding area, maximum water depth, duration, evacuation places and evacuation routes.
- Problems of evacuation, response and rehabilitation will be analyzed and countermeasures for improvement will be studied.

ii. Flood Damage Estimation in Monetary Terms based on Recorded Floods

- Survey on assets based on statistical data, landuse maps/data, data of LGUs, and field sample survey.
- Analyze damageable values and damage rates.
- Estimate damage amount in monetary terms for the recent major floods (max. medium and average) based on flood hazard maps, assets, damage values, and damage rates.
- Estimate annual damage in monetary terms of the river basin.

<u>Step. 2 Simulation of Floods and Flood Damage</u>

- Case of necessity to assess damages with and without structural mitigation measures.

i. **Develop Physical Model for Probable Floods**

Develop mathematical simulation models for the following:

- Develop rainfall runoff model for river basins to simulate rainfall runoff discharge by probable rainfall.
- Develop hydraulic model to simulate flood water level and discharge of probable floods by inputting the results of the rainfall runoff model.
- Simulate flooding conditions such as flooding area, flood depth and duration based on the results of the hydraulic model.

ii. **Develop Economic / Financial Model**

- Based on the assets data, asset values and damage rates, and the results of the Physical Model, estimate losses of probable floods.
- Based on the losses of probable floods, estimate average annual loss and return period losses of the river basins in monetary terms.

b. Regional Model

In order to estimate impacts to the economy of region and country, it is necessary to develop regional models for floods. Country level model will be the sum of the results of the regional models. Since there have been no regional models for floods developed in the Philippines until now, the following two methods are proposed in this study (refer to Figure 6.3 (2)).

i. **Proposed Regional Model 1: Regional Model Based on a Basin Model**

- Since a region is composed of river basins, develop a river basin model for the each river basin in the region.
- Based on the river basin model for each river basin, estimate damages of respective flood and annual damage to each river basin in monetary terms.
- Estimate regional damage of the respective flood in monetary terms and annual damage by sum of the damages of each river basin of the region.
- It is necessary to develop river basin models for each river in a region. It is recommended to develop river basin models for the priority areas first (such as the problem areas shown in Figure 3.14).

ii. **Proposed Regional Model 2: Provisional Regional Model based on Reported Damages, recommended only for provisional application:**

- Since it takes time to develop river basin models for each river basin in a region, reported damages by DCCs can be applied for developing the regional model.
- However, since the accuracy of damage estimation of the DCCs is insufficient due to limited manpower and time for estimation, it is recommended to apply this model (Regional Model 2) for provisional application until development of the Regional Model 1.

- Based on the reported historical provincial damages, estimate historical regional damages in monetary terms under price level of present year.
- In order to increase accuracy of estimation of regional damages in monetary terms, adjust the historical regional damages by applying adjustment factors based on the results of some sample river basin models in the region (or in the country). Adjustment factors are the rates of estimated damages based on river basin model vs. reported damages of the river basin. Adjustment factors are necessary to be studied from now on.
- Based on the adjusted historical regional damages, estimate annual regional damage in monetary terms.

(2) Risk Model for Sediment including Landslide

Usually, disasters caused by sediment flows, including landslides occur in more remote areas than floods. Therefore, a river basin model is to be developed for sediment (including landslide). Furthermore, since it is rather difficult to simulate with sufficient accuracy for sediment disasters or landslide by mathematical simulation model, it is more recommendable that it be based on surveys for the recorded major disasters, and any information from the investigation of experts of sediment and geology.

The Risk Model for Sediment (including Landslide) is to be developed by the following procedure (refer to Figure 6.4).

a. Study major Sediment (including Landslide)

- Study sediment / landslide damaged areas with their sediment deposition area and depth as well as flooding area and depth.
- Study sediment production in the upper catchments by landslide, slope failure and erosion.
- Study unstable sediment along rivers.
- Interview people on the damage conditions, sediment depth and flood depth, and conditions of evacuation, response and rehabilitation.
- Collect information from LGUs.
- Produce sediment and landslide risk maps.
- Problems of evacuation, response and rehabilitation will be analyzed and countermeasures for improvement will be studied.

b. Sediment including Landslide Damage Estimation in Monetary Terms

- Survey assets based on statistical data, landuse maps/data, data of LGUs, and field sample survey.
- Assess asset values and damage rates.

- Estimate damage amount in monetary terms for the recent major sediment (including landslide) damages (max. medium and average sizes) based on sediment and landslide risk maps, assets, damage values, and damage rates.
- Estimate potential damage amount in monetary terms based on the risk maps.
- Estimate average annual damage in monetary terms for the river basin.

c. Resources to be improved

In order to increase accuracy of the above River Basin Model and the Regional Models for floods and river basin model for sediment including landslide disasters, the following resources need to be improved, preferable starting in the priority areas shown in Figure 3.14.

- Topographic maps.
- Landuse maps.
- Meteo-hydrological observation networks and improvement of data quality.
- Integrated databases for assets of provinces and river basins.
- Accuracy of the reports on provincial property damages by DCCs.

6.3 Earthquake

6.3.1 Proposed Overall Direction

Hazard and risk mapping, and risk modeling need to be developed in the same scale for efficient use and methodology. The maps should cover, first the national scale, and also the regional scale, targeting the highly populated and urbanized areas with high value assets, such as the Greater Metropolitan Manila, Metropolitan Cebu, and Davao. Following these, other areas that are listed in the PHIVOLCS's list hazard map plans shall be considered together with the highly urbanized areas, as defined by NSO.

PHIVOLCS has already developed the earthquake hazard maps on a national scale for PGA, landslide, liquefaction, active faults and a map showing the tsunami prone shorelines in the Philippines. These, especially the PGA, may be utilized for the rudimentary risk modeling. For the regional level hazard maps and risk modeling, further efforts on data development will be needed.

For regional level development, Figure 6.5 describes the general flow of recommended risk modeling development.

Table 6.3 provides a brief summary on the direction of hazard and risk mapping, risk modeling, and Database Development.

Table 6.3 Proposed Direction of Hazard and Risk Mapping, Risk Modeling, and Database Development

Requirements for Hazard (Risk) Mapping	Recommendation and Suggestions on Direction for Risk Modeling Development	Data Requirement for Database Development
Evaluation/ analysis based Hazard Mapping 1. Earthquake ground motion - PGA Distribution - Intensity Distribution 2. Liquefaction 3. Tsunami 4. Earthquake induced landslide Risk Mapping 1. Building damages 2. Casualties 3. Infrastructure damages Different types of risk maps: Ground motion, tsunami, fire, and earthquake induced landslide	Risk Modeling will be developed onto the risk map. Additional information on financial aspects will be integrated into the model	Available data - Building statistics - Population - Technical data Further required/ necessary development data - Historical damage data - Infrastructure related data - Financial related data

6.3.2 Requirements for Hazard and Risk Mapping

There are two types of approaches to developing hazard maps for earthquakes: one is hazard maps based on the historical records, and the other is based on the evaluation and analysis. To expand the hazard map to a risk map, evaluation and analysis based hazard mapping should be carried out. The hazard and risk mapping procedure explained here is for the regional level.

(1) Hazard maps

Earthquake hazard maps are defined here as a map of the physical hazards, excluding the possible damages. The following are possible hazard maps that could be developed:

a. Earthquake ground motion
   i. PGA Distribution
   ii. Intensity Distribution
b. Liquefaction
c. Tsunami
d. Earthquake induced landslide

Examples of some hazard maps are shown in Figures 6.6, 6.7 and 6.8.

(2) Risk maps

Earthquake risk maps show possible damages, including the property damages, and casualties. The following are the possible risk maps to be developed.

a. Building damages
b. Casualties
c. Infrastructure damages
d. Fire

Different types of risk maps may be developed through the combination of hazards and damages. Commonly developed are the combination of earthquake ground motion and building damage, casualties, and infrastructure damages. A combination of tsunami hazard and building damage, casualties, and infrastructure damage may be also important to develop. Figures 6.9, 6.10, 6.11, and 6.12 show some examples of risk maps.

6.3.3 Recommendation and Suggestions on Direction for Risk Modeling Development

Risk evaluation through the development of risk models will include the possible damages of man-made structures and economic losses induced by them. Risk Modeling will produce risk maps. Financial information will be integrated into the risk maps so that the potential damage can be calculated.

As already described above, PHIVOLCS has already developed national level hazard maps. Simple risk maps for building collapse can be developed. To better understand the national financial risk, a simple model could be developed based on the national level hazard map, and then developed into risk models with financial information. Information on the assets, including the building values, and public asset values may be added for the model development.

6.3.4 Data Requirement for Database Development

The primary purpose of database development is to meet the requirement for the hazard and risk mapping, and risk modeling. Very roughly, available data are the following:

a. Building inventory
b. Population
c. Topographic map (old and partially new)
d. Geological Map (1:50,000, partially covering the nation)
e. Earthquake data
f. Land use (14 selected provinces)
g. Pubic schools (Partially)

The following data would be required to complete the level of data required to make the database more complete:

a. Damage data (Historical data)
b. Infrastructure related data
c. Financial related data

It can be concluded that for earthquake hazard and risk mapping, the development of a geological map compiled at scale 1:50,000 is indispensable for regional level assessment. Also, developing the damage records by using a more efficient database structure is very important for future studies and plans.

6.4 Volcanic Disasters

6.4.1 Hazard Mapping of Volcanoes

(1) Existing Conditions

For the preparation of volcanic hazard mitigation, it is essential to know the potential hazard area. PHIVOLCS has already compiled a hazard map for six active volcanoes at a scale 1:50000. In the particular case of Pinatubo, Lahar and flood hazard maps were compiled in 2002. The potential hazard area for lahar and flooding is indicated by five zones in this map.

For Taal volcano, Base Surge Hazard Map was compiled in 1999. Potential hazard area is shown by shading on the map. The whole Volcanic Island is designated as a permanent danger zone.

For Mayon volcano, a Pyroclastic Flow Hazard Map was compiled in 2001. This map shows the 6 km radius permanent danger zone from the summit and the area prone to pyroclastic flow. The designated moderate hazard zone is between 6 to 8 km areas from the summit. The 10 km zone from the summit is designated as endangered zone only if Mayon erupts violently. Locations of municipal boundary and river channels are also indicated in this map. Contours are shown at 100 meter intervals.

For Bulusan volcano, Pyroclastic Hazard Map was compiled in 1998. Three danger zones are delineated in this map.

For Canlaon volcano, based on the interpretation of aerial photography, a detailed geological map was compiled that can provide basic information for hazard mapping. The danger zone of this mountain is delineated at 4 km radius from the summit and 19 barangays are located in the potentially hazardous zone.

For Mt. Hibok-Hibok, the 3 km radius zone from the summit is delineated as a high danger zone and all of the northern part of Camiguin Island is classified as a danger zone. Within this danger zone, more than 21,000 people are living.

These Volcanic Hazard Maps have already been disseminated to relevant agencies for necessary evacuation planning. Examples are shown in Figures 6.13 to 6.29.

(2) Volcanic Hazard Mapping

For the six most active volcanoes, volcanic hazard mapping has been compiled. Each map has a scale of 1:50000. This scale does not have enough resolution to show the details of volcanic hazard. Generally, due to a lack of accurate and updated base data and information, even the most recent research output have to be drawn on very old maps. Also, lack of basic materials for conducting hazard mapping is one of the largest constraints for natural disaster mitigation research and planning. Large-scale topographical maps such as 1:5,000, aerial photography, satellite imagery, geological maps and existing land use maps should be prepared first for potentially high risk areas by volcanic hazard.

(3) Existing Loss Estimation for Volcanic Disaster

Volcanic disaster causes serious damage to people, houses, infrastructures and agriculture in surrounding areas. Depending on the type of eruption, a large amount of volcanic ash causes enormous damage to not only surrounding areas, but also wider areas, even on a worldwide scale. In the cases of volcanic eruptions of Mt. St. Helens in U.S.A and Mt. Pinatubo, it has been suggested that the effect of volcanic ash ejected into the air leads to a reduction in sunshine and causes harmful influences on weather patterns and agricultural products. In this sense, damage evaluation of large volcanic eruptions needs to be done for both macro and regional effects.

In the present damage evaluation system used in the Philippines, regional officers in charge of disaster management verify the amount of damage, and the results are reported to NDCC through the PDCC and the RDCC. In addition, it is regulated that persons in national agencies such as DPWH, DOH and DA and so on, recognize situations of damage in each sector and report them to their own organizations. Generally, in order to promptly and adequately grasp situations of damage, it is essential to use aerial photography, site survey and others. However, this kind of survey method for damage information collection is often not totally performed in the Philippines. In actual circumstances, in the case of a large-scale disaster, the collection of damage information, estimation and evaluation of damage cost and preparation of a restoration plan are conducted mostly through international support.

6.4.2 Directions for Preparing Risk Models

Violent volcanic eruptions such as that of Mt. Pinatubo do not occur frequently. Existing historical data on the volcanic eruptions of the Philippines shows several very violent eruptions such as Mayon, 1814, Taal, 1754 and 1911, Hibok-Hibok, 1952 and Pinatubo, 1991. Heavily affected areas by these eruptions are limited to the near-by areas of the volcanoes. However, ash fall can reach more than a 100 km area depending on the direction and velocity of the wind. For the identification of a volcanic hazard risk area, the possibility and interval of violent eruptions, as well as the size of the potential area affected, it is important to understand what happened in the past.

Existing Hazard Maps for Volcanoes show the potential area of pyroclastic flow or base surge area and the potential area of lahar and flooding. These hazard maps have not yet been integrated on the detailed land use map which includes infrastructure distribution and population data. To conduct risk analysis in terms of total damage cost in a volcanic area, volcanic hazard maps should be integrated with socio-economic data. For this reason, detailed and systematic data inventory for the high priority area should be promoted.

Research on potentially active volcanoes should also be promoted based on detailed scales. Volcanic hazard maps and risk analysis should be conducted. The possibility of a volcanic eruption can not simply be determined by looking at current symptoms of the volcanoes. A study of the geological history of the volcano

is necessary. Mt.Pinatubo erupted very violently in 1991 after a long quiet period. According to the study by PHIVOLCS, the last eruption of Mt.Pinatubo before 1991 eruption was estimated at about 450 years prior!

In the Province of Bataan, Mt.Natib and Mariveles are located and are considered to be potentially active volcanoes. These two volcanoes show similar geological and geomorphological characteristics to Mt. Pinatubo. The location of these volcanoes to Metropolitan Manila is closer than Pinatubo. If these volcanoes have a similar eruption as that of Pinatubo, potential volcanic hazard risk to the National Capital Region is believed to be much bigger than the Pinatubo case.

PHIVOLCS basically intends to conduct detailed research on the following potentially active volcanoes, Mt. Apo, Cabalian, Cancajang, Corregidor, Cuernos De Negros, Isarog, Kalatungan, Labo, Malinao, Malindig, Mandalagan, Mariveles, Natib, Negron, San Cristbal and Silay, to determine whether they are active or not. Based on the detailed geological and geomolphological data, volcanologists can reconstruct the history of volcanic activities including the type and magnitude of eruptions. These research results on the past volcanic eruptions are the key to forecasting future risk. Accumulation of scientific data on volcanoes is a basic and necessary step to have a more accurate understanding on volcanic hazard risk.

6.4.3 Direction of Volcanic Data Improvement

The first priority is to conduct a detailed volcanic survey of active volcanoes. Although volcanic surveys have been completed on the six very active volcanoes, there are still another 16 active volcanoes in the Philippines. For potentially active volcanoes, detailed volcanic surveys should also be conducted to clarify the possibility of future eruptions. If the volcanoes are judged as being active, at least one set of monitoring equipment should be installed to monitor their volcanic activity.

To support a detailed volcanic survey, aerial photography and large scale topographical maps such as 1: 5,000~10,000 should be prepared. Detailed research on volcanic geology and geomorphology is the first step to acquire necessary data and information on future volcanic disaster. Enhancement of the monitoring system of very active volcanoes is also encouraged.

Chapter 7. Assessment of Available Basic Data for Disaster Management Activities

CHAPTER 7. ASSESSMENT OF AVAILABLE BASIC DATA FOR DISASTER MANAGEMENT ACTIVITIES

7.1 Existing Basic Data Relevant to Disaster Management

This section discusses the relevant and currently available basic data needed for disaster management. The Chapter also discusses, the condition, issues and concerns related to this data, and presents recommendations for improving the data to make it more useful for disaster management activities.

Basic data relevant to disaster management activities and other studies can be grouped into five main categories:

a. Physical Conditions
b. Socio-Economic
c. Public Facilities
d. Infrastructure
e. General Hazard Data

The list of existing available data is attached in the appendix.

7.2 Physical Conditions

7.2.1 Base Maps

There are three available scales for maps covering the entire Philippines. These are:

a. 1:1,500,000
b. 1:250,000
c. 1:50,000

There are some areas for which larger scale topographic maps are available. Many LGU's in the Philippines have, on their own, initiated the preparation of base maps of their respective areas. This is based usually on aerial photography or satellite imagery. The scales used ranges from 1:2000 to 1:25,000.

(2) Scale 1:1,500,000

The 1:1,500,000 maps covering the Philippines were originally compiled by the Philippine Coast & Geodetic Survey in 1954, while some locations were updated from 1987 to 1997. The map is published by NAMRIA in paper form and covers the entire country on one sheet.

(3) Scale 1:250,000

The 1:250,000 map series covering the Philippines was produced in 1954 with information from the Philippine Coast & Geodetic Survey, Army Map Service Corps of Engineers and the US Coast & Geodetic

Survey. The 1:250,000 series of maps are published by NAMRIA and consists of 55 sheets. Contours are at 100 m intervals. These maps have already been digitized and are being used by PHIVOLCS for disaster related activities.

(4) **Scale 1:50,000**

The 711 series of maps were originally published by the US Army Service and compiled from aerial photographs taken in 1947 to 1953. Contours are at 20 m intervals. The total number of sheets for the 711 series is 842.

The 701 series map published by NAMRIA covers most of Luzon and replaces the 711 series of maps covering the area. The maps were produced using aerial photography taken from 1976 to 1979. The total number of sheets for the 701 series is 151.

The National Topographic Mapping Series (NTMS) of maps will eventually replace the S701 and S711 maps. The Philippines will eventually be covered in 672 sheets. The series is currently being updated and presently, about 79 sheets are available. Production of the NTMS started in 1988.

(5) **Larger scale topographic maps**

At NAMRIA, topographic maps at a 1:10,000 scale are available for some areas, namely:

a. Metro Manila and adjoining areas (1982)
b. Ilocos Norte
c. La Union
d. Baguio City
e. Subic
f. Legaspi City
g. Roxas City
h. Zamboanga City

In 2003, 1:5,000 scale base maps were made for Metropolitan Manila as part of the JICA funded MMEIRS Project. A comprehensive GIS that contains information about Metropolitan Manila's infrastructure, public facilities, natural and social conditions and other data was also prepared.

A 1:5,000 scale topographic map was produced for Metro Cebu in cooperation with the German Agency for Technical Cooperation (GTZ) from aerial photographs taken in 1988. Other areas with 1:5,000 topographic maps are Bacolod City, Iligan City and Metro Iloilo.

(6) **Topographic Maps at the National Irrigation Authority**

NIA is tasked with the development, construction, monitoring and maintenance of all irrigation systems throughout the country. The total land area now under irrigation is 1,338,800 ha of which 678,500 ha falls under the National Irrigation System (NIS), while 486,100 ha under the Communal Irrigation System (CIS)

and the remaining 174,200 ha is under Private Pump Irrigation Systems. The potential irrigable area of the country is estimated at 3,128,000 ha hence there is still about 1,789,200 ha or 57.2% of the country's total irrigable area to be developed. The topographic maps at NIA, which were compiled at a large scale, can be a significant source of topographic information for disaster management. Most of the data are still in analogue format, but converting these data to digital format would make the data useful in GIS analyses.

(7) General Characteristics of Available Base Map Data

Existing base map data covering the whole country are for the most part, outdated. The 1:1,500,000, 1:250,000 and 1:50,000 scale maps date back mostly from the 1950's. Efforts to update the already more than 20 years old, 1:50,000 scale maps in the 701 series published by NAMRIA have been limited to Luzon.

Work on the National Topographic Mapping Series which started in 1988 has so far produced only 79 of the 672 sheets planned, covering approximately only 11% of the country. Figure 8.1 shows the index of existing 1:50,000 scale maps at NAMRIA. Digital versions of base maps that could be used for GIS analysis are available for the 1:250,000 series. For 1:50,000 only about 10% have been digitized.

(8) Local Capabilities for Topographic Mapping

Table 7.1 summarizes locally available equipment and personnel to conduct topographic mapping among NAMRIA and three major private companies.

Table 7.1 Locally Available Equipment, Capability & Capacity for Topographic Mapping, GIS and Remote Sensing

Item	National Mapping Resources Information Authority (NAMRIA)	Certeza Surveying & Aerophoto Systems Inc.	F.F. Cruz & Co., Inc. Geomatics Division	Geo-Surveys & Mapping	Total
Aircraft	0	3	2	1	6
Aerial Cameras	0	2	2	1	5
Analogue Plotters	3	3	2	0	8
Analytical Plotters	1	2	0	0	3
Digital Plotters	1	3	3	3	10
Precision Scanners	1	1	1	1	4
GPS Equipment	15	10	6	4	35
Remote Sensing	Yes	Yes	Yes	Yes	
GIS Capability	Yes	Yes	Yes	Yes	
Technical Staff	30 (Mapping Department)	40	25	30	125

Sources: NAMRIA, JICA, Certeza, GSMI, FF Cruz

Two basic methods to update 1:50,000 base maps that can be considered are aerial photography and satellite-based mapping. Each has its own advantages and disadvantages.

The total land area of the Philippines is approximately 300,000 sq km. The effort to conduct aerial photography to cover the whole of the Philippines, it has been estimated, will take roughly 8.5 years assuming all six available aircraft locally continually conduct aerial photography. Weather conditions in the Philippines permit only on the average, 21 good aerial photography flying days a year. Ideal flying conditions for aerial photography is also affected by geographic location. Mindanao is generally considered a difficult area to conduct aerial photography due to cloud cover. Another 12 years would be required to conduct digital mapping after aerial photography is finished considering currently available equipment and personnel.

The conduct of aerial photography can be speeded up by using high altitude aircraft. This type of aircraft is not available locally. With high altitude aircraft, it is possible to finish aerial photography in one to two years. Local capabilities for digital mapping can also be supplemented by overseas companies to hasten the map updating process.

Satellite based mapping is comparatively faster than aerial photography based mapping. Assuming satellite imagery is available for the whole country, in some estimates; it will take roughly from 3 to 5 years to process and cover the whole country at 1:50,000 scale considering current capacities.

Aerial photography does offer the advantage of higher resolution of images compared to commercially available satellite imagery. A combination of both methods may be utilized to update the 1:50,000 base maps of the whole country.

(9) Recommendations to Update Base Map Data

The 1:250,000 and 1:50,000 scale maps can be used for indicative studies and policy making at a national down to the provincial level. These maps can be used for studies to identify areas for further detailed investigation. At the moment, existing maps at these scales are for the most part, outdated. Therefore there is an urgent need to update these maps. Agencies such as PHIVOLCS, MGB and other government agencies need these maps as a basis for hazard and risk mapping.

Map updating is a costly process so priority to update maps should be given to specific areas depending on their vulnerability to hazards in the areas. It would be prudent to focus attention on updating the 1:50,000 maps first since the 1:250,000 base maps can be derived from this.

For the interim, although the existing maps are quite old, contour and spot elevation data from these maps can still be useful. Currently, digital data is only available for the 1:250,000, while only about 10% is available for the 1:50,000 maps. For the interim, the 1:50,000 could be digitized so that they could be used for further GIS and engineering analyses. Slope analyses using digital data at 1:50,000 should be done to narrow down areas for further investigation. For studying rainfall induced landslides, this kind of analysis is very important.

Special areas that are deemed most at risk from different types of disasters can be subject to larger scale mapping.

For flooding, some areas should be mapped at a scale of 1:10,000 or larger, to better understand flooding phenomena in these areas. Depending on the terrain, 1 or 2 meter contour intervals should be generated. With a better understanding as to why certain areas are flooded, appropriate measures can be taken to reduce hazards posed by flooding. It is recommended that the severity of disaster potential (example: problematic areas of floods, sediment and typhoon disasters) be considered as one of the factors for planning and updating the schedule of the topographic maps (example: Cagayan, Abra, Laoag and Bicol River Basins, Mindoro, Negros Occidental, Leyte, Surigao del Norte and Surigao del Sur).

For earthquake related studies, especially in urban areas such as Metropolitan Manila, 1:5,000 mapping is appropriate. At this scale, more features such as building footprints can be distinguished. In the Earthquake Impact Reduction Study for Metropolitan Manila (MMEIRS), 1:5,000 topographic maps were used as a basis for hazard and risk mapping. Community Based Disaster Management activities for selected areas conducted as part of MMEIRS made use of these maps to identify individual structures that can be at risk and resources such as evacuation sites, in case of an earthquake. This kind of study should be replicated in other urban centers in the country such as Metro Cebu and Metro Davao.

7.2.2 Aerial Photographs

(1) Existing Aerial Photography

Aerial photographs are the basis for producing topographic maps but they are also very useful for analyzing potential hazard areas especially for slope erosion and landslides. They can also be used for earthquake and volcano studies. Figure 8.2 shows the coverage and year prepared of the existing aerial photographs in the Philippines, owned by NAMRIA. The coverage is about one third of the country. Furthermore, as many of them were taken before 1990, there is a possibility that forest cover and land use in river basins have been changed since then.

(2) Recommendation to Improve Aerial Photography Data

It is recommended that the aerial photographs in conjunction with updating topographic maps be updated, taking due consideration of sediment and landslide potential areas/basins for one of the top priority areas (for example: Southern Leyte, Surigao Norte and Sur, Mt. Mayon, Mt.Pinatubo and Camiguin).

7.2.3 Land Use / Land Cover Maps:

(1) Existing Land Use/Cover Maps

Two sets of Land Use/Land Cover maps are currently being distributed by NAMRIA. One was funded by the World Bank and the Swedish Space Corporation (SSC) and the other was sponsored by the Japan Forest Technical Association (JAFTA).

The World Bank and SSC Land Cover Maps were produced using SPOT satellite images taken in 1987-1988. These maps were outputs of the project, "Mapping the Natural Conditions of the Philippines".

Given emphasis on these maps are forests, extensive and intensive land use, and coastal areas covering approximately 300,000 km^2 of land area. Supporting statistics are also available. Topographic maps at 1:250,000 scale were used as base maps

The JAFTA Land Use and Forest Type maps give emphasis on the type of forest such as old-growth, mossy, residual, sub-marginal, pine and mangrove, usage of land such as brush reproduction, coconut, plantation, grass lands, agriculture, bare/rocky and built up area. Statistics supporting classification in contained in a book called Forest Register. These maps were the results of "Wide Area Tropical Resource Survey (FY1994) which was carried out by the JAFTA. These were based on Landsat TM data of 1993 selected from image scenes with least cloud cover. A topographic scale of 1:100,000 was used.

For selected provinces, updated Land Cover maps are available. The Secondary Education and Improvement Project – School Mapping Exercise (SEDIP-SME) of the Department of Education produced land cover maps compiled at 1:50,000 scale, for 14 selected provinces using Spot 20 m multispectral imagery. Figure 8.3 shows an example of a land cover map compiled for Southern Leyte. The provinces covered by SEDIP-SME are:

a. Ifugao, CAR
b. Benguet, CAR
c. Antique, R6
d. Guimaras, R6
e. Agusan del Sur, CARAGA
f. Surigao del Sur, CARAGA
g. Romblon, R4
h. Masbate, R5
i. Negros Oriental, R7
j. Biliran, R8
k. Leyte, R8
l. Southern Leyte, R8
m. Zamboanga del Sur, R8
n. North Cotabato, R12

(2) Recommendations to Improve Land Use / Land Cover Data

Although for selected areas of the country, 1:50,000 land use / land cover maps are available, other areas are either covered at 1:250,000 or 1:100,000 scale. For disaster management activities, updated Land Use / Land Cover data are very important. Higher resolution land use and land cover maps need to be

compiled, preferably at 1:50,000 scale for the whole country. For priority areas such as urban areas and potential hazard and high risk areas, land use maps should be compiled at scales from 1:5,000 to 1:10,000.

7.2.4 Geological Data

(1) Available Geological Maps at MGB

Understanding the rock and mineral structure of an area is vital in determining hazards that exist in the area. The Mines and Geosciences Bureau (MGB) is directly in charge of the administration and disposition of the country's mineral lands and mineral resources. The MGB has produced geological maps at 1:50,000 scale limited areas of the Philippines. They are distributed in hardcopy form. About half of the maps are published while the other half comes in the form of reproducible whiteprint. Figure 8.4 shows the available geological maps at scale 1:50,000 at the MGB. Geological maps at 1:250,000 are available in hardcopy format.

(2) Recommendations to Improve Geological Data

It is recommended that geological maps at the 1:10,000 level be prepared for the development of city/municipal level hazard maps for flood and landslide. The geological maps at 1:250,000 converted to digital form would be useful for earthquake hazard mapping.

7.3 Socio-economic Data

7.3.1 Population Data

Population data for the whole country is available from the National Statistics Office (NSO). These data can be extracted from the Data Kit of Official Philippine Statistics (DATOS), which is being distributed by NSO for a fee. DATOS is a collection of statistics for each region, province, city municipality, and barangay in the country. The data on total population presented in DATOS are the official census figures for the 1980, 1990, and the 2000 Census of Population and Housing as well as the 1995 Population Census.

7.3.2 Building Inventory

Data on individual building counts per barangay can be obtained from NSO in the form of Public Use File (PUF). The PUF is a text file containing raw data such as outer wall and roof material, construction year, state of repair and approximate roof area for each building included in the 2000 Census on Population and Housing. The census on housing is complete enumeration of all housing units whether occupied or vacant at the time of the census.

7.3.3 Administrative Boundaries

There are four levels of administrative boundaries in the Philippines. They are Regional, Provincial, City/Municipal and Barangay boundaries. Many disputes exist between LGU's in the Philippines regarding the

exact locations of their boundaries. At the moment, there is no map that shows the definite boundaries of all LGU's. Topographic maps published by NAMRIA do show administrative boundaries but they are not generally accepted as final.

For disaster management activities, there are two main sources of boundary data that covers the whole country, which could be useful. One source is the NSO, the boundary data can be found in GIS format in the Data Kit of Official Philippine Statistics (DATOS), which is being distributed by NSO for a fee. It includes boundary information from the regional level down to the barangay level. The boundary data were digitized based on sketches, prepared by survey enumerators in the field thereby making it difficult to judge the accuracy and scale at which the maps were prepared. The data was digitized by NSO with technical assistance provided by NAMRIA.

The other significant source of boundary data is DPWH. The data is also in GIS format. DPWH believes that their administrative boundary data were digitized from NAMRIA base mapping in the early 1990's from 1:250,000 series maps. DPWH has made minor modifications to municipalities and cities boundaries. DPWH has also generated Congressional District, Provincial and Regional Boundaries based on the constituent municipalities and cities. It is believed that the Congressional District, Provincial and Regional Boundaries are correct as of January 2003 (assuming the accuracy of the municipalities and cities). There are 1606 municipalities/cities in the DPWH layers, although National Census data year 2000 indicates there may be 1609; however the remaining 3 cannot be identified from known sources. It is also believed that the Municipal/City boundaries in the vicinity of Lake Lanao in Mindanao are highly inaccurate, maybe as much as 4 km out from the National Road Network.

In terms of location accuracy, DPWH boundary data is deemed more reliable compared to that of NSO. There may be cases where NSO would be more useful, such as studies and planning activities that go down to the barangay level. NSO boundaries may be appropriate for applications making use of NSO statistical data since the boundaries reflect the actual boundaries followed by survey enumerators in the field.

7.3.4 Recommendations to Improve Socio-economic Data

For the Philippines, census, the basic data units used are regional, provincial, city/municipal boundaries and barangay boundaries. Maps reflecting a more accurate boundary of census should be made, preferably in GIS format as in the 2000 Census. The 2000 census basically used sketches of enumeration areas prepared by the surveyors themselves which were later digitized.

Considering the existence of conflicts between local government districts in their areas of jurisdiction, a unified map showing final LGU boundaries is difficult to achieve. For disaster management, focus is most likely better if it is accorded to the data from the National Statistics Office which uses regional, provincial, municipal/city and barangay boundaries as their basic units of census. The use of GIS by NSO in presenting

census 2000 is commendable, but the accuracy in preparing these boundaries could be improved. This can be done by giving additional GIS mapping capability to NSO.

7.4 Public Facilities

7.4.1 Hospital

The DOH with the assistance of NAMRIA, mapped all the Regional Health Units (RHU), hospitals and municipal health centers throughout the Philippines as part of the Women's Health & Safe Motherhood Project. Attributes such as facilities available and personnel were also captured for each RHU, hospital, and municipal health center.

7.4.2 Public Elementary and High Schools

The Department of Education (DepEd) maintains a database called Basic Education Information System (BEIS). The BEIS contains a listing of all public elementary and high schools in the Philippines. The list is compiled and maintained by the Research and Statistics Office of the Department of Education Central Office. Attribute information of each school such as number of students, teachers and other school related data are included. It is updated yearly from information gathered from each school by DepEd Regional Offices.

Locations of public elementary and high schools for selected provinces were plotted on 1:50,000 scale base maps as part of the DepEd's Secondary Education Improvement Project – School Mapping Exercise (SEDIP-SME) project. Schools were assigned codes compatible with the codes used by DepED's BEIS database. This would facilitate linking of school locations with BEIS. In addition, pictures, school site development plans and other schools' documents are also available. These data are summarized in an application called "Geographic Database of Secondary Schools" which was developed as part of the project.

7.4.3 Recommendations to Improve Public Facilities Data

Locations of all public elementary and high schools other than those included in SEDIP-SME project have not been compiled. Public elementary and high schools are often used as evacuation centers in times of disasters, therefore attribute data describing the conditions and capacities such as number of classrooms in these schools should be gathered. In some cases the school buildings themselves are vulnerable to disasters, making them unfit evacuation centers. Therefore a systematic school location and attribute information gathering effort should be promoted.

Other public facilities data such as those of the fire and police stations and other key public facilities relevant to disaster management such as provincial, city/municipal halls on a national scale should be collected and converted to GIS format. The locations of these facilities and their capabilities are important resources to disaster management.

7.5 Infrastructure

7.5.1 Road Data

National Road Data was collected using vehicle-mounted GPS with differential post-processing. It is believed that this data is accurate to +/-10 meters. The vast majority of this data was collected in year 2000, but the network in Regions IX and XII were collected in late 2002. Some gaps remain (due to impassable roads, failed bridges at the time of survey). DPWH has processes and procedures in place to maintain this data, therefore updates will be available in future, probably on an annual basis.

Provincial Roads were digitized from NAMRIA base mapping in the early 1990's from the DPWH 1:250,000 series maps. DPWH has made no attempt to reconcile this data with the (National Road Network). It is known that some roads in this provincial layer have now been moved to National jurisdiction, and should therefore be deleted from this layer. DPWH may clean this layer in future, however it is not a high priority at present.

7.5.2 Bridge Data

The DPWH conducted an inventory of bridges under DPWH control throughout the Philippines under the "Nationwide Bridge Inspection Project". This is a part of an umbrella project called "Rehabilitation and Maintenance of Bridges along Arterial Roads". Attributes of bridges such as type and dimensions of bridges are included in the database.

7.5.3 Recommendations to Improve Infrastructure Data

Most of the infrastructure data mentioned above has been in one form or another stored in digital form. There is now a need to compile all these data together in one coordinate system so GIS analyses such as overlay can be performed.

Road data, other than that covered under the DPWH roads survey, designed for cover under the national roads should be gathered. Local roads at the provincial and municipal level should be gathered. These are important inputs to disaster management planning and rescue efforts. Accessibility to disaster sites need to be known. Also in some cases, such as roads blockages due to earthquakes or landslide, alternate routes need to be determined to enable aid to reach those who need it.

For the same reasons that road data needs to be improved, bridge information should also be improved. Bridge data up to the provincial and municipal level are also important for accessibility considerations.

Other transportation related facilities data such marine ports and airports should also be gathered on a national scale. These are also important for accessibility considerations. Capacities of these ports are necessary especially for transport of relief supplies in cases of disaster.

7.6 General Hazard Data

7.6.1 BSWM

Bureau of Soils and Water Management (BSWM) of the Department of Agriculture is the main producer of agricultural related thematic maps in the country and the range of BWSM's map products are generated based on NAMRIA's topographic base maps of 1:50,000 and 1:250,000. They are mainly in analogue format, with a limited number in digital format.

The "Philippine Land and Soils Management Atlas" is a major publication of the BSWM through its Agricultural Land Management Division (ALMED). Preparation of the atlas was based and synthesized from a series of project activities namely: Land Resource Evaluation Project (LREP), Regional Land Use Assessment (RLUA), and the Crop Development and Soil Conservation Framework for Luzon, Visayas and Mindanao.

The process covered by the resource assessments for the country took 15 years of continuous field work and consultations with local government, business institutions and other government agencies concerned with the rational use of the land.

The atlas aims to provide basic situationer and benchmark information for the estimation of agricultural development that can be pursued in the different regions and in various land, agro-climatic and economic scenarios. The atlas serves as a basic tool for the formulation of a regional framework plan and its integration into economic development plans. The various situation maps were presented individually to satisfy the needs of resource scientists who may wish to develop new map themes. The atlas also provides important decision maps that will assist planners, investors and small farmers to make sound decisions on land use as well as in their choice of crops and management systems.

There are three basic kinds of maps presented in the atlas:

a. Commodity Development & Soil Conservation Planning Guides; which include Rice, Corn, Coconut, Fruit Tree, Vegetable, Industrial Crops and Pasture Livestock Based System Maps.
b. Decision Maps; which include; maps that show Land Limitations, Cropping Systems and Hydro Ecological Conditions
c. Land Factor Maps; which include maps that show Slope Classifications, Land Use and Vegetation and Erosion

(1) BSWM's Slope and Erosion Maps

The slope maps at BSWM are published at a scale of 1:250,000 and they cover the whole country. These maps are published in the form of hardcopies. The slope classifications were prepared manually based on NAMRIA's 1:50,000 topographic maps. The slope classifications were determined by investigating the distance between contours using the terrain quantification method. Table 7.2 summarizes the slope classifications by region for the whole country. The classifications of slope used are as follows:

a. Level to near level (0-3% gradient)

b. Gently sloping to undulating (3-8% gradient)
c. Undulating to rolling (8-18% gradient)
d. Rolling to moderately steep (18-30% gradient)
e. Steep (30-50% gradient)
f. Very steep (>50% gradient)

Table 7.2 Distribution of Slope Classes by Region, 1991

	SLOPE CLASSES													
	Level to nearly level M (0-3%)	% of Total	Gently Sloping to undulating N (3-8%)	% of Total	Undulating to rolling O (8-18%)	% of Total	Rolling to moderately steep P (18-30%)	% of Total	Steep Q (30-50%)	% of Total	Very Steep R (>50%)	% of Total	TOTAL AREA (Ha.)	% of Phil Total
PHILIPPINES	6,563,424	22%	2,448,678	8%	4,690,589	16%	5,164,466	17%	4,986,911	17%	6,163,849	21%	30,017,917	100%
LUZON	3,442,039	24%	1,016,269	7%	1,926,147	14%	1,882,495	13%	2,097,249	15%	3,775,293	27%	14,139,492	47%
CAR	122,138	7%	44,743	2%	111,889	6%	251,482	14%	235,492	13%	1,063,624	58%	1,829,368	6%
I	485,382	38%	45,105	4%	47,555	4%	212,998	17%	189,973	15%	303,006	24%	1,284,019	4%
II	673,866	25%	163,464	6%	367,723	14%	406,316	15%	355,128	13%	717,261	27%	2,683,758	9%
III	810,555	44%	159,114	9%	234,164	13%	233,090	13%	234,577	13%	151,582	8%	1,823,082	6%
IV	981,574	21%	351,877	7%	819,406	17%	370,565	8%	790,586	17%	1,442,008	30%	4,756,016	16%
V	368,524	21%	251,966	14%	345,410	20%	408,044	23%	291,493	17%	97,812	6%	1,763,249	6%
VISAYAS	1,139,701	20%	422,671	7%	854,329	15%	1,313,708	23%	1,104,971	19%	843,155	15%	5,678,535	19%
VI	487,379	24%	190,503	9%	324,582	16%	418,820	21%	274,024	14%	327,002	16%	2,022,310	7%
VII	247,905	17%	114,080	8%	210,895	14%	330,401	22%	292,112	19%	304,547	20%	1,499,940	5%
VIII	404,417	19%	118,088	5%	318,852	15%	564,487	26%	538,835	25%	211,606	10%	2,156,285	7%
MINDANAO	1,981,684	19%	1,009,738	10%	1,910,113	19%	1,968,263	19%	1,784,691	17%	1,545,401	15%	10,199,890	34%
IX	373,518	20%	187,190	10%	430,122	23%	497,451	27%	252,181	13%	128,048	7%	1,868,510	6%
X	437,728	15%	405,722	14%	450,901	16%	392,407	14%	483,300	17%	662,712	23%	2,832,770	9%
XI	552,294	17%	248,048	8%	507,046	16%	693,276	22%	693,814	22%	474,812	15%	3,169,290	11%
XII	618,144	27%	168,778	7%	522,044	22%	385,129	17%	355,396	15%	279,829	12%	2,329,320	8%

Source : BSWM

The erosion maps at BSWM cover the whole country. These maps were based on a combination of field investigations, soil survey and interpretation of aerial photographs conducted from the mid seventies to the late eighties. Field investigation is still ongoing in selected areas. The NAMRIA 1:50,000 scale maps were used as a base for the erosion maps and were reduced to 1:250,000 for publishing. These maps are also published in the form of hardcopies.

Erosion is a critical environmental factor that is brought about by natural (rainfall intensities, flood, earthquake, surface runoff, etc) and artificial processes (harsh activities of man such as overlogging and shifting cultivation). BSWM's erosion maps can help in soil conservation activities.

All factors being the same, erosion increases with slope gradient and slope length. Erosion is also affected by land use and vegetation. Where the soil is left with little or no cover at all, infiltration is reduced and runoff is increased. Table 7.3 summarizes the distribution of erosion classes by region for the Philippines in 1991.

The classifications used by BSWM in the erosion maps are:

a. No apparent erosion (E0)

d. Slight erosion (E1)

e. Moderate erosion (E2)

f. Severe erosion (E3)

g. Unclassified erosion (EU)

Table 7.3 Distribution of Erosion Classes by Region, 1991

	EROSION CLASSES											
	NO APPARENT EROSION E0	% of Total	SLIGHT EROSION E1	% of Total	MODERATE EROSION E2	% of Total	SEVERE EROSION E3	% of Total	UNCLASSIFIED EROSION EU	% of Total	TOTAL AREA (Ha.)	% of Phil Total
PHILIPPINES	7,131,482	24%	8,995,318	30%	8,479,288	28%	5,082,156	17%	329,673	1%	30,017,917	100%
LUZON	4,081,268	29%	4,065,149	29%	4,127,613	29%	1,709,155	12%	156,262	1%	14,139,492	47%
CAR	130,367	7%	515,825	28%	737,134	40%	413,729	23%	32,313	2%	1,829,368	6%
I	514,881	40%	242,343	19%	262,226	20%	264,569	21%		0%	1,284,019	4%
II	726,022	27%	374,153	14%	1,158,953	43%	416,644	16%	7,986	0%	2,683,758	9%
III	923,250	51%	400,855	22%	323,659	18%	143,297	8%	32,021	2%	1,823,082	6%
IV	1,341,043	28%	1,896,162	40%	1,134,444	24%	317,337	7%	67,030	1%	4,756,016	16%
V	445,705	25%	635,856	36%	511,197	29%	153,579	9%	16,912	1%	1,763,249	6%
VISAYAS	1,240,751	22%	1,743,632	31%	1,444,384	25%	1,126,073	20%	123,695	2%	5,678,535	19%
VI	551,633	27%	541,365	27%	497,893	25%	391,721	19%	39,698	2%	2,022,310	7%
VII	181,247	12%	376,717	25%	558,010	37%	328,733	22%	55,233	4%	1,499,940	5%
VIII	507,871	24%	825,550	38%	388,481	18%	405,619	19%	28,764	1%	2,156,285	7%
MINDANAO	1,809,463	18%	3,186,492	31%	2,907,291	29%	2,246,928	22%	49,716	0%	10,199,890	34%
IX	354,500	19%	582,033	31%	705,116	38%	212,343	11%	14,518	1%	1,868,510	6%
X	330,216	12%	964,821	34%	920,531	32%	603,451	21%	13,751	0%	2,832,770	9%
XI	529,049	17%	1,090,510	34%	574,877	18%	966,174	30%	8,680	0%	3,169,290	11%
XII	595,698	26%	549,128	24%	706,767	30%	464,960	20%	12,767	1%	2,329,320	8%

Source: BSWM

(2) Plans to Improve Map Data at BSWM

The maps at BSWM are prepared mainly at scales from 1:250,000 to 1:500,000. The scales used limit the resolution of the map and could only be used for regional and strategic planning of land resources. Future updates of BSWM's atlas data to a higher resolution are planned on a per project basis. This is mainly dependent on requests from LGU's for more detailed maps of their area.

At the moment, most of the maps are still in analogue format. The BSWM also plans to digitize the atlas to make it usable for GIS, but this plan is hampered by lack of manpower.

(3) Recommendations to Use BSWM Data Effectively

Slope and erosion potential are important determinants of an area's susceptibility to landslide. Among BSWM's maps are slope and erosion potential maps for the whole country. Although these maps are published at 1:250,000 and were prepared manually, these data could still be used more effectively through converting the map data by digitizing so that it can be used for GIS analyses. Figure 8.5 shows an example of an erosion map converted to GIS format. Figure 8.6 shows a zoom up of Barangay Punta, San Fernando, Southern Leyte, site of the December 2003 landslide which killed 105 people and damaged 103 houses. This is an example of how BSWM erosion data can be overlaid on contour data to help assess hazards hazard. It can be seen from the map that most of the soil in Barangay Punta are classified as having a severe erosion potential. Combining this information with other physical and socio-economic factors, a risk model can be developed. It is also recommended that the contour data from existing 1:50,000 maps are digitized. From this, a more accurate slope classification map can be generated. Figure 8.7 shows an example of a slope map for Southern Leyte. The current slope classification map produced by BSWM was done manually. Computer techniques can be employed to reclassify slope areas to improve accuracy. This will also open up the possibility of further analyses combining slope, erosion and other data using GIS techniques.

7.6.2 PAGASA

The mandate of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) is to provide protection against natural calamities and utilize scientific knowledge as an effective instrument to insure the safety, well-being and economic security of all the people, and for promotion of national progress. The agency has a staff of 1200 personnel and has an annual budget of P 360 million.

The functions of PAGASA include the following:

a. Maintaining a nationwide network pertaining to observation and forecasting of weather and other climatological conditions affecting national safety, welfare and economy;
b. Carry out observations, collections, assessments and processing of atmospheric and allied data for the benefit of agriculture, commerce and industry;

c. Engage in studies of geophysical and astronomical phenomena essential to the safety and welfare of the people;
d. Carry out research on the structure, development and motion of typhoons and formulate measures for their moderation; and
e. Maintain effective linkages with local and international scientific organizations, and promote the exchange of scientific information and cooperation among personnel engaged in atmospheric, geophysical and astronomical studies.

Some of the most destructive weather events are short-lived, local disturbances. Until now, PAGASA has focused on slowly changing, large scale features of the atmosphere. This is because of the limits of operational systems used by the agency to monitor the atmosphere.

In addition, PAGASA forecasters have had only rudimentary computer systems to assimilate, analyze and communicate complex weather in near real-time. PAGASA has yet to provide warning of severe weather and flash flood that is satisfactory to the general public. At times, PAGASA had been able to react to events providing warnings of severe weather or flash floods after detecting these events, or after reports of actual occurrences. It has been difficult for PAGASA forecasters to predict small-scale violent weather, resulting in short lead times for warnings.

Unfortunately, problems besetting PAGASA prevent it from doing its mandated functions more effectively. These problems are mainly from lack of updated equipment and training of personnel. In 1997, PAGASA came up with a 6 year modernization program but none of the objectives have been implemented yet.

(1) PAGASA's 6 Year Modernization Program

Basically, PAGASA's 6 year program targets the following points:

a. Modernization of the physical resources and operational techniques through the acquisition of state-of-the-art instruments, equipment and facilities, with emphasis on weather and flood monitoring and warning system and agro-meteorological observation system to strengthen services for agriculture.
b. Intensification of human resources development to keep pace with rapid scientific and technological advances.
c. Upgrading of research and development capability through a more rationalized and totally integrated approach and identified activities, with focus on improvement of operations, as well as the development of specialized services for cost-recovery.
d. Establishment of regional service centers in strategic growth areas to broaden the agency's bases for service delivery to the countryside.

The agency's 6 year modernization program principally calls for a re-tooling of PAGASA with modern equipment and facilities. Targeted to be acquired are advanced observational and surveillance systems for

meteorological and hydrological elements, satellite-based telecommunications network, super-computers for data processing, analyses, and forecasting, computer-based workstations for generating increased volume of more detailed information. Weather surveillance radars capable of monitoring wind fields and cloud formation in three dimensions will enable PAGASA to advance its operational activity to "now casting".

The program also includes human resource development that emphasizes on professional education and training. It also calls for the establishment of five regional centers in five areas to improve delivery of services to the countryside.

The total estimated cost of the program in 1997 is 2.0 billion pesos.

(2) Focus of Improvements at PAGASA

For disaster management activities, focus should be given to rainfall data collection capabilities. At the moment, rainfall data is collected in 6 hour intervals. This should be improved to at least 1 hour intervals.

In heavy rainfall areas, more weather forecasting systems using weather surveillance radar should be installed. Only four areas have weather surveillance radar systems installed, they are Appari, Baler, Virac and Guiuan. With the exception of the radar in Baler, all these radars belong to the old generation of radars (Circa 60' s and early 70's). Of these four radar systems, only three are working, Guiuan is not orperational. There is no coverage for Mindanao. Other heavy rainfall areas should be considered for installation. Adopting these improvements is very important to disaster management. Figure 8.8 shows the existing Weather Surveillance Radar of PAGASA.

7.6.3 Office of Civil Defense (OCD)

(1) GIS in OCD

The Office of Civil Defense is the main coordinating agency for disaster management on a national scale. GIS at the agency started around 1998 with the purchase of ESRI GIS software. At the moment maintenance of GIS is under the charge of the Information Technologies Unit (ITU), which has a staff of three.

Digital data relevant for disaster management consists of databases mostly residing in the agency's Emergency Management Information System (EMIS). EMIS consists of several databases such as the Response Groups Database which catalogues government and private emergency response units. This database is the most used with about 1000 listed units. Another database is the Disaster Monitoring Database used to track disaster incidents. Some of the databases in EMIS are now available online through OCD's website on a test basis.

The OCD does not have much by way of digital maps to cover the whole country. In 2000, several GIS datasets were installed at OCD as part of a contract with a private company, most of the data though in concentrated in the Metropolitan Manila and is based on JICA's circa 80's base maps. To keep track of operations and incidents outside Metro Manila, NSO's DATOS digital maps are used. As mentioned in another section of this report, these are basically sketches of regional down to barangay boundaries prepared by field personnel involved in the 2000 census.

(2) Recommendations to improve data in OCD

Priority should be given to building GIS databases in OCD. This includes integrating data already residing in OCD. As a national agency coordinating operations throughout the country, OCD should be equipped with better base maps preferably at 1:50,000 scale showing more detail such as roads and river features. For some key areas, such as Metropolitan Manila, a scale of 1:5,000 to 1:10,000 is recommended. Other data relevant to disaster management such as public facilities on a national scale should be installed.

The databases included in EMIS at the moment are not integrated yet with GIS. Adding locational information to these databases will make the data more useful for disaster management. Response units together with countrywide disaster coordinating councils can be integrated with GIS maps to show the distribution of resources for disaster management. Disaster events should be catalogued and integrated with the GIS.

7.7 General Recommendation for Data Improvement for Disaster management

GIS analysis is a very powerful tool to analyze the different physical, social and economic factors that affect disaster management. Therefore there is a need to unify these varied types of information. A common or compatible standard digital format such as AutoCAD or Arcview should be adopted. Also, common coordinate systems should be used. PRS 92 is the recommended system to store data.

There is also a need to gather other data that come from private sector sources. On a national scale, lifeline data such as power, water and telecommunications utility facilities data should also be gathered. Based on previous experiences collecting data, these data are sometimes difficult to collect. Utility data especially those coming from the private sector are difficult to collect. The telecommunications industry in the Philippines is a very competitive field, telecom companies are usually hesitant to share data. Lifeline facilities can themselves be damaged during disasters; therefore knowing where these facilities are and knowing which facilities are vulnerable to damage are very important to disaster mitigation activities.

Chapter 8. Survey on Disaster Risk Management in the DCCs

CHAPTER 8. SURVEY ON DISASTER RISK MANAGEMENT IN THE DCCS

8.1 Purpose of the Survey

The PDCCs and some of the CDCCs throughout the nation were surveyed to better understand their capabilities and extent of efforts, including the available resources and budgetary allocations for disaster management. The questionnaire was designed to understand the experience of targeted regions on the following.

a. Past disasters, the amount and types of damage, and its cause
b. Type of effort spent on disaster damage recovery
c. Changes in disaster management systems before and after the experience
d. Type of effort taken for mitigation, emergency response, evacuation, and recovery
e. Available institutional and organizational structures

8.2 Methodology

Two types of approaches were taken for this survey. The first approach is an in-depth direct qualitative survey interview of key informants. Surveyors visited the disaster affected provinces or cities to interview disaster action officers or officer equivalent in the position. A total of 12 sample areas were selected for this type of survey, based on the historical disaster experiences. Table 8.1 shows the type of disaster and areas selected. The survey was conducted in the last two weeks of April 2004.

Table 8.1 Area Selected for Key Informant Survey by Disaster Type

Type of Disaster	Selected PDCC or CDCC
Flooding/ Landslide	Cagayan, Camarines Sur, Capiz, Mindoro Occidental, Southern Leyte
Earthquake	Baguio, Antique, Mindoro Oriental
Volcano Eruptions	Albay, Pampanga, Zambales, Batangas

The other approach taken is a qualitative survey conducted through the distribution of the questionnaire to respondents. The questionnaire was distributed to and collected from all 80 PDCCs through the OCD.

8.3 Responses

There are a total of 29 qualifying results that are assessed here: 1) 12 results coming from selected sample areas; and 2) 17 from PDCCs. The response rate was 36%. Table 8.2 shows the area profile of collected responses.

Table 8.2 Area Profile of Collected Responses

Region	Key Informant Q's (Y/N)	Province (PDCC/CDCC)	Experienced Disasters		
			Flooding / Sediment	Earthquakes	Volcanoes
II	Y	Cagayan	Yes	N.A.	N.A.
III	N	Bulacan	Yes	No	No
	N	Nueva Ecija	Yes	Cabanatuan 1990/7/16	Pinatubo 1991
	N	Tarlac	Yes	Cabanatuan 1990/7/16	Pinatubo 1991
	N	Nueva Ecija (San Jose City)	Yes	Cabanatuan 1990/7/16	Pinatubo 1991
	N	Tarlac (CDCC)	Not indicated	Cabanatuan 1990/7/16	Pinatubo 1991
	Y	Baguio (CDCC)	Yes	Cabanatuan 1990/7/16	N.A.
	Y	Pampanga	Yes	N.A.	Yes
	Y	Zambales	Yes	N.A.	Yes
IV	Y	Batangas	Yes	N.A.	Yes
	N	Quezon	Yes	Yes	No
	N	Marinduque	Not indicated	No	No
	Y	Mindoro Oriental	Yes	Yes	N.A.
	Y	Mindoro Occidental	Yes	N.A.	N.A.
V	Y	Albay	Yes		Yes
	N	Camarines Norte	Yes	No	No
	Y	Camarines Sur	Yes	N.A.	N.A.
	N	Catanduanes	Yes	No	No
	N	Sorsogon	Yes	No	No
VI	Y	Antique	Yes	Yes	N.A.
	Y	Capiz	Yes	N.A.	N.A.
VII	N	Cebu	Not indicated	No	No
	N	Siquijor	Not indicated	No	No
	N	Bohol	Not indicated	Bohol 1990/2/8	No
VIII	Y	Southern Leyte	Yes	N.A.	N.A.
X	N	Bukidnon	Yes	Yes	No
	N	Camiguin	Yes	No	Camiguin 1951/12/4
XII	N	Sultan Kudarat	Yes	Palimban 2002/3/6	No

Source: Survey on Disaster Risk Management in the PDCC/CDCC, 2004, the World Bank

8.4 Assessment of PDCC Survey

8.4.1 Characteristics of the Disasters

a. Out of the 29 answers, 25 provinces answered that they had been affected by flood-related disasters (8 by earthquake and 6 by volcanoes). Disasters related to water are the most common.

b. Out of the water-related disasters, floods, flash floods, and landslides are the predominant type of disasters that affected the provinces. Damages due to such disasters were caused by local heavy rain, extreme typhoon, tropical depression, and insufficient discharge of river. Major damages were to agriculture, properties, infrastructure/ lifelines, and people.

c. Of the provinces that experienced earthquakes, damages were mostly to properties (buildings, lifelines). Earthquakes induced many landslides, and ground cracks were seen in many places.

d. Of the provinces that experienced volcanic disasters, the damages were caused by pyroclastic flow, lava flow, volcanic gas, and volcanic ash (direct cause) and lahar. Damages were mainly to buildings, agriculture, people and fisheries.

8.4.2 Problems and Directions for Disaster Risk Management

a. All PDCCs responded that they had taken some kind of preparatory measures. Disaster management activities consisted mostly of the training of key personnel and drills in the community. However, these are difficult to execute on a regular basis due to the budget constraints and lack of resources that are needed in the activities.

b. The PDCCs considered that there was still a need for training of key personnel and for structural measures to be put into place. However, these could not progress, due to the budget constraints.

c. The PDCC answered that the regular communication/ information sharing between PDCC, MDCC and BDCC was done through telephone/ cell phone, radio, or meeting/discussion held quarterly or monthly.

d. Most of the PDCCs had some mitigation measures (93% answered yes). Major measures taken were: 1) information campaigns; 2) building and improvement of structures; and 3) afforestation. However, lack of funding is the largest constraint for the successful adoption of these measures. Sometimes, the negative attitude of people made adoption difficult. The PDCC considered that: 1) further improving of facilities/ structures; 2) allocating funds; and 3) organizing response team/ institution, were necessary actions to take up.

e. For evacuation, PDCC, MDCC, or BDCCs make the decision on the timing to evacuate. In some areas, local officers make this decision as well. In most of the cases, evacuation was effective; however in some cases the negative attitude of people and lack of evacuation centers made the process difficult. Improving evacuation centers and facilities is the highest concern for the PDCC.

f. For the emergency response, approximately 80% of the PDCC answered that there were constraints; the most important being the lack of equipment for emergency response, inadequate information, and the negative attitude of the people. Therefore, the PDCCs considered equipment procurement and training of the personnel are most important.

g. For effective rehabilitation, approximately 60% responded there were constraints, which could be mitigated through: 1) access to additional funding allocations; and 2) increased supplies needed for hazard management.

8.4.3 Data and Hazard Mapping Requirements for Disaster Risk Management

a. Approximately 70% of the PDCCs responded that they had created some kind of hazard map, because those commonly available are not accurate.

b. Almost all respondents answered that they had identified evacuation places and routes. People also knew the location and routes through dissemination of maps, etc. However, some of the PDCCs considered that the evacuation center was inadequate in its function, and the route was sometimes blocked and not passable.

8.4.4 Opinions and Suggestions for Disaster Risk Management

a. Many of the PDCCs considered a "Specific Permanent Unit" for continuous disaster management, essential. This should be set up with permanent trained personnel and with a regular allocated budget. The current system is not permanent and has a large influence owing to the change of administration.

b. Lack of funds for continuous activities is a large constraint for the PDCCs. Many of them considered it effective if the 5% calamity fund is available for preparedness and mitigation activities.

c. Training and drills of the PDCC members, LGU officials and people in the community for disaster management are considered very important for ensuring precision and spontaneity in responding to emergencies.

8.4.5 Other Issues

<u>Assessments from the Key Informant Survey</u>

a. Generally, the PDCC is not very active. However, those provinces that continually suffer from disasters or have suffered large damage in the past have a great concern for disaster management activities.

b. Active PDCCs are willing to integrate further information (such as the MGB hazard maps) to their plans, and eager to receive more information from relevant agencies.

c. For disaster information, the PDCC is generally very much dependent on PAGASA (or central agencies), and they put in a fairly limited effort. Some of the PDCCs also understand that the information given is not accurate for their area.

8.5 Conclusion

a. In the Philippines, water-related disasters are most common. Of these, flood, flash flood, and landslides are predominant. These are caused by local heavy rain, extreme typhoons, tropical depressions, and insufficient river discharges. Priority needs to be put into reducing vulnerability to water-related disasters for DCCs.

b. Many DCCs have been trying to put efforts for disaster management system development, for all stages of preparedness, mitigation, emergency response, and rehabilitation. Also, regular communication within and inter DCCs are under activation. However, lack of funds and human resources make it difficult to carry out continuous and in-depth activity, and as a result, their activities are found not to be very effective.

c. There is a problem of insufficient communication systems between PDCCs, MDCCs and BDCCs, which is a key constraint for information gathering on disaster areas before, during and after disasters. This is even clearer for remote areas, making it difficult to conduct early evacuation and response. It is necessary to consider improvement of communication systems between the DCCs.

d. The DCCs are generally very much dependent on central agencies, for example, on information distribution. Yet, the information of central agencies is not accurate for all of them. Strengthening of the information systems or the disaster management system of the central government agencies is the priority issue to assist the DCC. At the same time, the DCCs need to themselves put effort for effective disaster management activities.

e. Many of the DCCs hope to own "Specific Permanent Unit" for disaster management, such as the DCC of Albay (Bicol Region) which has created such a unit through legislative action, has allocated its own budget and trained personnel, and is continuously working on disaster risk management. Creating a permanent unit for disaster management through legislative action is one of the important strategies to consider.

f. Training, drills and education for the DCC members, LGU officials and people in the community are highly expected by the DCC. Training and drills on water-related disaster management are recommended to be prioritized.

Chapter 9. Summary of Findings and Recommendations

CHAPTER 9. SUMMARY OF FINDINGS AND RECOMMENDATIONS

9.1 Introduction

Based on an analysis and synthesis of information available from this follow-on study the findings and recommendations are summarized below. First, mechanisms of disasters including recommended directions for risk management are presented in detail, for each hazard. This is followed by recommended directions in four areas: 1) strengthening data networks, 2) preparing hazard maps, 3) developing risk models and 4) improving disaster management capacity. Finally, all the key recommendations are highlighted under the section on overall recommendations.

9.2 Mechanisms of Disasters and Directions for Risk Management

9.2.1 Flood, Sediment and Typhoon

(1) Based on an analysis of historical flood, sediment and typhoon damages, the mechanism of these disasters is found to be a manifestation of one or more of the following: 1) insufficient discharge capacity of rivers and weak resistance of slopes against erosion; 2) insufficient mitigation measures against floods and sediment disasters including landslide; 3) insufficient guidance to people for early evacuation; 4) insufficient evacuation networks in wider areas; 5) access road problems; and 6) insufficient rescue equipment.

(2) Conditions of flood, sediment and typhoon disasters will be influenced by the capacity of disaster management. Mitigation measures composed of structural measures (river improvement etc.) and non-structural measures (flood forecasting and warning systems, and reforestation etc.) are necessary to be taken up in a well-balanced and integrated approach. However, current disaster management is mainly concentrated on emergency response in a very ad hoc manner, and not so much focused on mitigation and preparedness.

(3) Although floods, sediment and typhoon disasters happen all over the country, eight particularly problematic areas in terms of affected persons or property damage (total or per-capita) are identified: 1) Northeastern Luzon including Cagayan River Basin; 2) Northwestern Luzon including Laoag and Abra River Basins; 3) Central Luzon including Agno, Pampanga, and the river basins around Mt.Pinatubo; 4) Metro Manila including Pasig-Laguna Bay River Basin; 5) Bicol and surrounding areas including Bicol River Basin; 6) Southern Luzon and Eastern Mindoro; 7) South and Northeastern Panay and Western Negros including Panay, Jalaur and Ilog-Hilabangan River Basins, and 8) Leyte and Northeastern Mindanao.

(4) Although the proportion of storm surge damage disasters seems to be small in the country, they cause destructive damages to poor coastal villages that depend on fishery. Due to the difficulty of accessing the damaged areas, the damage conditions by storm surge have not been made clear

until now. It is recommended to investigate the storm surge phenomenon and its damages from now on.

(5) Directions for improving floods, sediment and typhoon disaster risk management are as follows:

a. Provide structural mitigation measures for substantial flood and sediment control. It is advisable to consider the above high priority problematic areas for implementation of structural measures.

b. Provide non-structural measures such as: 1) reforestation to recover and enhance natural storage and resistance against rainfall runoff and slope erosion; 2) strengthening of rainfall and water level observation networks to capture spatial variability in rainfall and floods more accurately, and provide real-time information to DCCs for warning; and 3) preparation of hazard maps to control land use including housing in the hazard prone areas.

c. Promote early evacuation by strengthening evacuation centers, improving communication networks of the PDCC-MDCCs (CDCCs)-BDCCs, and educating people.

d. Establish wider evacuation networks as supporting systems by surrounding barangays and municipalities for the damaged barangays and municipalities.

e. Improve access roads and acquire alternative accesses to and from damaged sites.

f. Strengthen rescue activities (communication, facilities and equipment).

g. Improve disaster management capacity for floods, sediment and typhoon disasters. Strengthening coordination including funding arrangements among concerned agencies for mitigation and preparedness is recommended for well-balanced and integrated approach for enhancing the safety of flood plains and coastal zones.

h. Formulate Master Plans for the disaster risk management basin by basin.

9.2.2 Earthquake

(1) Throughout the 400 years of recorded earthquake history, occurrence of destructive earthquakes defined as those that rendered the buildings unfit for use, averaged approximately once in every seven years by available information.

(2) Active faults in the Philippines are distributed everywhere such that it is geo-technically difficult to define areas safe from earthquake occurrence. Other risks can be found in the socio-economic factors; areas with rapid population growth, high population density, and urban-structural vulnerability. Areas with high economic development, such as the area with high GRDP, will have a large damage impact if a disaster occurs. These areas can be stated as having a high risk potential.

(3) Based on several discussions with the key personnel in PHIVOLCS, the budget constraints on procuring basic equipment and funding hazard and risk evaluation activities is found to be the obstacle for sustainable disaster management. For example, the number of monitoring stations

and systems are small compared to Japan and Taiwan. Seismographs need is high and must be addressed, particularly for strong motion databases for the metropolitan areas so as to obtain the necessary basic data that will contribute to disaster management activities.

(4) Based on the analysis of historical impacts of earthquakes, there are four types of damages that may cause large casualties and economic losses:

a. Building damages by ground shaking. This type of damage has a high frequent occurrence possibility – and when and if it does occur, causes large casualties.
b. Liquefaction that causes local destruction with high casualties may occur.
c. Tsunamis have less frequent occurrence possibility, but if they do occur, cause the largest causalities.
d. Fire may spread depending on the condition of urban infrastructure. The casualties will be large if fire spreads.

(5) Following are the directions for improving earthquake disaster risk management:

a. Study the methodologies for strengthening/retrofitting four dominant building types distributed in the Philippines and implement the recommended measures. Area development in the populated area by private fund, and heavily populated area by public fund is another strategy to prevent building collapse.
b. Develop hazard maps on tsunami, liquefaction and earthquake-induced landslide. These maps play an important role for public awareness and earthquake disaster management. Development of liquefaction potential maps is important to avoid further property development in the vulnerable area. Tsunami and earthquake-induced landslide hazard maps are also important for disaster management, land use control, etc.
c. Fire break activities such as introduction of fireproof district through re-development or building development will have most effective result to reduce damage from fire spread. However, community empowerment of rescue operation and awareness on fire prevention will be effective in terms of practicability.
d. Strengthen infrastructure, especially those that play a vital role during emergency response. This can be achieved by securing the emergency road network and important public facilities such as hospitals and buildings that play a role as disaster management operation centers.
e. Educate the public and build capacity on disasters such as understanding the effect of tsunami, ground shaking, fire spread, liquefaction, and aftershocks to mitigate the damage and losses.
f. Strengthen monitoring systems for earthquake and tsunamis by introducing networked stations. Early warning and information dissemination systems, especially on tsunamis is vital for reducing the catastrophic impacts.

g. Conduct more research on locating the active faults (nation-wide) and evaluation of fault activities located near the metropolitan/ large cities.

(6) Areas with large populations and assets such as: 1) Greater Metropolitan Manila; 2) Metropolitan Cebu; and 3) Davao are the potential priority areas to focus on.

9.2.3 Volcanic Eruption

(1) According to the available data, there are 22 active and 27 potentially active volcanoes in the Philippines. Among these active volcanoes, six very active volcanoes are identified such as Pinatubo, Taal, Mayon, Bulusan, Canlaon and Hibok-Hibok. Pinatubo, Taal, Mayon and Hibok-Hibok volcanoes which have a history of very violent eruptions.

(2) Volcanic disasters will cause direct and indirect disasters. Direct disasters are caused by lava flow, ash fall, pyroclastic flow, base surge and gas ejection. Indirect disasters are caused by mudflow called lahar due to heavy rainfall. In these volcanic eruptions, lava flow, pyroclastic flow, base surge and gas ejection affect the nearby areas of the volcano location. However, ash fall will affect a much wider area, more than 100 km radius, depending on wind direction and velocity. Lahar will basically flow along the main river channels. Lahar will bury the river channels and cause flooding, especially in the rainy season or during typhoons accompanied by heavy rainfall. Lahar disasters last a very long time after big eruptions.

(3) Each volcano has its own characteristics of eruption. Eruption type and interval, period of activity and magnitude of eruption are different from each volcano. These characteristics of volcanoes should be clarified by detailed geological, geomorphological, geophysical and geo-chemical researches. Through the accumulation of scientific data and knowledge, future volcanic activity can be forecasted more accurately. Research should cover the several potentially active volcanoes which are located close to large urban areas.

(4) Existing monitoring systems of volcanoes need to cover both active and important potentially active volcanoes.

(5) In order to prepare a volcanic disaster management plan, it is essential to understand the potential hazard area by volcanic eruptions. Hazard mapping for the volcanic area is the first step. PHIVOLCS has already compiled Hazard Maps for 6 active volcanoes; however, resolution of the map needs to be improved by large scaled base maps for accurate hazard maps enabling detailed disaster management planning and risk analysis.

(6) Basic materials such as aerial photography and large scale topographic maps, satellite imagery, existing land use map, infrastructure and demographic data for volcanic area is mandatory to support the research work and disaster management planning for the volcanic area.

(7) Regional development plans for the volcanic area should be prepared together with disaster management planning to raise the level of living standards. Studies of the best utilization of the

volcanic resources such as tourism development including educational and environmental aspects should be conducted. Infrastructure development such as improvement of road networks and social facilities should also be planned.

(8) High priority areas to focus on are Taal and Mayon from the aspect of possible damage.

9.3 Directions for Strengthening Data Networks

9.3.1 Topographic Maps and Aerial Photographs

(1) As there are many old topographic maps of NAMRIA with scale 1:50,000 in the country, it is recommended to update the topographic maps to a larger scale, preferably 1:5,000 or 1:10,000 taking into account severe disaster (damage) prone areas as first priority.

(2) It is necessary to increase coverage of aerial photographs and update old ones by considering severe disaster prone areas especially sediment and landslide potential areas. Aerial photographs on highly urbanized areas shall be put in priority to develop existing land use conditions.

9.3.2 Rainfall and Water Level Observation Networks

(1) The current number of rainfall stations and water level gauging stations is too small to correctly catch the phenomenon of heavy rainfall and flood water in river basins. In order to catch this phenomenon correctly, it is recommended to increase the number of rainfall stations and water level gauging stations.

(2) Although real-time data of heavy rainfall and flood water level before and during disasters are mandatory for deciding early evacuation actions by LGUs and DCCs, these real-time data are generally are not available. Therefore, it is recommended to conduct observation of rainfall and water level by LGUs in cooperation with PAGASA (for rainfall) and DPWH (for water level).

9.3.3 Seismological and Volcanological Monitoring Networks

(1) The number of seismological and volcanological monitoring stations is not adequate to obtain basic accurate data. It is recommended to add at least 100 seismological stations to be evenly distributed across the country. Additional volcanological monitoring stations are recommended to be installed especially in the area of active and/or potentially active volcanoes.

(2) Detailed volcanic surveys of 16 active volcanoes besides the six very active volcanoes are the top priority. Potentially active volcanoes need to be evaluated for the possibility of future eruptions. For those judged active, at least one set of monitoring equipment is required to check on their volcanic activity.

9.3.4 Historical Event Information

(1) Past disaster records are very useful for understanding the characteristics of disasters, especially when the variety of new data cannot be obtained by equipment located throughout the nation, much depends on past records.

(2) Unfortunately data and information on disasters are scattered and collected by various organizations at different levels. These data are not gathered, collated and documented in a proper manner for future reference. It is therefore recommended to implement as soon as possible data and information management on disasters in the central office of OCD, and generate what are called Event Reports.

(3) Data on hazard, impact, cause and effect relationships, experiences and learning are very important. Hazard data includes observed or reported information on intensity, extent and duration of causal parameters like flood depth, wind velocity, etc. Disaster effects include casualties, property damage, content damage, business interruption, etc.

(4) Event reports should also be generated for future disasters in a much more planned and organized manner. Damage reconnaissance surveys should be undertaken by trained personnel soon after a disaster strikes and data on various aspects should be captured directly from the field.

9.4 Directions for Preparing Hazard Maps

9.4.1 Floods, Sediment including Landslide Disasters

(1) Hazard maps are necessary for managing land use including the control of housing in hazard prone areas – be it floods, sediment and/or landslides. Hazard maps of floods include a potential inundation area, maximum inundation depth, evacuation places and evacuation routes. Hazard maps of sediment / landslide include potential areas of landslide, deposition of unstable sediment, sediment flooding potential area with depth, evacuation places and evacuation routes.

(2) It is recommended to prepare hazard maps based on NAMRIA's topographic maps (1/50,000 or 1/10,000 scales), questionnaire survey on floods, sediment and landslide disasters, site reconnaissance, analysis by experts of flood, sediment and geology, and simulation (mainly for floods if necessary).

9.4.2 Earthquake Disasters

(1) For hazard map development for earthquakes, two types of maps are recommended. The first is the seismic hazard map for the whole country defined as a physical hazard map excluding potential damages. Examples are earthquake ground motion (PGA, MMI) and fire, following the earthquake. The second is the seismic micro-zonation map at scale 1:10,000 or larger for

use in the highly urbanized areas like metro Manila. These maps consider local site conditions like soil and, landslide and liquefaction potential to modify the macro map.

9.4.3 Volcanic Disasters

(1) Volcanic hazard maps for the six very active volcanoes have been compiled by PHIVOLCS. These hazard maps should cover other active volcanoes such as Mt. Parker. Basic scale of hazard maps should be improved especially for very active volcanoes to have more accurate information of volcanic disasters.

(2) In total, 27 potentially active volcanoes are distributed in the Philippines. Detailed volcanic surveys should be conducted on these potentially active volcanoes to clarify the future possibility of eruptions. Based on the findings of the detailed survey, hazard maps should also be prepared on these volcanoes according to priority.

9.5 Directions for Developing Catastrophic Risk Models

9.5.1 Model for Floods and Sediment Risks

1) The existing loss estimation on floods, sediment and typhoon disasters are conducted: a) during or just after the disasters; or b) through separate studies on a certain flood or sediment control projects. This is the same method as the River Basin Model described.

   The loss estimation during or just after disasters is conducted by concerned agencies such as DPWH, DA, DoH and LGUs through rough surveys and damage estimation. As the area-wise inventory data of assets is normally not available and time limitation for the survey and estimation, accuracy of the loss estimation of a) is rather low.

   Loss estimation through separate studies on a certain flood and sediment control projects is conducted by international or local consultants.

2) Risk models for floods are composed of a River Basin model and a Regional model. As the unit of floods is river basin, the River Basin Model is the basic model, and preferably shown on 1:50,000 or 1:10,000 topographic maps. The River Basin Model is developed based on flood surveys of recent major floods, and hydrological and hydraulic simulation. It is composed of physical models including the flooding area, maximum flood depth and duration of floods. In addition to the River Basin Model, Economic/Financial model for estimating losses can be developed.

3) To know the effects of floods in the region and country, Regional Models for monetary damage will be developed to estimate regional damages by floods. Regional Models can be developed by summing up the River Basin Models in a region, or basing it on historical provincial and

regional damage reports of DCCs. However, the latter model is recommended for provisional application due to insufficient data of each river basin in a region.

4) As sediment / landslide disasters happen in more limited areas than floods, the River Basin Model will be the basis for developing risk model.

5) In order to increase accuracy of the risk models for floods or sediment including landslides, improvement of topographic maps and landuse maps, strengthening of meteo-hydrological observation networks and improvement of an assets database must necessarily be conducted from now on.

9.5.2 Model for Earthquake Risks

(1) Risk modeling for economic and financial risks and for the development of risk maps, preferably at scales of 1:50,000 or larger is recommended.

(2) The risks to population and physical assets need to be modeled. The physical assets at risk are buildings and public infrastructure.

(3) Metro Manila requires a more detailed and micro level assessment of risks due to the high exposure and economic value concentration.

9.5.3 Model for Volcanic Risks

(1) For the risk modeling of volcanic hazard, it is essential to understand the potential hazard area based on the collection of scientific data on volcanic characteristics of eruptions. Based on the geological data, type of eruptions, magnitude and affected area can be assumed. Hazard maps should be prepared as the first step to identify the potential danger area around the volcano.

(2) For risk analysis of volcanic hazard, existing socio-economic, infrastructure and population data should be mapped at a detailed scale. These data should be combined with the hazard map and regional hazard risk should be evaluated in terms of damage area, type of assets and cost.

(3) Volcanic disaster management plans, incorporating both structural and non-structural measures should be prepared based on these findings.

9.6 Directions for Improving Disaster Management Capacity

(1) Development of a disaster management information system (DMIS) is the first step to improving existing disaster management capacity of concerned agencies. Accurate and timely information on disaster management should be collected and disseminated through the national agency to local municipality. Existing data collection and dissemination system of NDCC should be improved through introduction of new databases, software and information technologies, equipment and human resources development.

(2) The world is developing into being an information and knowledge society – especially with the emphasis on Information Technology and transparent e-governance. The need for sharing of

data today is unprecedented. Amongst the variety of datasets that would be involved, spatial (or map) information will be major "content". These spatial information sets are vital to make sound decisions at the local, regional and national level planning, implementation of action plans, infrastructure development, disaster management support, and business development. Natural resource management, flood mitigation, environmental restoration, land use assessments and disaster recovery are a few examples of areas in which decision-makers are benefiting from spatial information. Spatially referenced data and information on a wider variety of topics or themes (e.g., population, land use, economic transactions, hydrology, agriculture, climate, soils) are being produced, stored, transferred, manipulated and analyzed in digital form. With the availability of satellite-based remote sensing data and the organization of spatial databases around a Geographical Information System (GIS), combined with the Global Positioning System (GPS), the process of semantic spatial information systems has now become a reality. Using GIS technology, users are now able to process maps – both individually and along with tabular data and "crunch" them together to provide a new perception – the spatial visualization of information. In this context, the establishment of National Spatial Data Infrastructure (NSDI) would be the right direction for the country. The NSDI must aim to promote and establish infrastructure at the national level for the availability of organized spatial (and non-spatial) data and multi level information networking to contribute to local, national and global needs of sustainable development, economic growth and social progress.

(3) Evaluation of disaster data and information needs to be supported by capacity building. Training of the authorities/officials involved in disaster management is very important to make sure they make informed decisions. Survey results of the PDCCs indicated that many consider the training of the disaster management personnel to be very important, and are willing to have such training. Disaster management training for MDCCs and BDCCs should also be promoted because these personnel are the key in local disaster management. Preparation of a basic training kit in disaster management for MDCCs and BDCCs should be undertaken. National research agencies related to natural disasters such as Universities, PHIVOLCS and PAGASA should support this aspect of disaster management.

(4) Community based disaster management should be promoted. According to the past disasters in the world, community people have to survive by themselves for at least 72 hours. Therefore, it is important to raise people's awareness on disaster management through community activity, school education and training.

(5) In order to develop a national framework plan for integrated disaster risk management as recommended in the initial study the following feasibility studies are recommended.

a. Emergency communication and early warning systems
b. Information Technology including DMIS and NSDI

c. Risk management including risk transfer and insurance
d. Seismic microzonation
e. Vulnerability analysis and risk assessment
f. Damage and loss estimation methodology
g. Review of building codes
h. Institutional setup including legal aspects

9.7 Overall Recommendations for Improving Disaster Risk Management

1. Strengthen data observation, collection and dissemination networks, and standard mitigation practices for each hazard.
2. Establish a Disaster Management Information System (DMIS) to collect and disseminate information including warnings to all stakeholders.
3. Establish National Spatial Data Infrastructure (NSDI) to collect, store and share organized spatial (and non-spatial) data.
4. Prepare hazard maps of varying scales for planning and mitigation. Micro zoning, especially in case of earthquakes, needs to be undertaken on priority in urban concentrations like MMR.
5. Develop catastrophe risk models to forecast losses from future potential disasters and prepare risk maps of various scales.
6. Undertake feasibility studies on various aspects of disaster management to develop and implement an integrated disaster risk management plan.

Figures

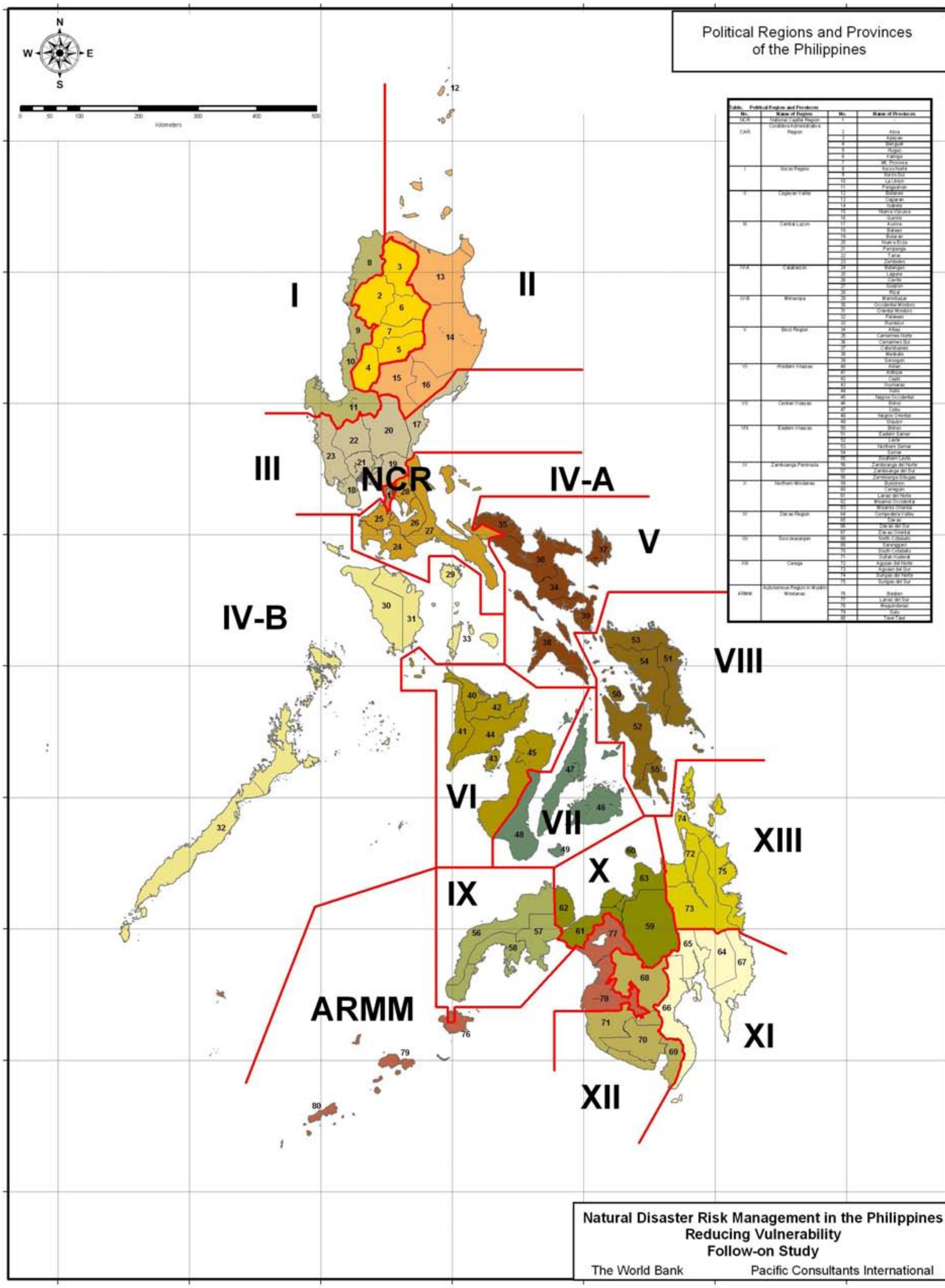


Figure 1.1 Political Regions and Provinces of the Philippines

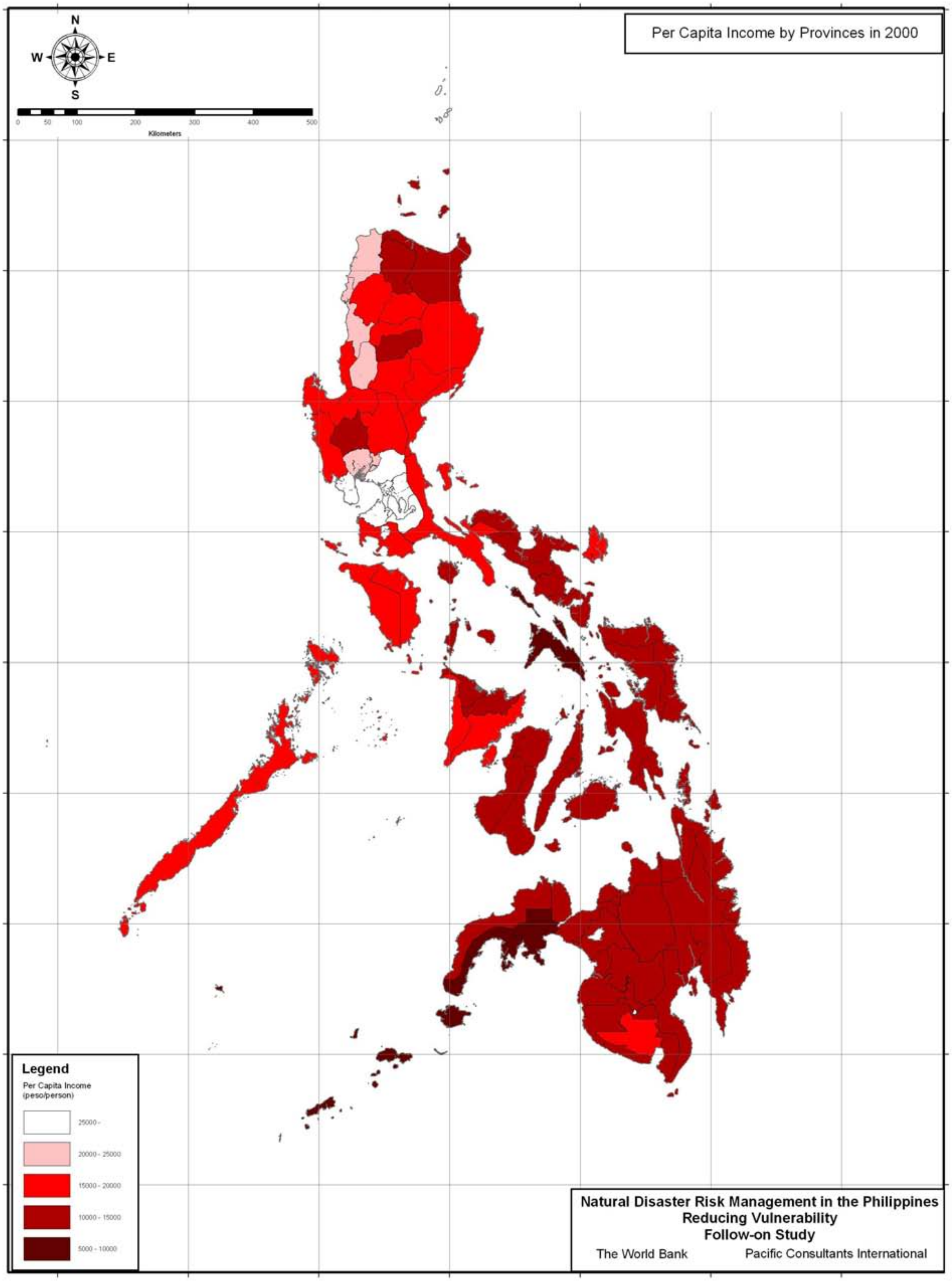


Figure 1.2 Per Capita Income by Provinces in 2000

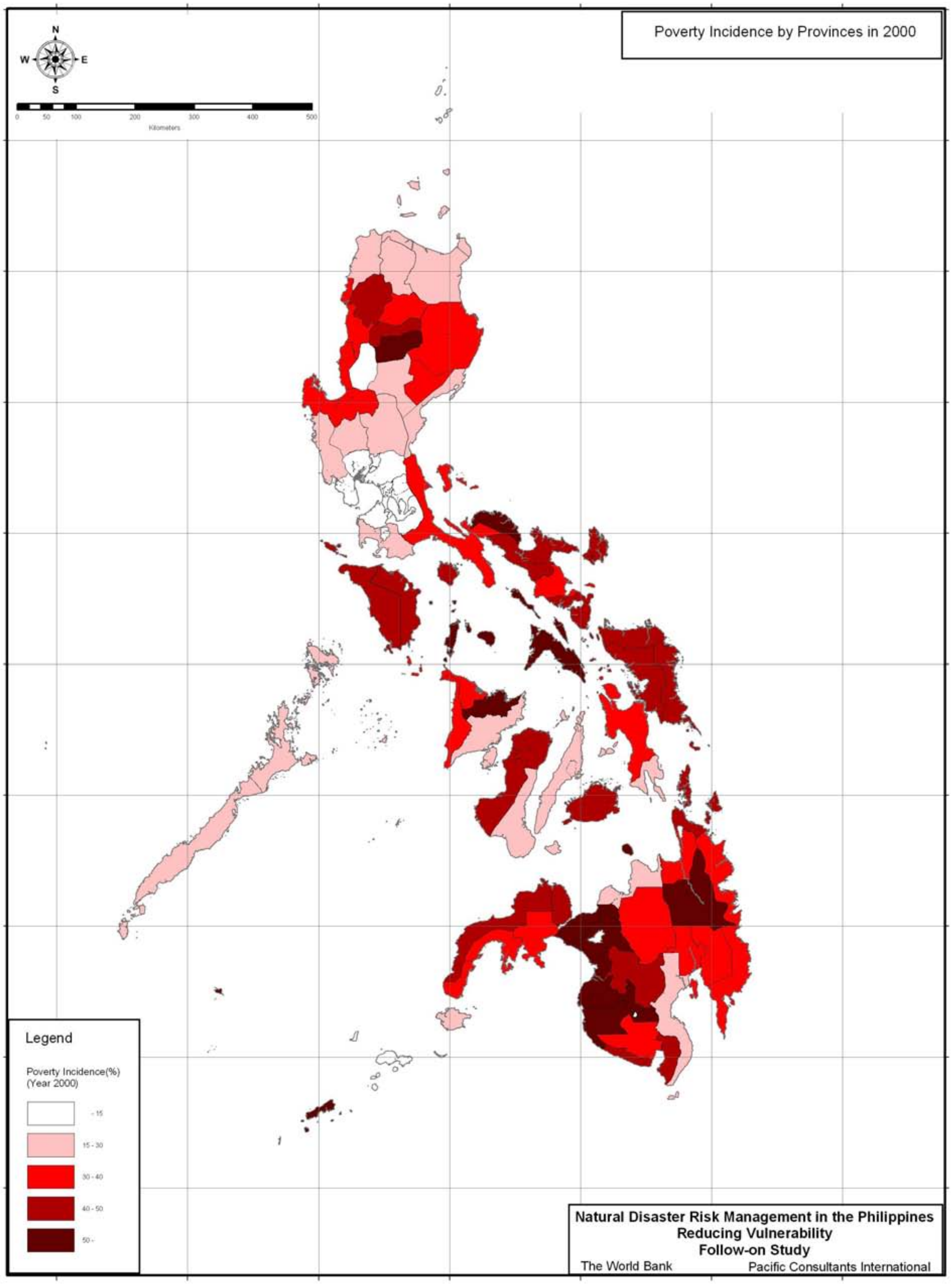


Figure 1.3 Poverty Incidences by Provinces in 2000

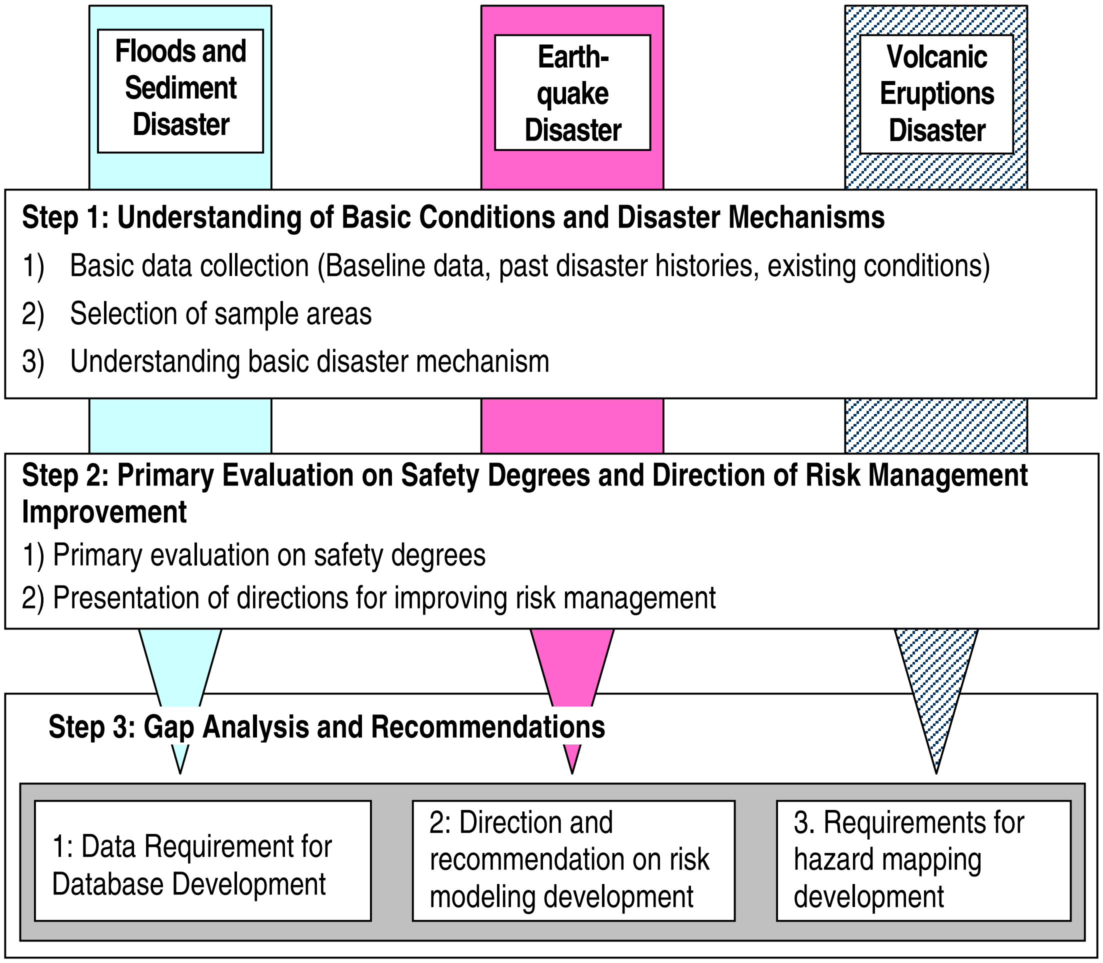


Figure 1.4 General Flow of the Study

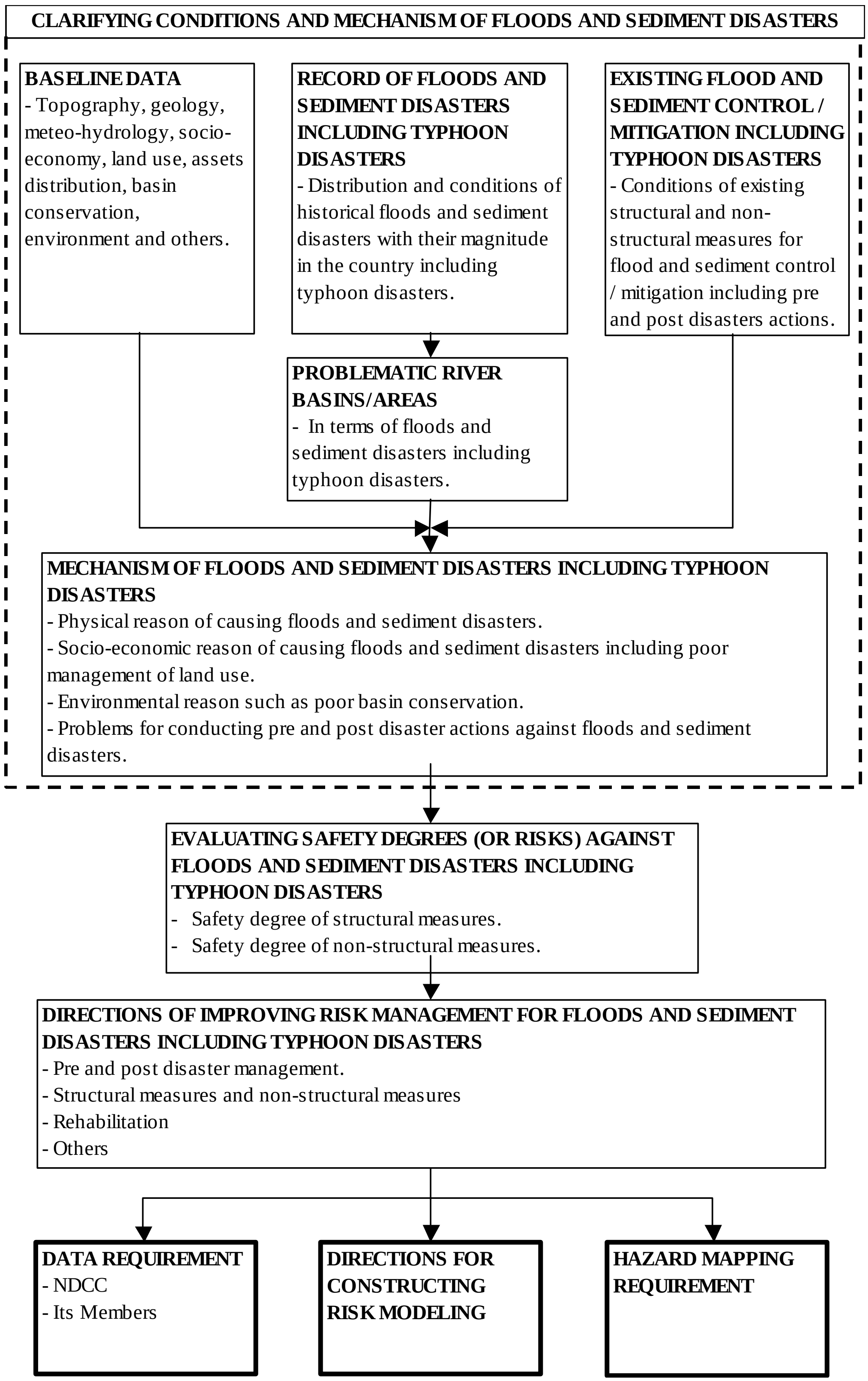


Figure 1.5 Basic Approach of the Study on Floods and Sediment Disasters

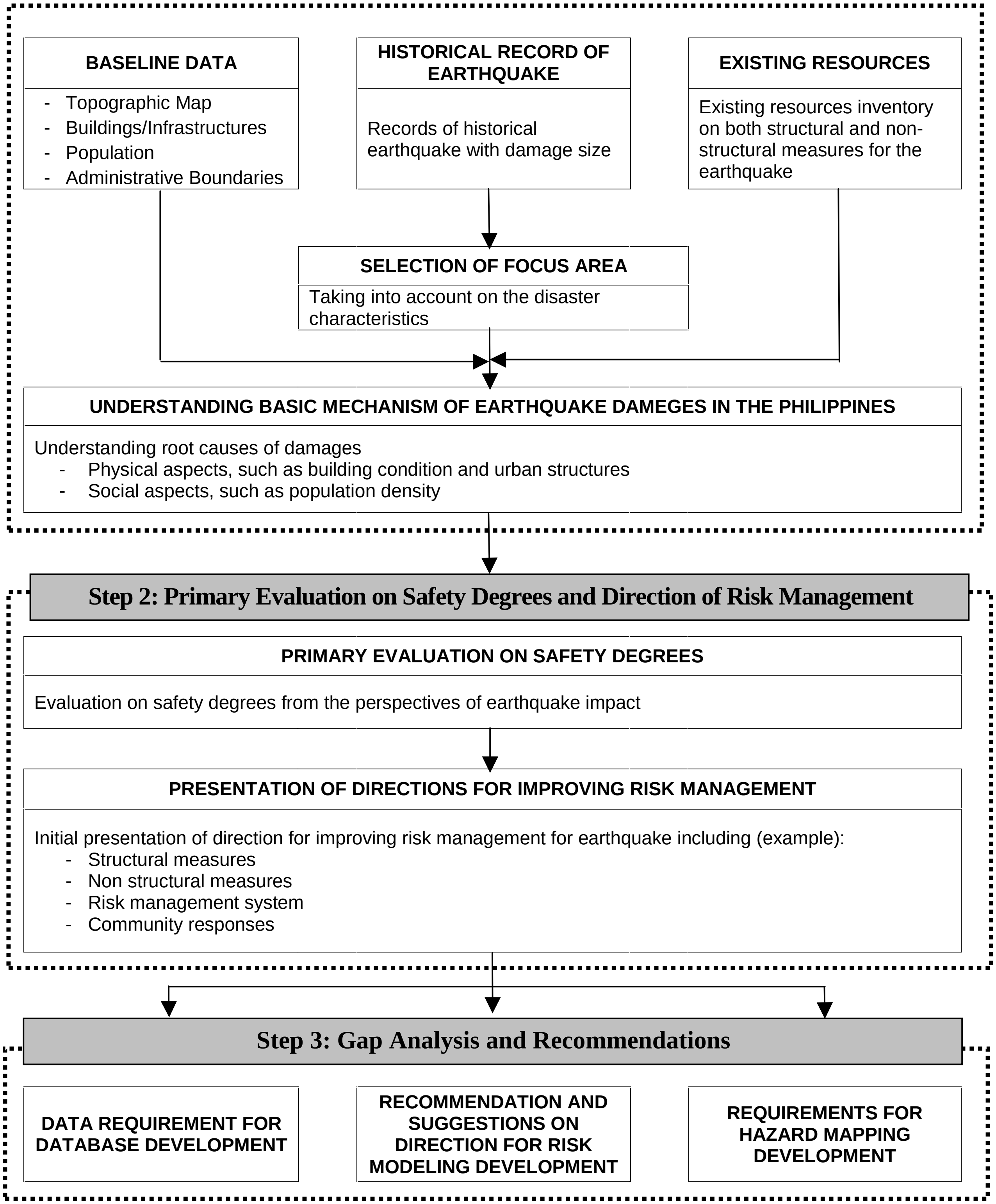


Figure 1.6 Basic Approach of the Study on Earthquake Disaster

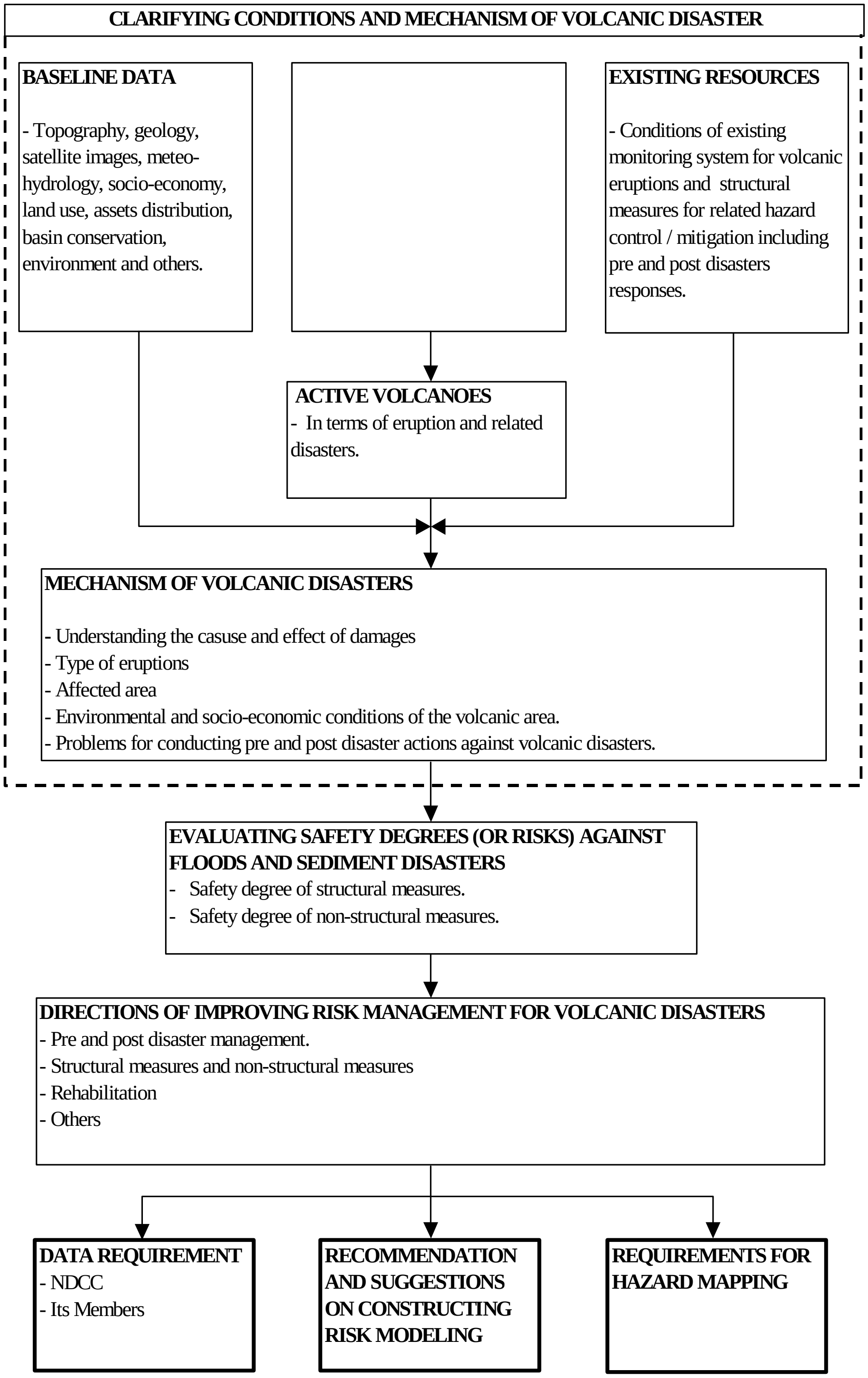
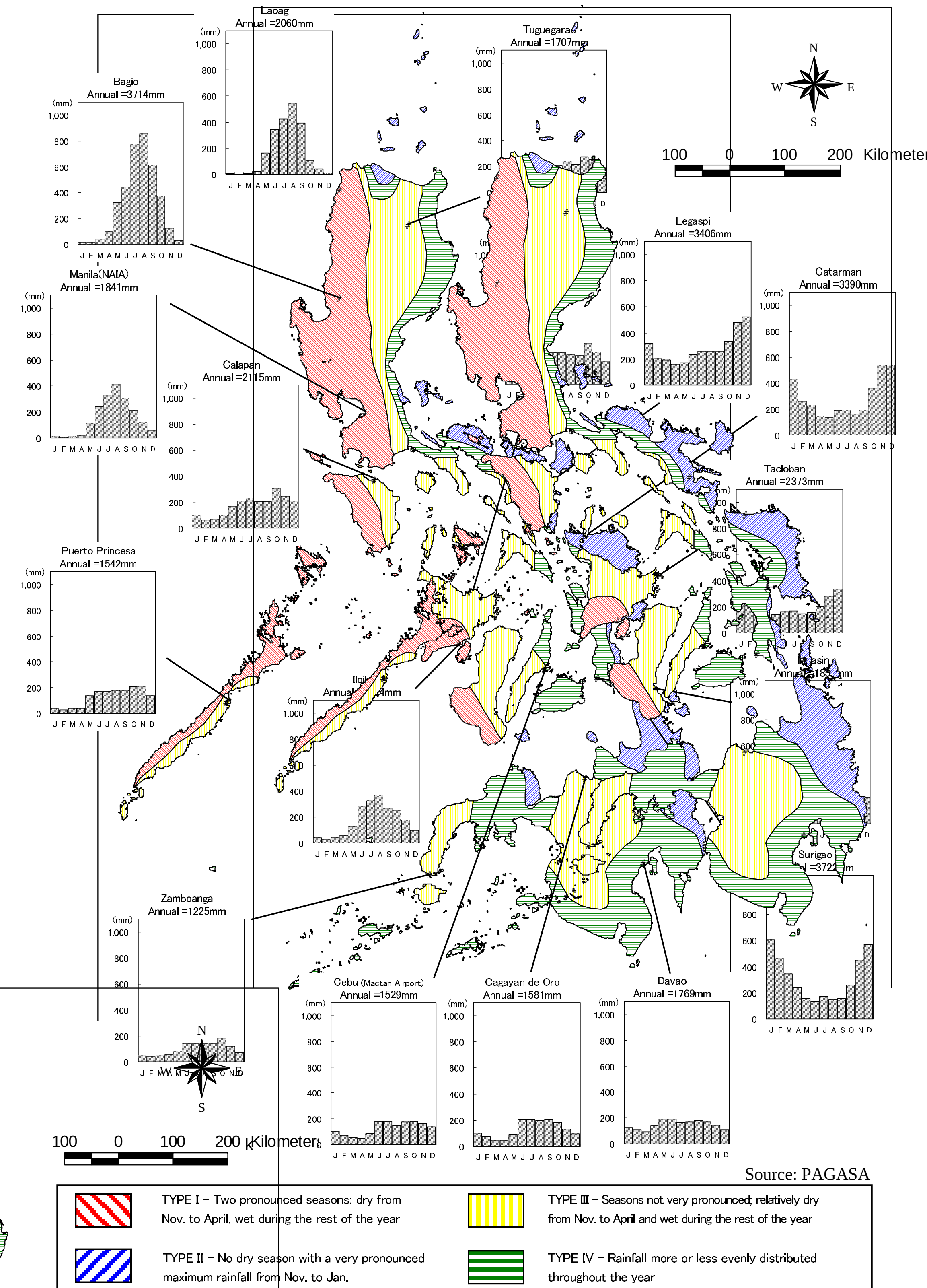
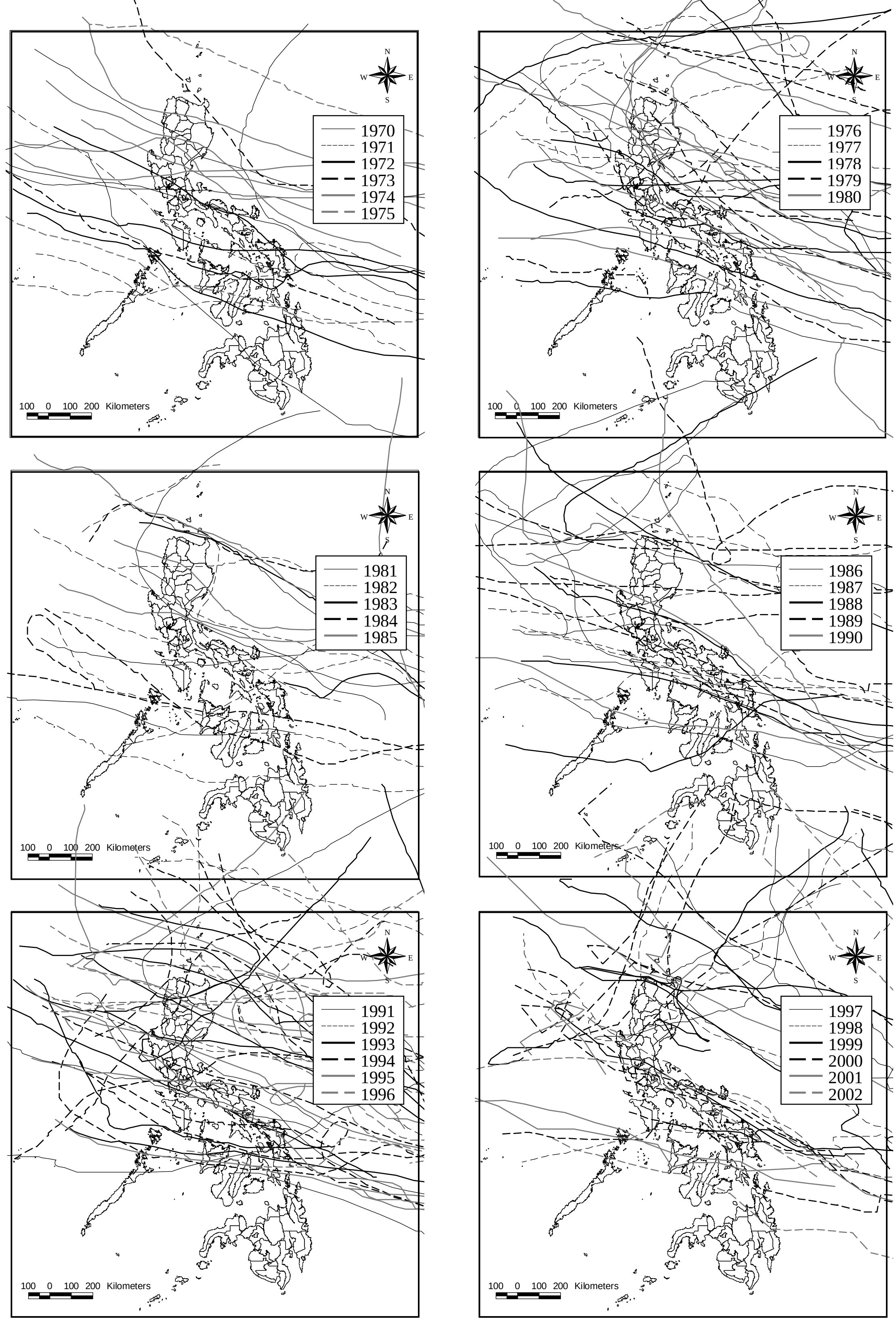


Figure 1.7 Basic Approach of the Study on Volcanic Disaster



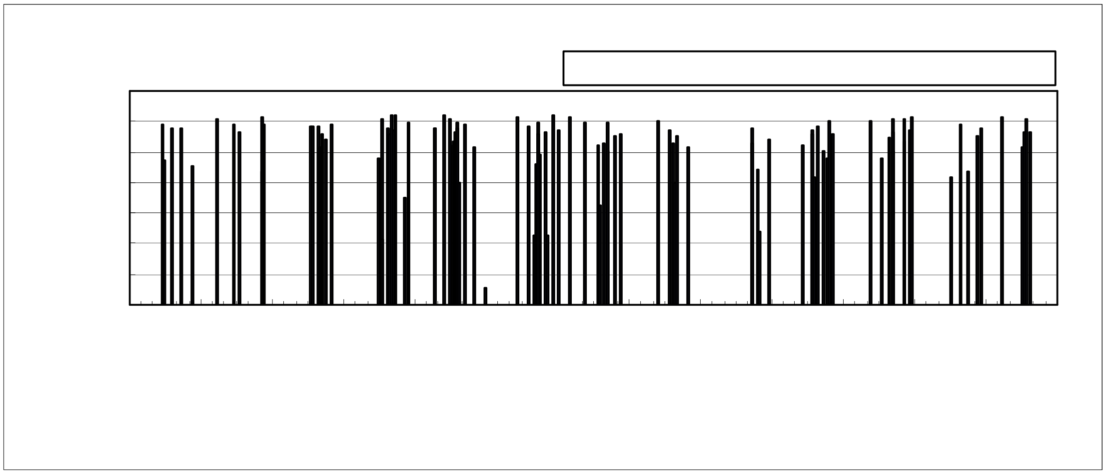
Source: PAGASA

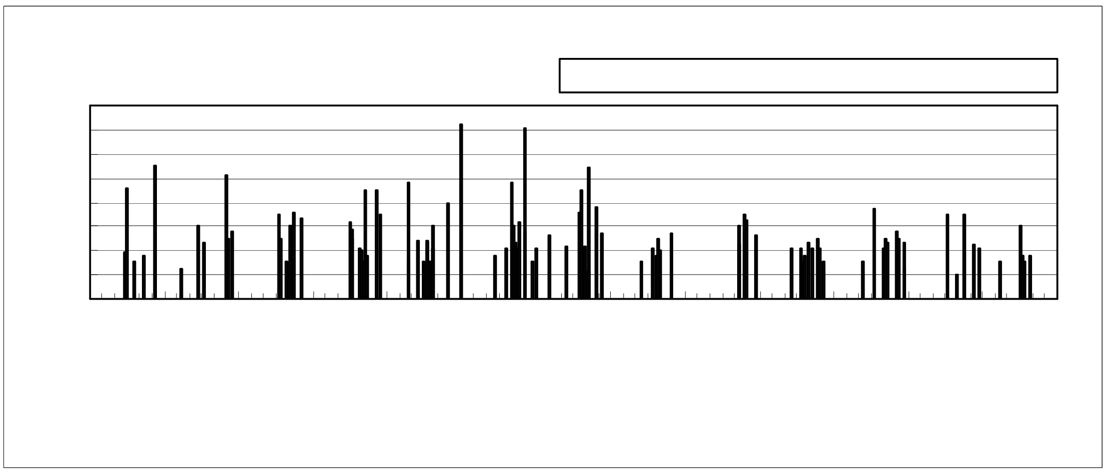
Figure 3.1 Climate Types and Monthly Rainfall Patterns in the Philippines

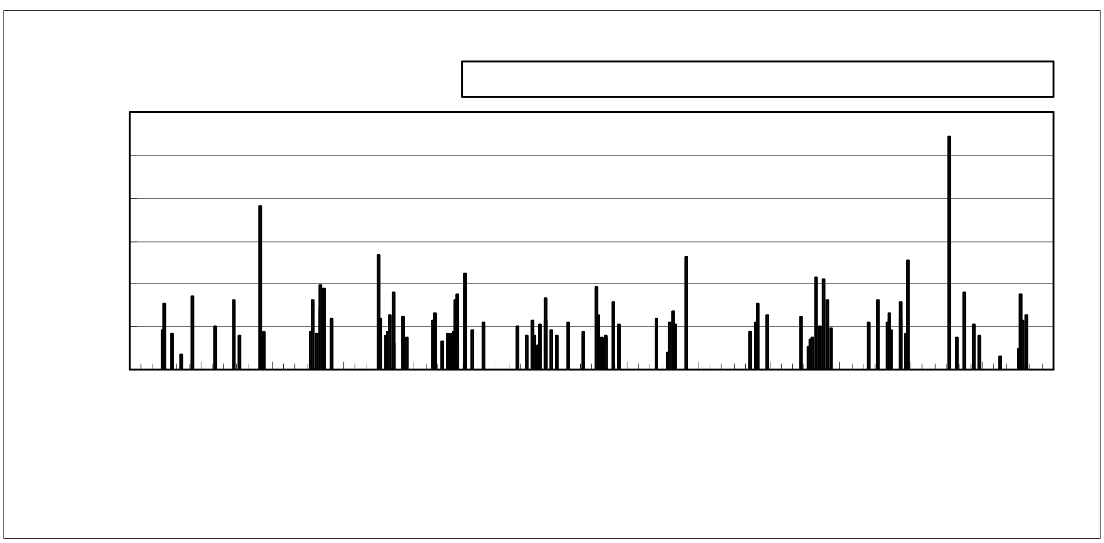


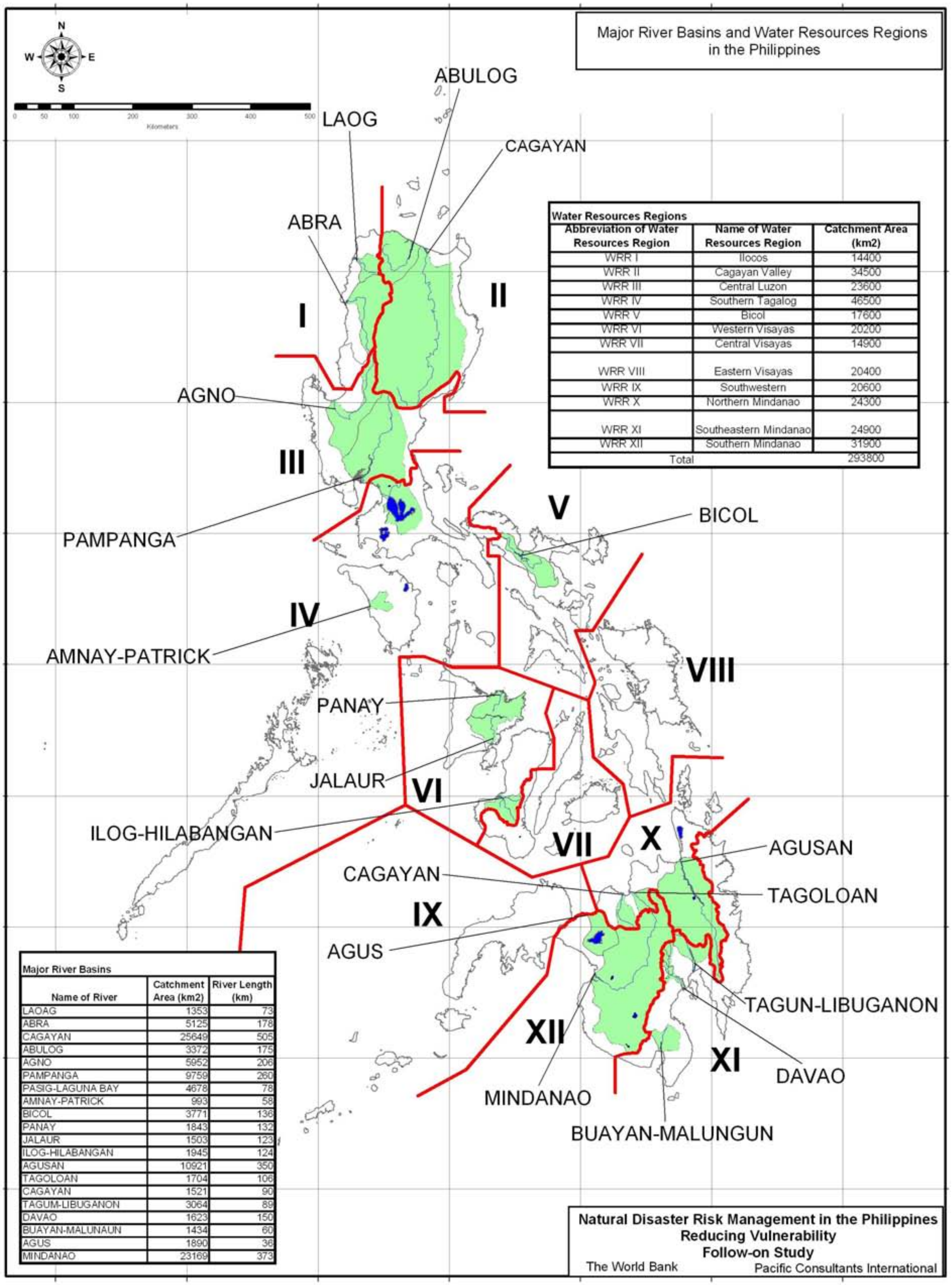
Source: PAGASA

Figure 3.2　　Destructive Typhoon Tracks from 1970 to 2002









Water Resources Regions

Abbreviation of Water Resources Region	Name of Water Resources Region	Catchment Area (km2)
WRR I	Ilocos	14400
WRR II	Cagayan Valley	34500
WRR III	Central Luzon	23600
WRR IV	Southern Tagalog	46500
WRR V	Bicol	17600
WRR VI	Western Visayas	20200
WRR VII	Central Visayas	14900
WRR VIII	Eastern Visayas	20400
WRR IX	Southwestern	20600
WRR X	Northern Mindanao	24300
WRR XI	Southeastern Mindanao	24900
WRR XII	Southern Mindanao	31900
Total		293800

Major River Basins

Name of River	Catchment Area (km2)	River Length (km)
LAOAG	1353	73
ABRA	5125	178
CAGAYAN	25649	505
ABULOG	3372	175
AGNO	5952	206
PAMPANGA	9759	260
PASIG-LAGUNA BAY	4678	78
AMNAY-PATRICK	993	58
BICOL	3771	136
PANAY	1843	132
JALAUR	1503	123
ILOG-HILABANGAN	1945	124
AGUSAN	10921	350
TAGOLOAN	1704	106
CAGAYAN	1521	90
TAGUM-LIBUGANON	3064	89
DAVAO	1623	150
BUAYAN-MALUNAUN	1434	60
AGUS	1890	36
MINDANAO	23169	373

Figure 3.4 Major River Basins and Water Resources Regions in the Philippines

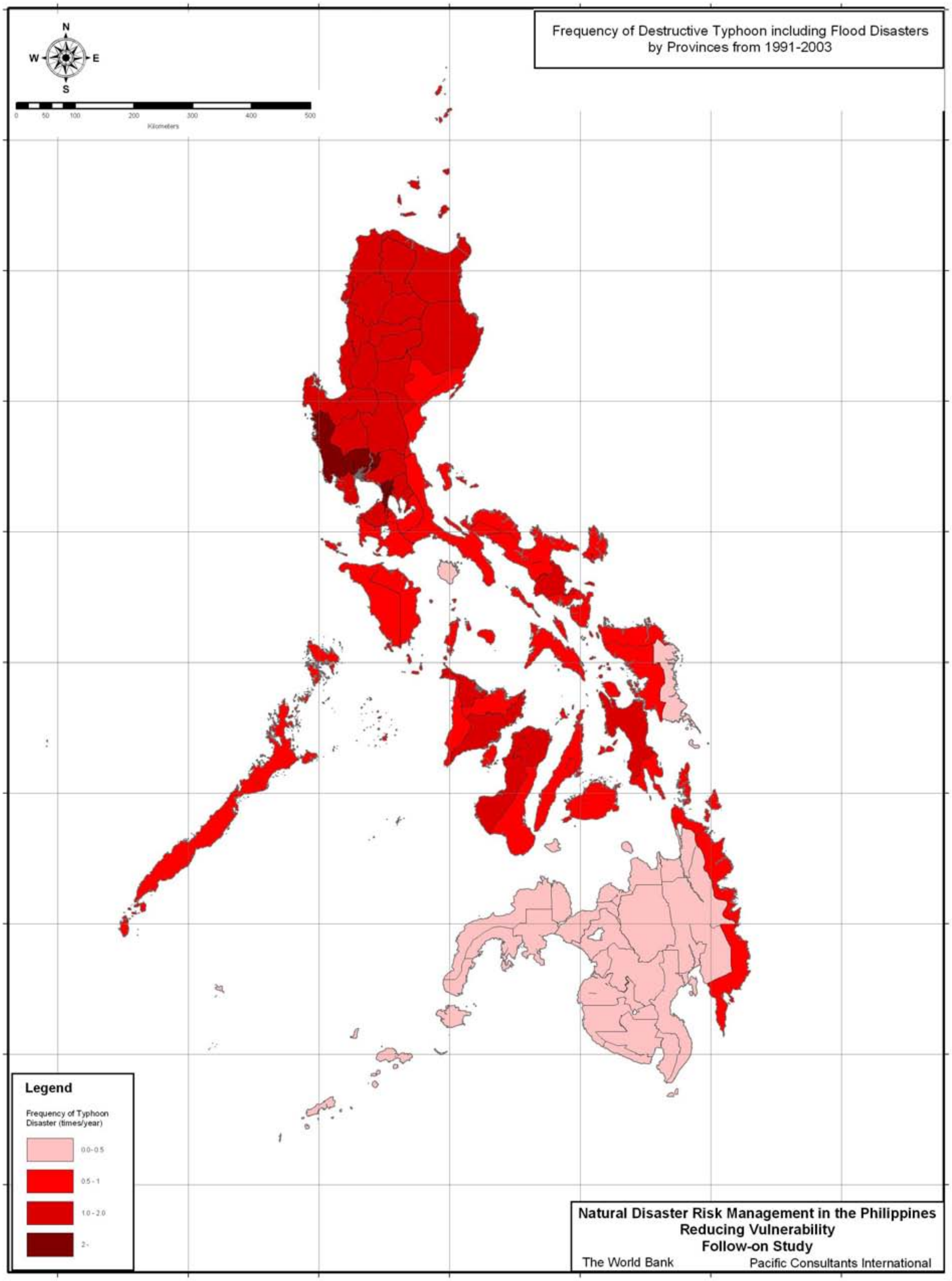


Figure3.5 (1) Frequency of Destructive Typhoon including Flood Disasters by Provinces from 1991-

2003

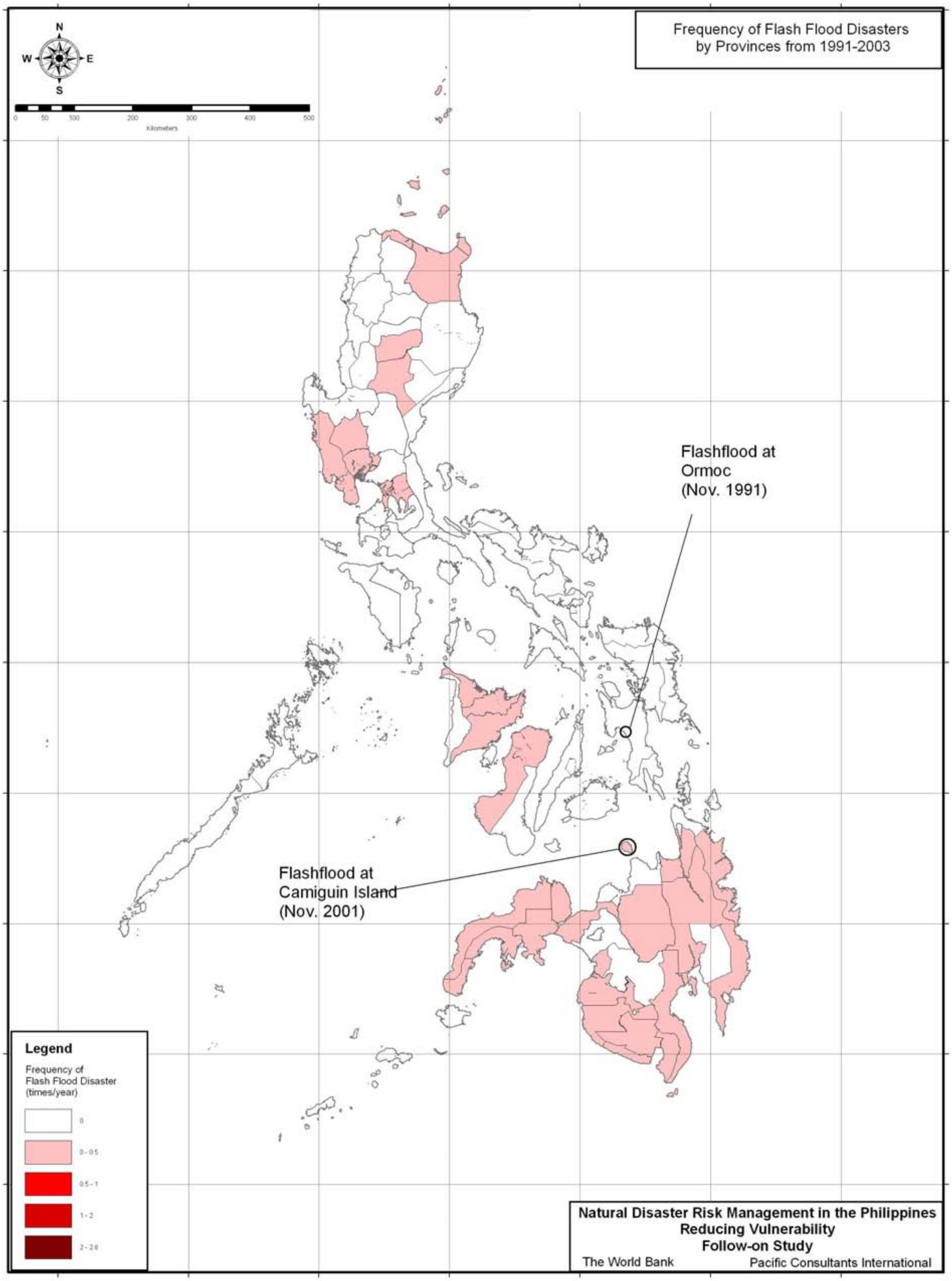


Figure 3.5(2) Frequency of Flashflood Disasters by Provinces from 1991-2003

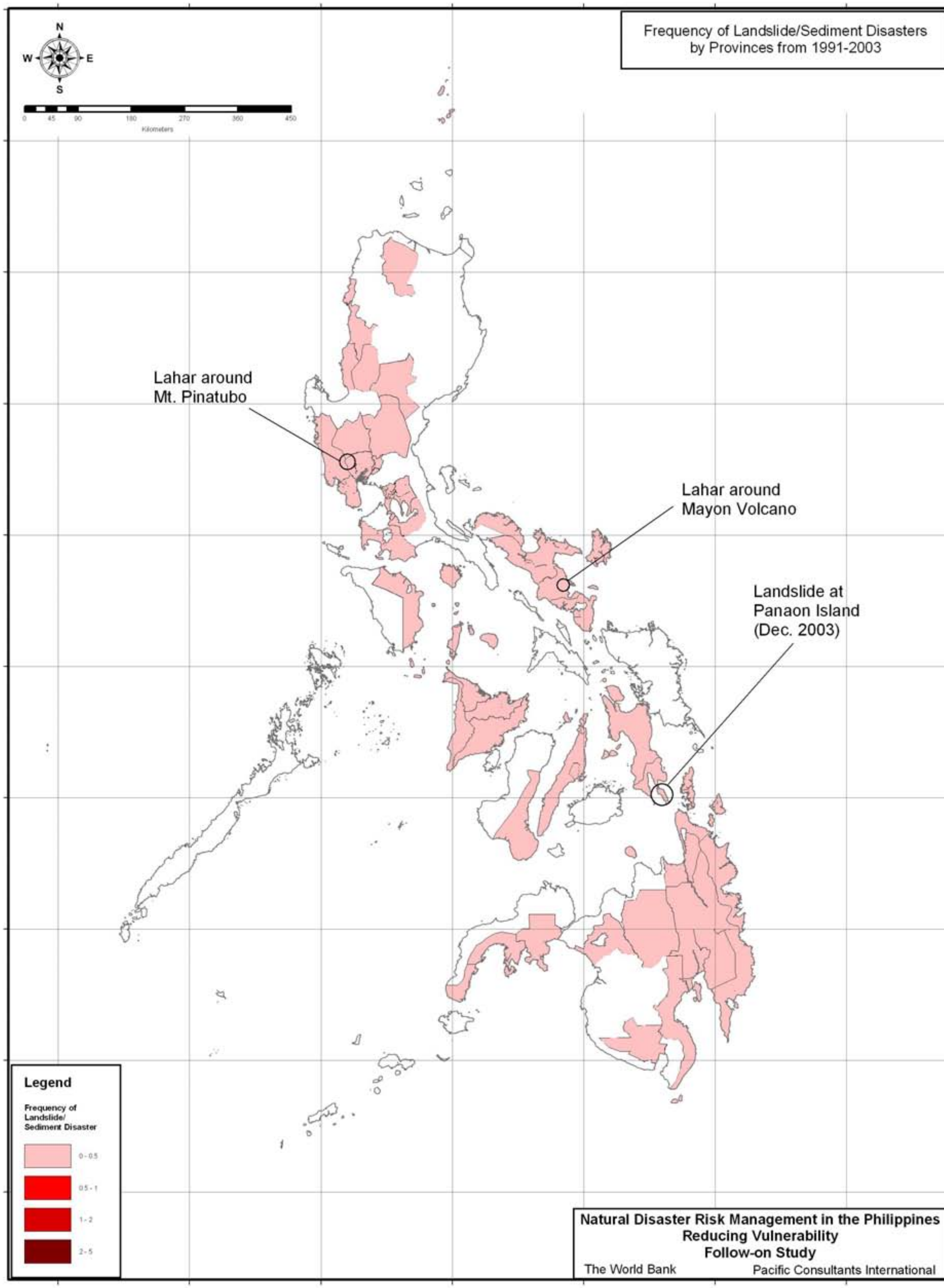


Figure 3.5(3) Frequency of Landslide / Sediment Disasters by Provinces from 1991-2003

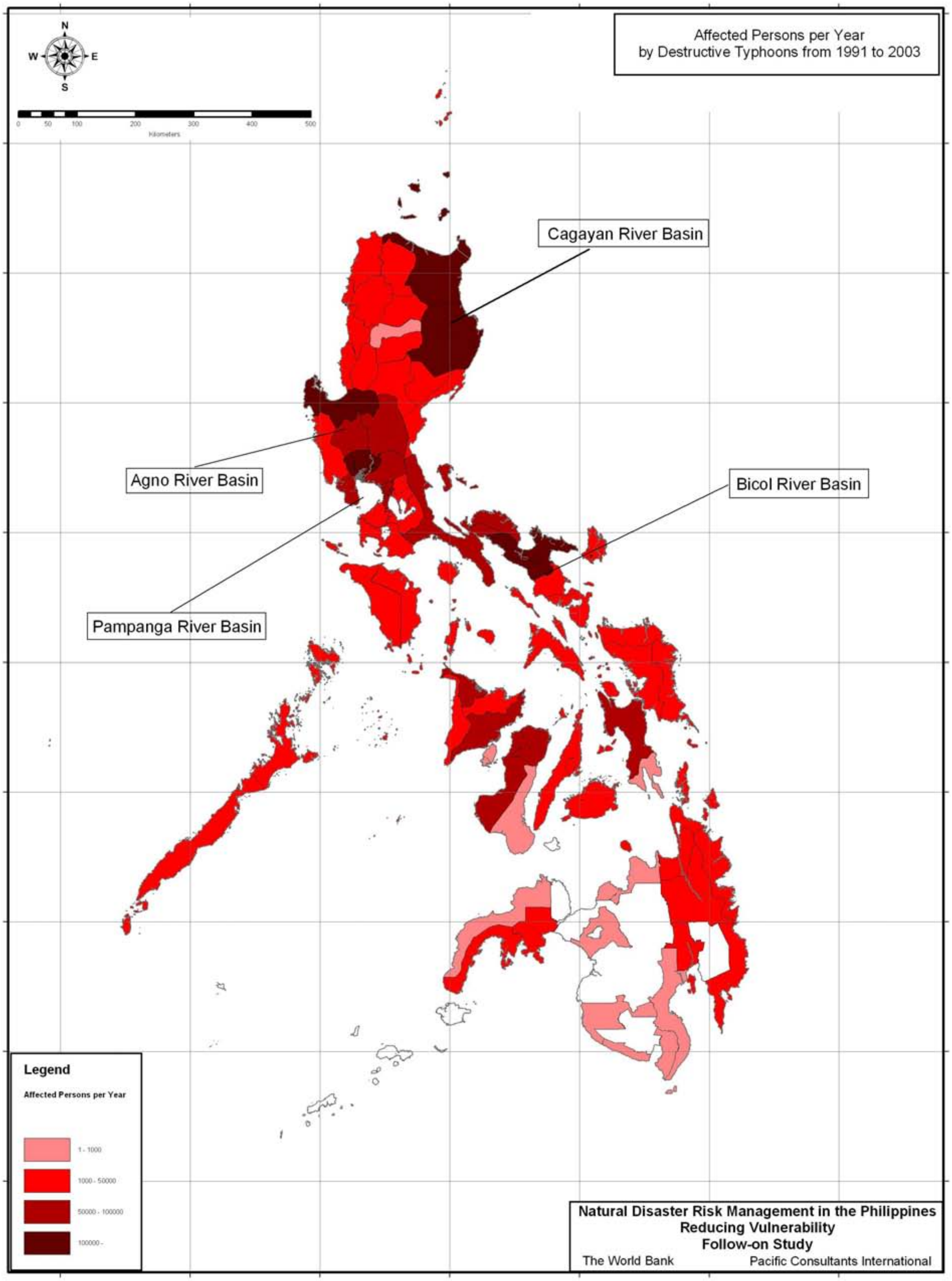


Figure 3.6 Affected Persons per Year by Destructive Typhoons from 1991 to 2003

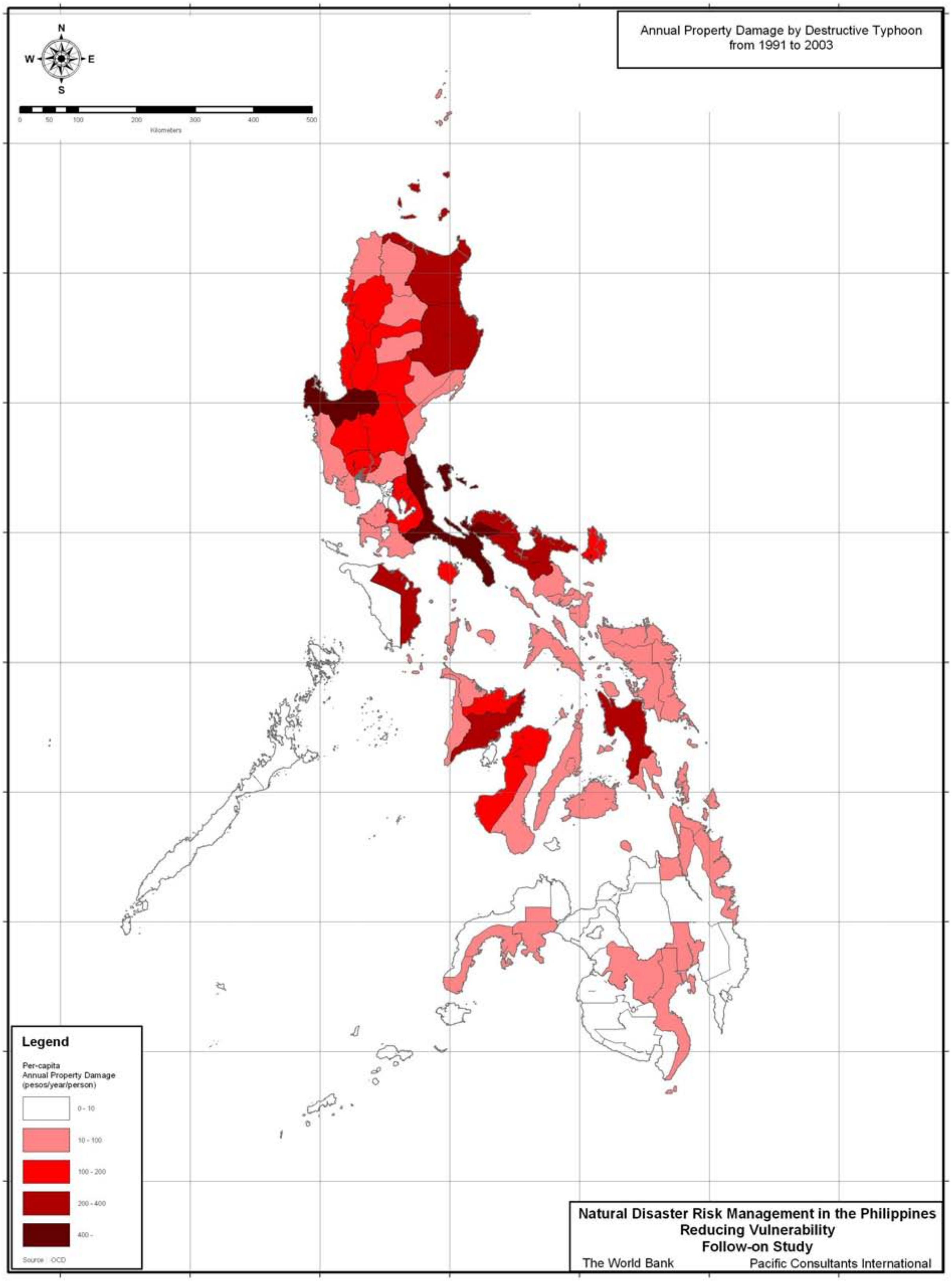


Figure 3.7 Annual Property Damage by Destructive Typhoons from 1991 to 2003

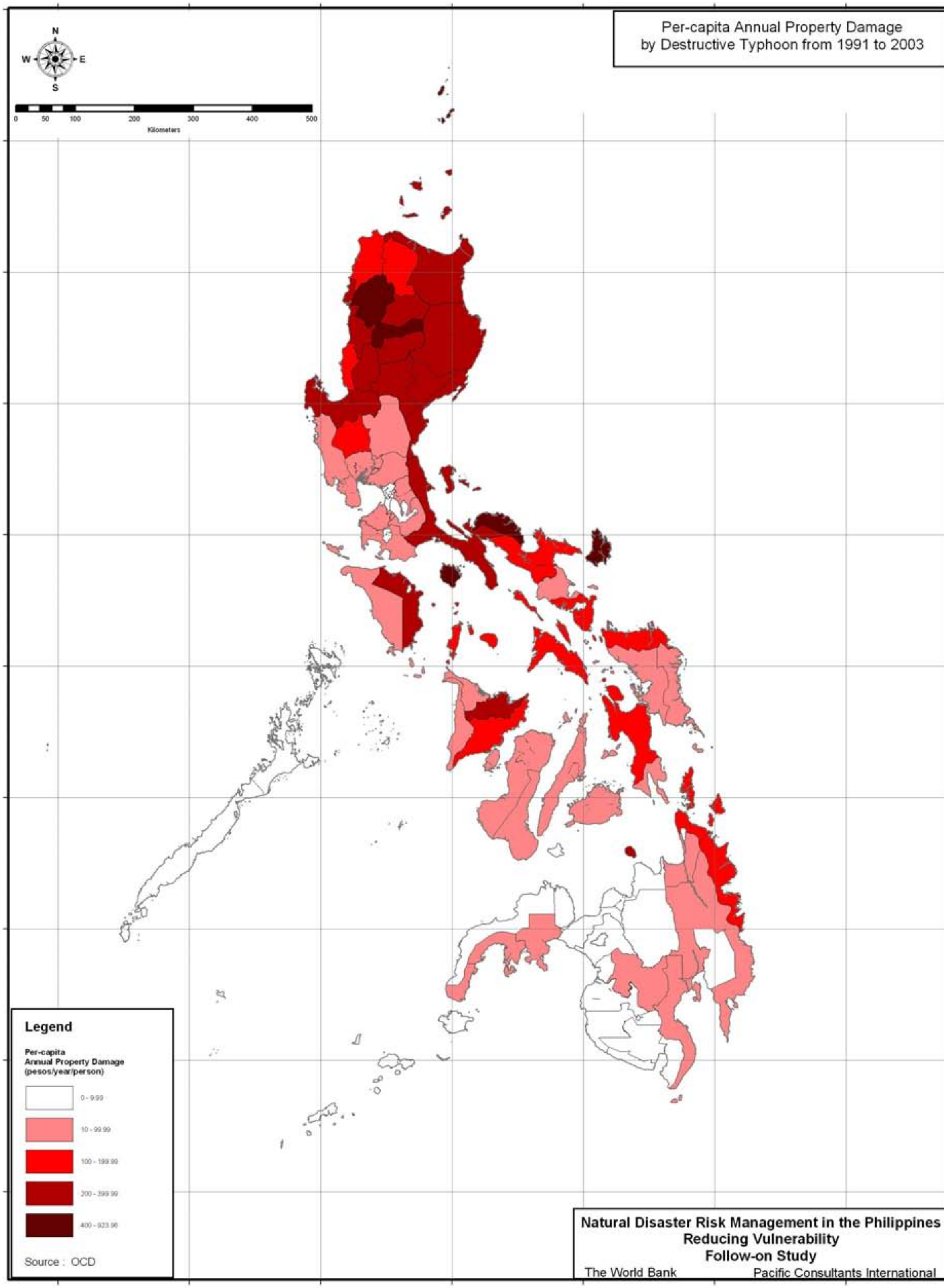


Figure 3.8 Per-capita Annual Property damage by Destructive Typhoons from 1991 to 2003

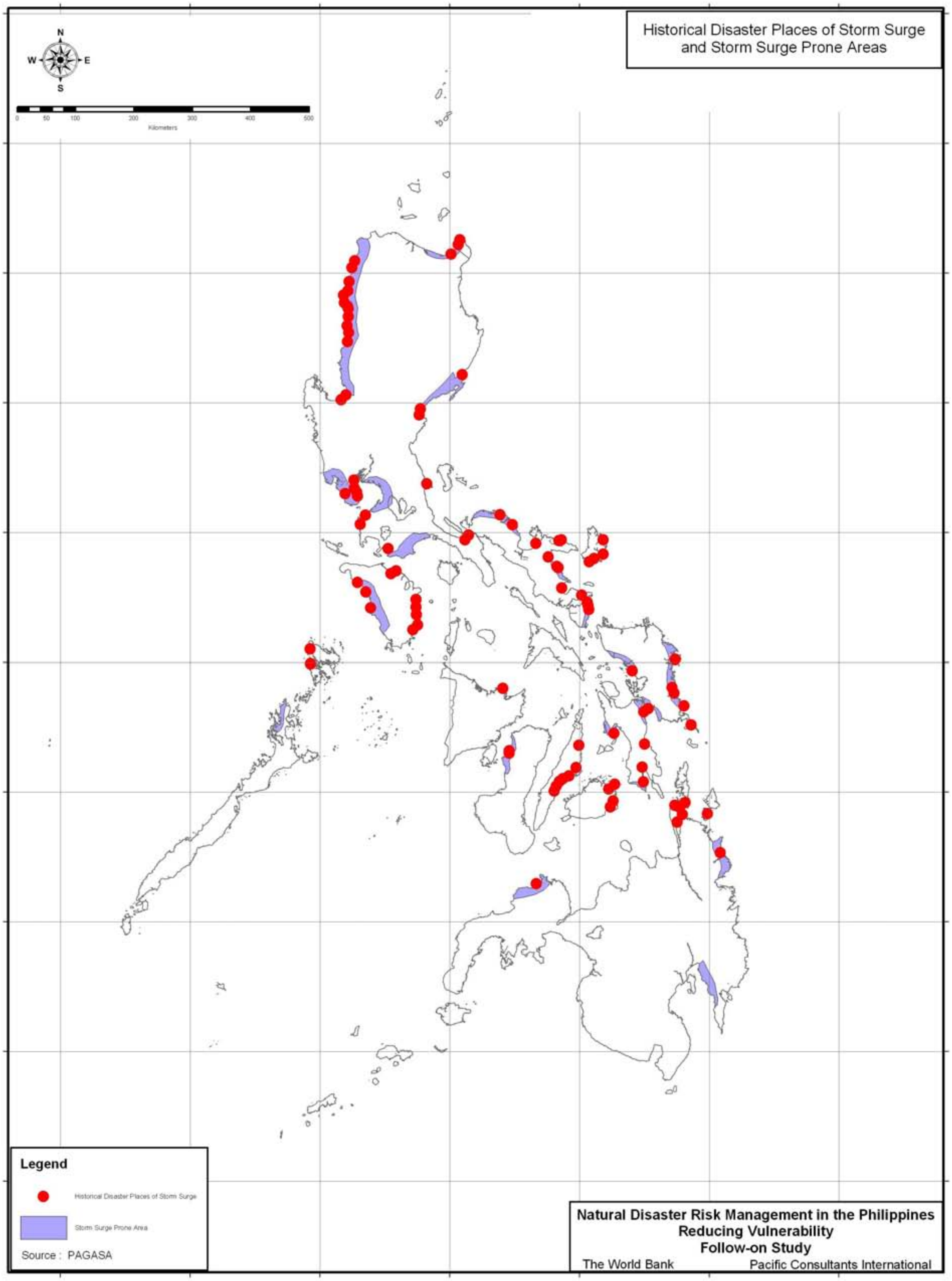


Figure 3.9 Historical Disaster Places of Storm Surge and Storm Surge Prone Areas

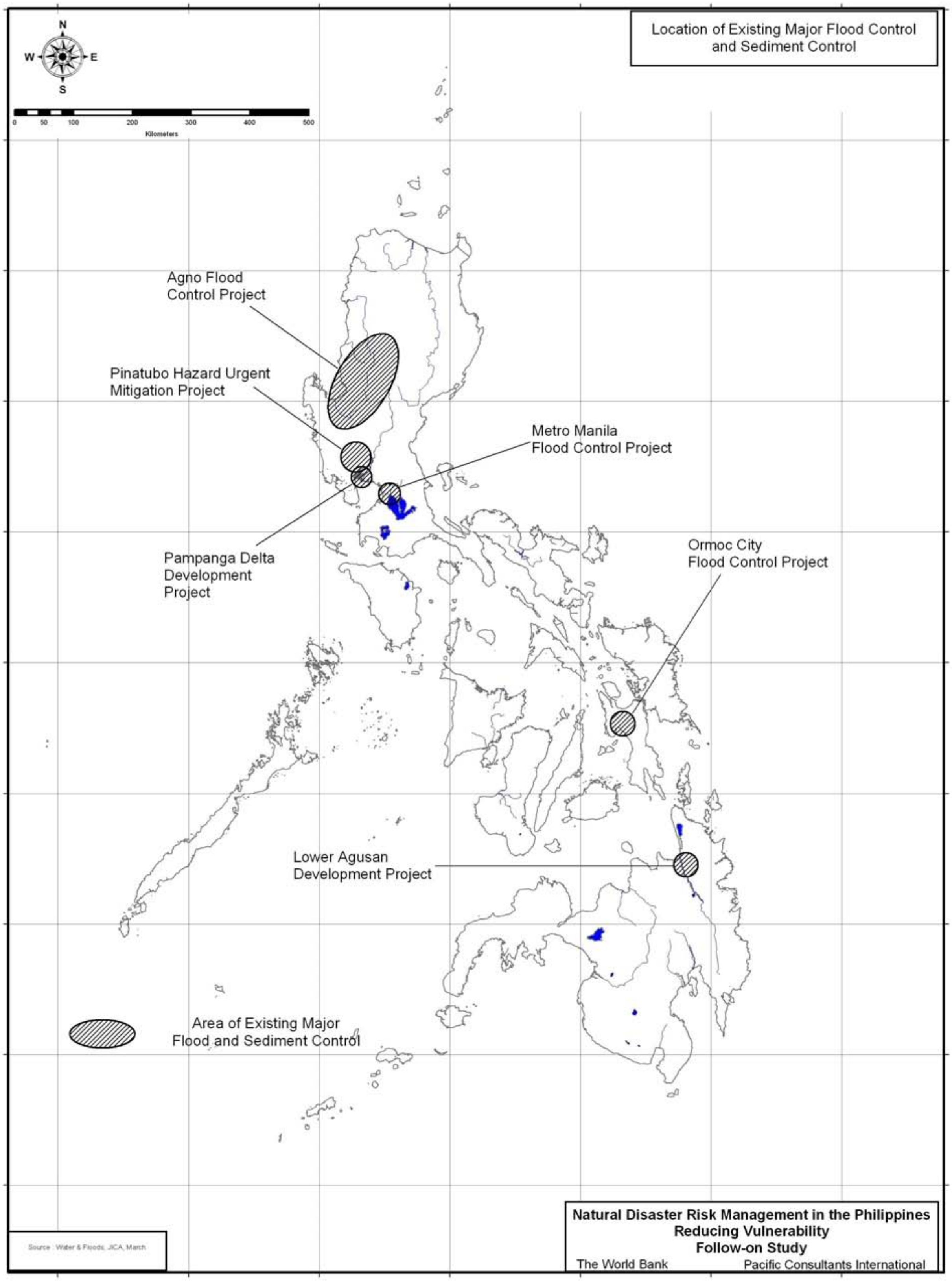


Figure 3.10 Location of Existing Major Flood Control and Sediment Control

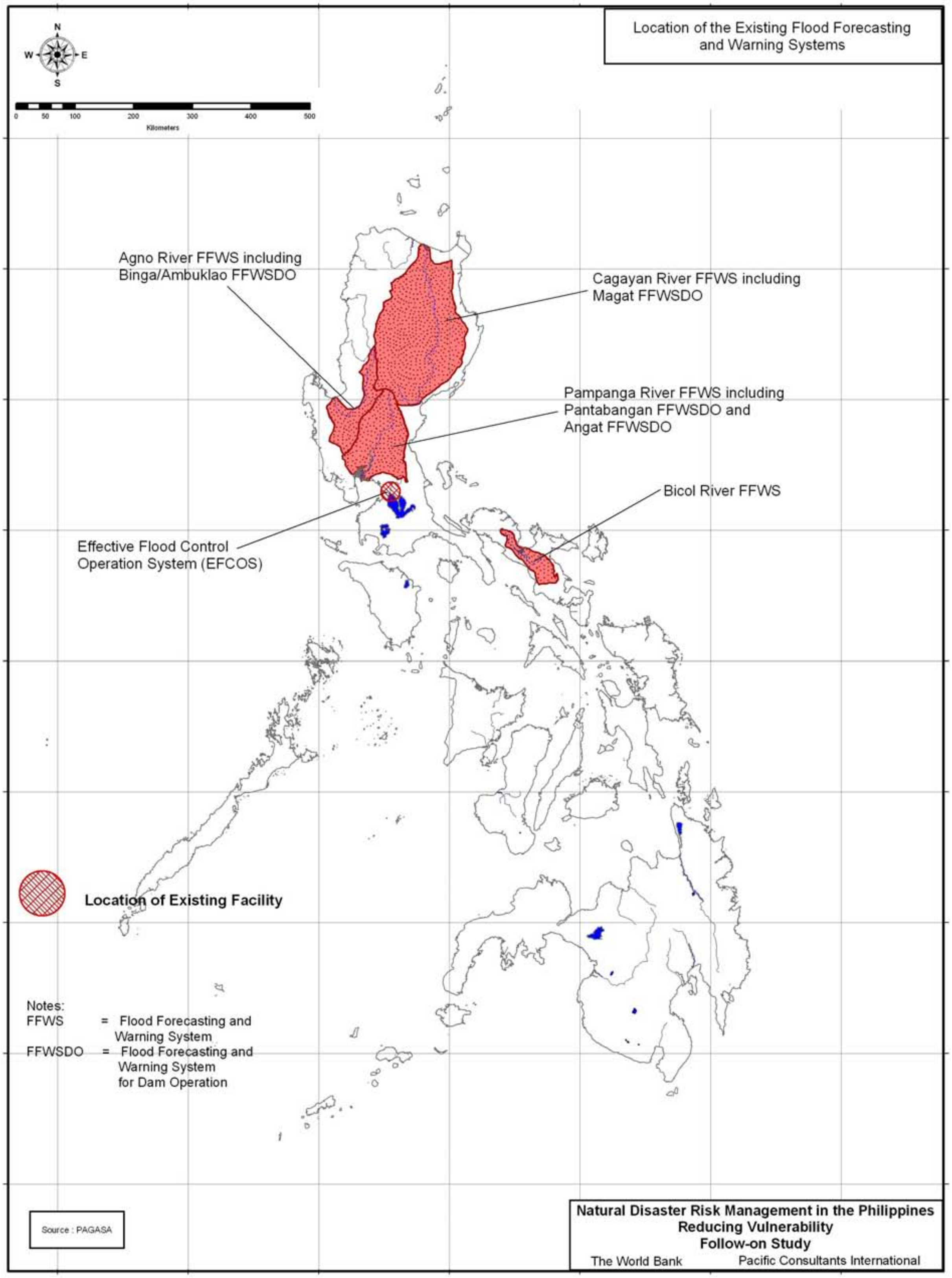
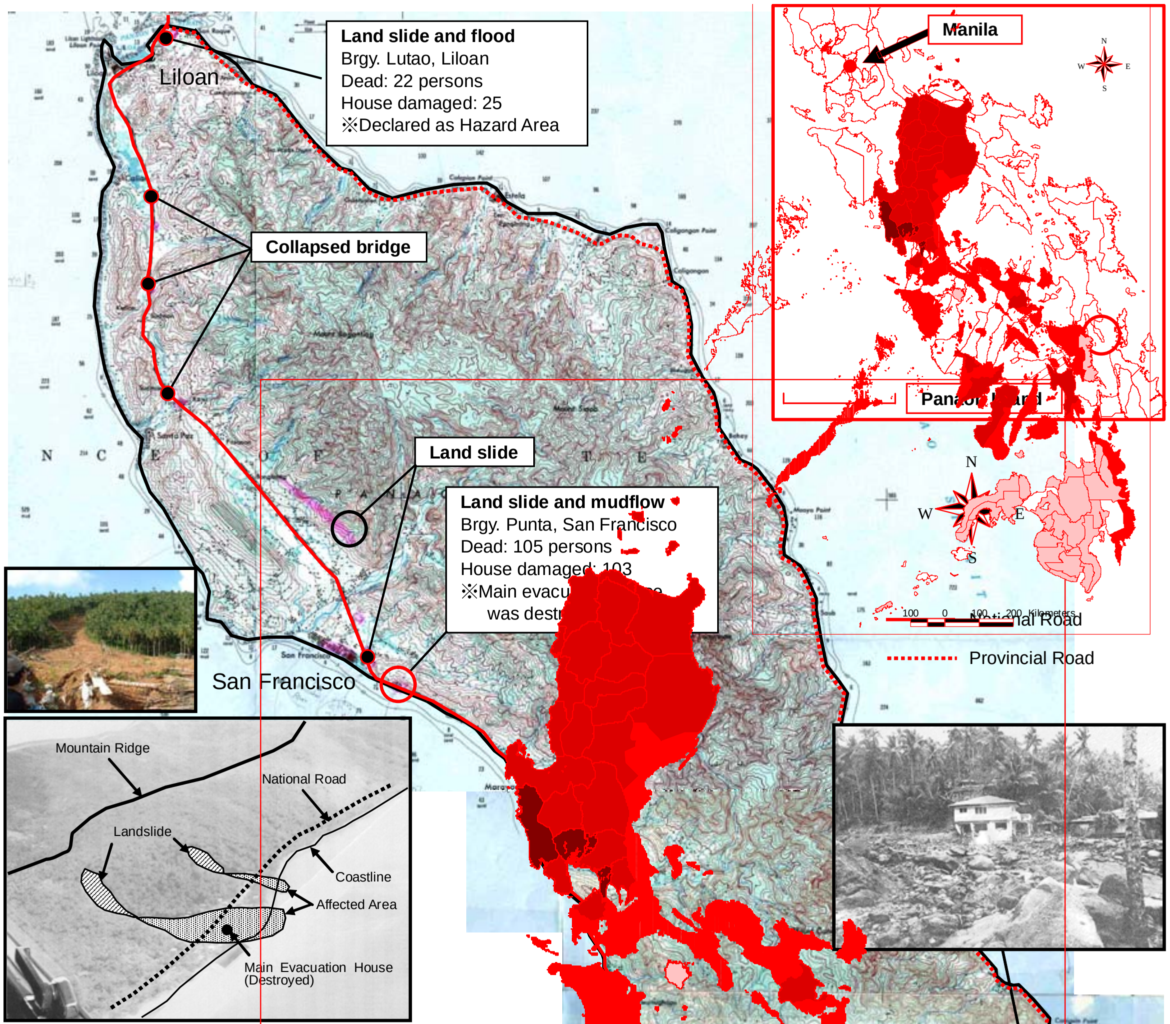


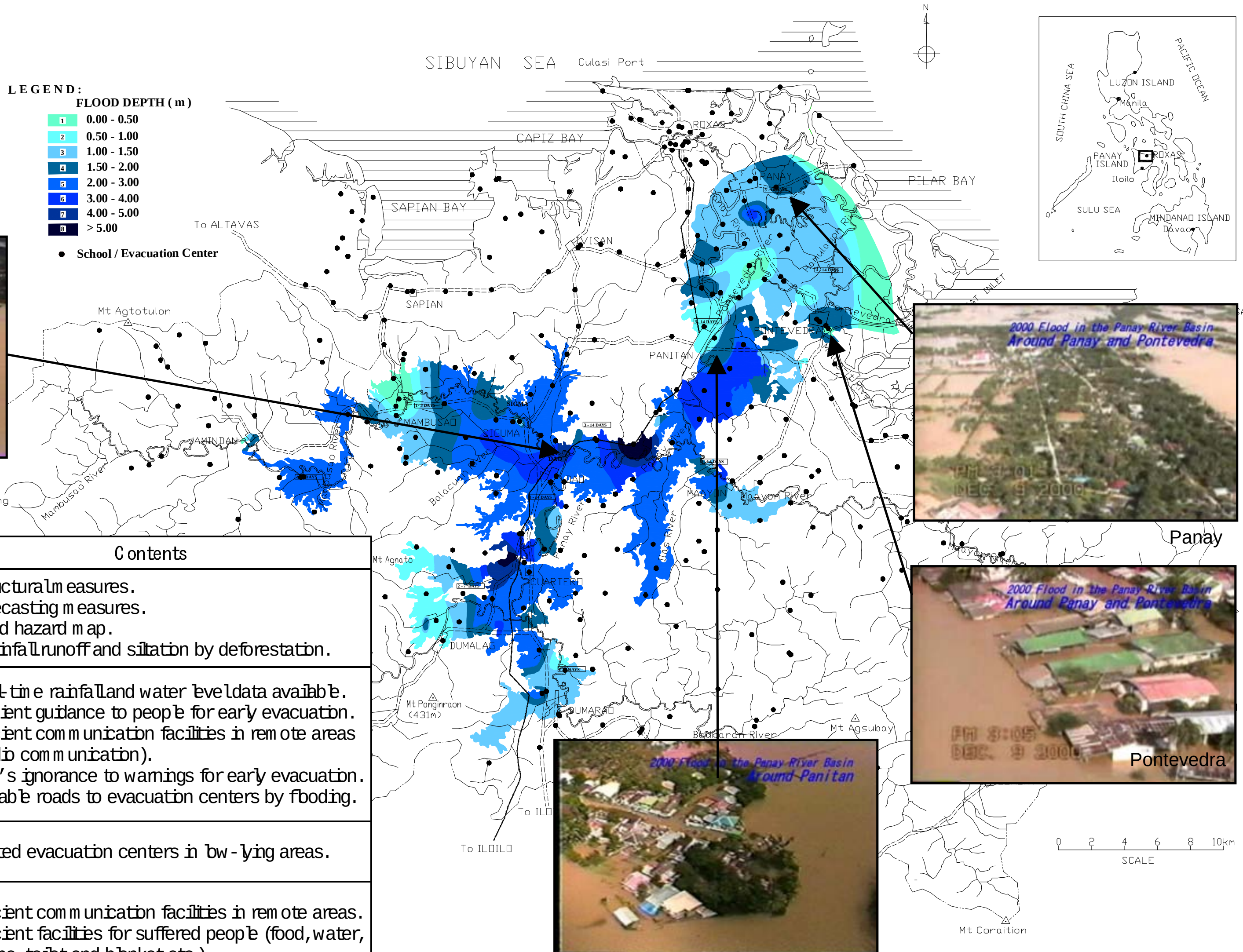
Figure 3.11 Location of the Existing Flood Forecasting and Warning Systems



	Problems	Contents
Mitigaiton	No Mitigation Measures against Floods, Landslide and Debris/Mud flow	· No structural measures. · No forecasting measures. · Uniform coconut plantation with week resistance against landslide. · No investigation on potential hazard areas.
	Late Evacuation Actions	· No real-time rainfall data available. · Insufficient guidance to people for early evacuation. · Lack of communication facilities in remote areas. · People's ignorance to early warning. · Impassable road due to flooding and landslide. · Impossible evacuation by boats due to high waves.
	Improper Evacuation Places	· Unsafe evacuation places: major evacuation house of Barangay Punta was destroyed by landslide with mudflow.
Response	Took Long Time until Reaching the Rescue Team	· Lack of rescue equipments (heavy equipments and basic equipments such as shovels and ropes). · Only one road was not passable due to landslides. · Lack of communication facilities (no radio communication). · Lack of first aids medicines and sanitary facilities.
Rehabilitation	Took Long Time for Rehabilitation	· Lack of budget. · Bad accessibility to the site. · Difficulty of land acquisition for relocation.

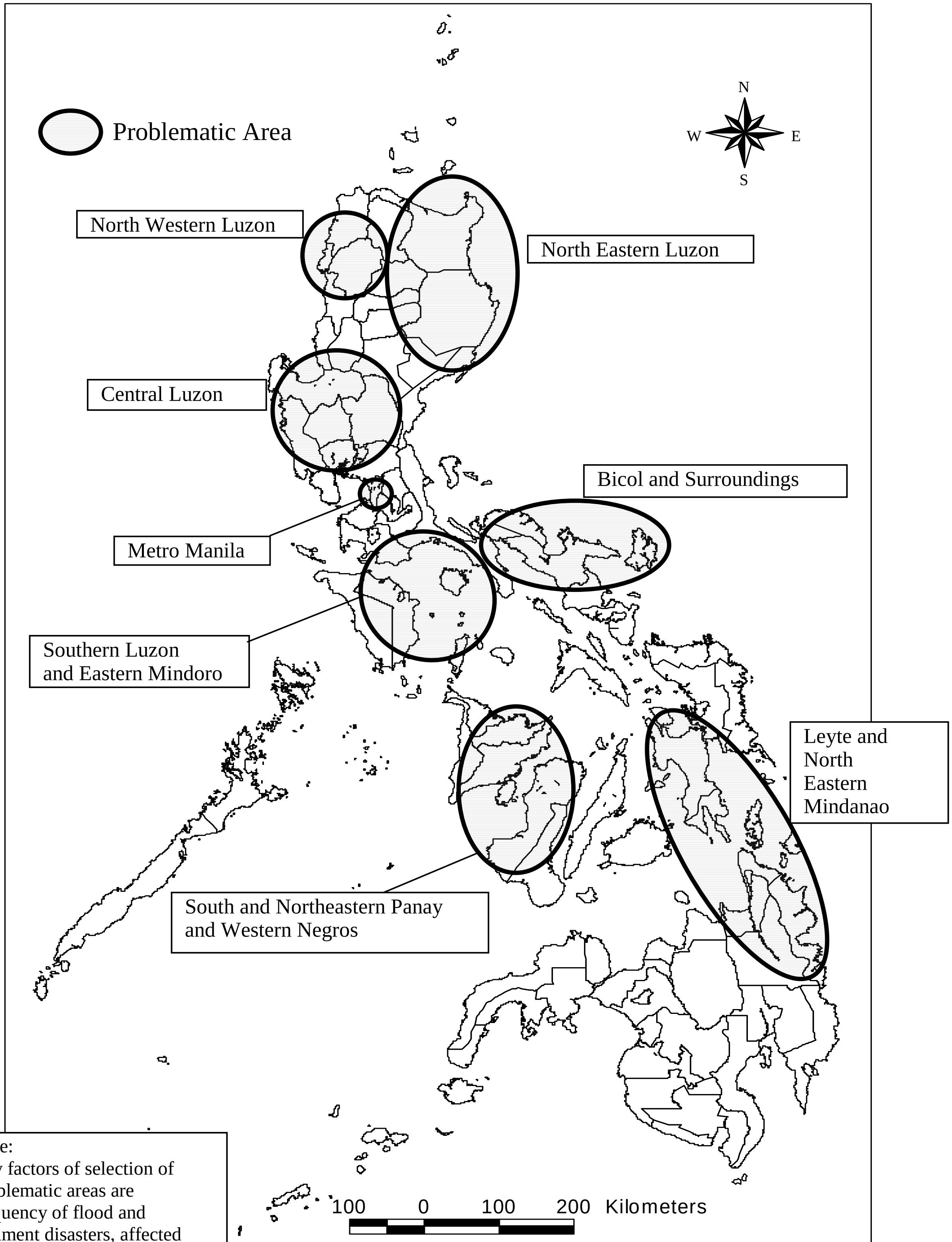
100 0 100 200 Kilometers

Figure 3.12 Condition of Landslide Disaster of Panaon Island in Southern Leyte in Dec.2003



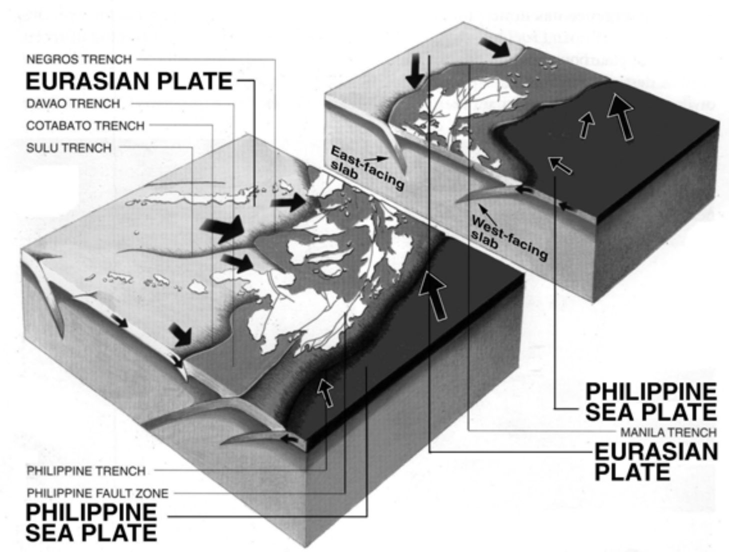
	Problems	Contents
Mitigation	No Mitigation Measures against Floods	•No structural measures. •No forecasting measures. •No flood hazard map. •High rainfall runoff and siltation by deforestation.
	Late Evacuation Actions	•No real-time rainfall and water level data available. •Insufficient guidance to people for early evacuation. •Insufficient communication facilities in remote areas (no radio communication). •People's ignorance to warnings for early evacuation. •Impassable roads to evacuation centers by flooding.
	Improper Evacuation Places	•Inundated evacuation centers in low-lying areas.
Response	Insufficient Rescue Activity	•Insufficient communication facilities in remote areas. •Insufficient facilities for suffered people (food, water, medicine, toilet and blanket etc.). •Insufficient equipments for rescue (rubber boats etc).

Figure3.13 Inundation Area of December 2000 Flood with Evacuation Places of Panay River Basin



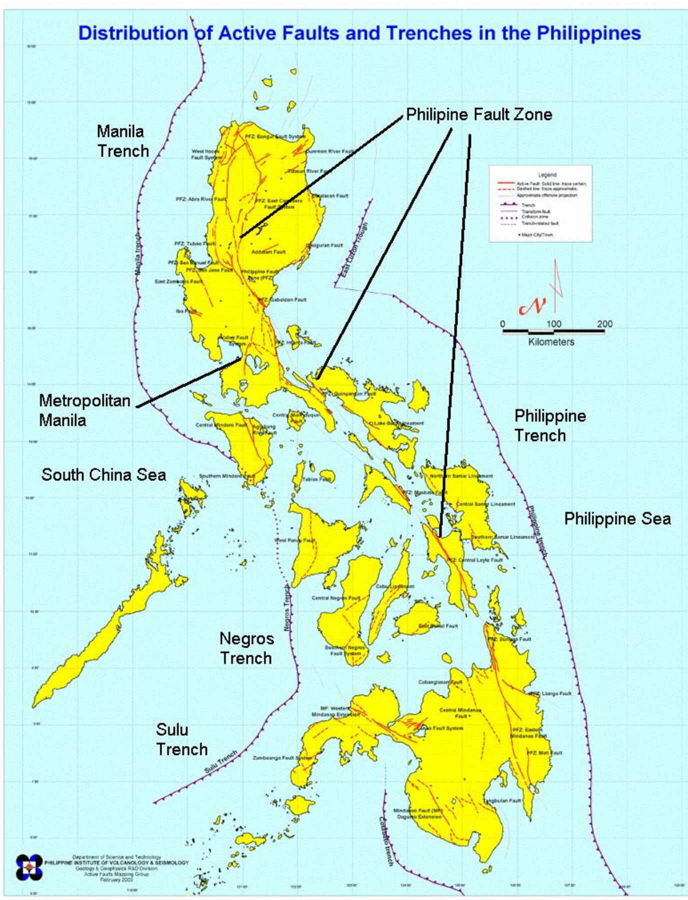
Note:
Key factors of selection of problematic areas are frequency of flood and sediment disasters, affected persons and property damage (total and per-capita)

Figure3.14 Problematic Areas of Flood, Sediment Disasters



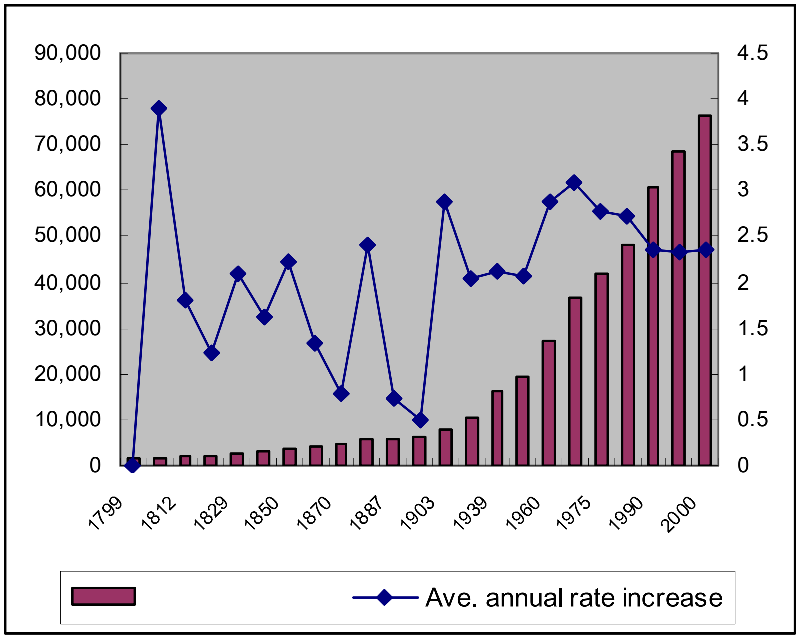
Source: PHIVOLCS

Figure 4.1 Philippine Archipelago with its Bounding Trenches, Subduction Zones, and Trenches



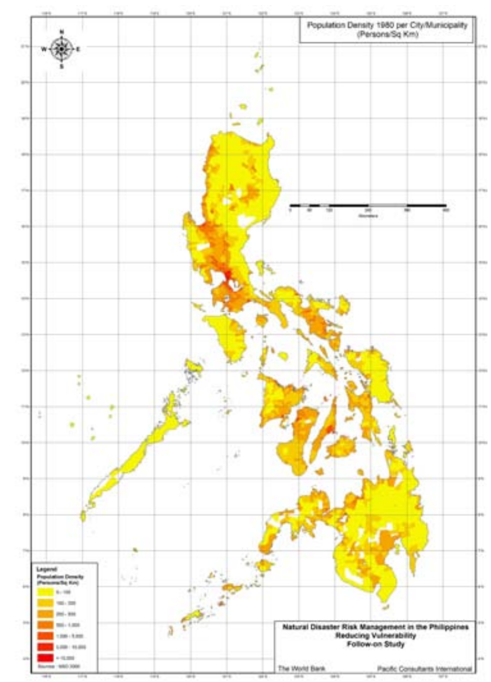
Source: PHIVOLCS

Figure 4.2 Distribution of Active Faults and Trenches in the Philippines

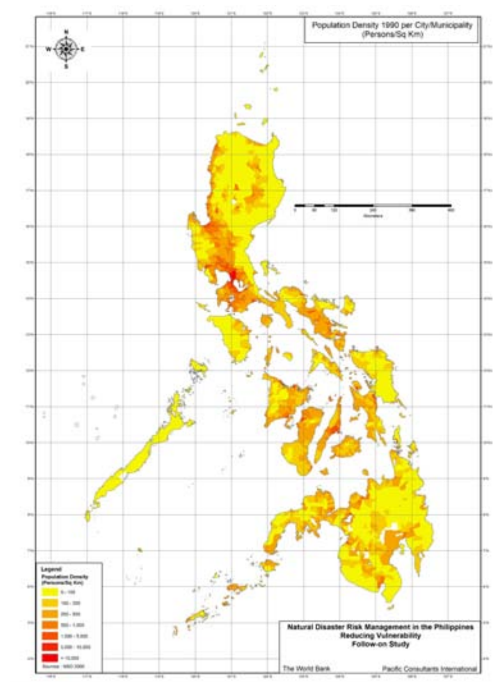


Note: Created from census data summary of National Statistics Office

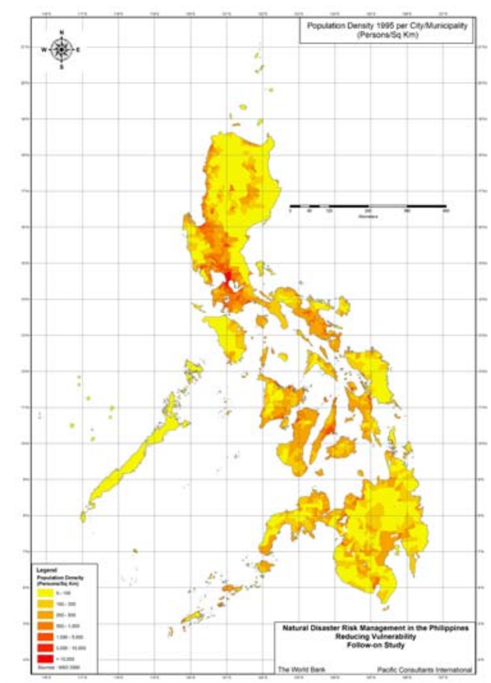
Figure 4.3 Population and Average Annual Rate Increase of the Philippines



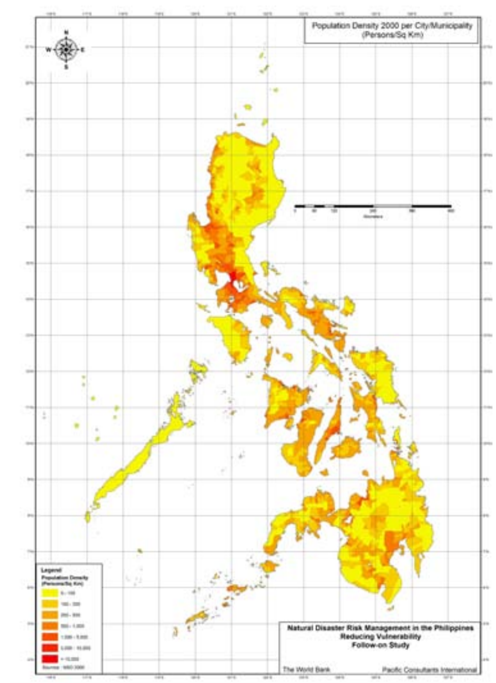
Population density distribution 1980



Population density distribution 1990



Population density distribution 1995



Population density distribution 2000

Figure 4.4 Population Density Distribution of the Philippines by Years by Municipality

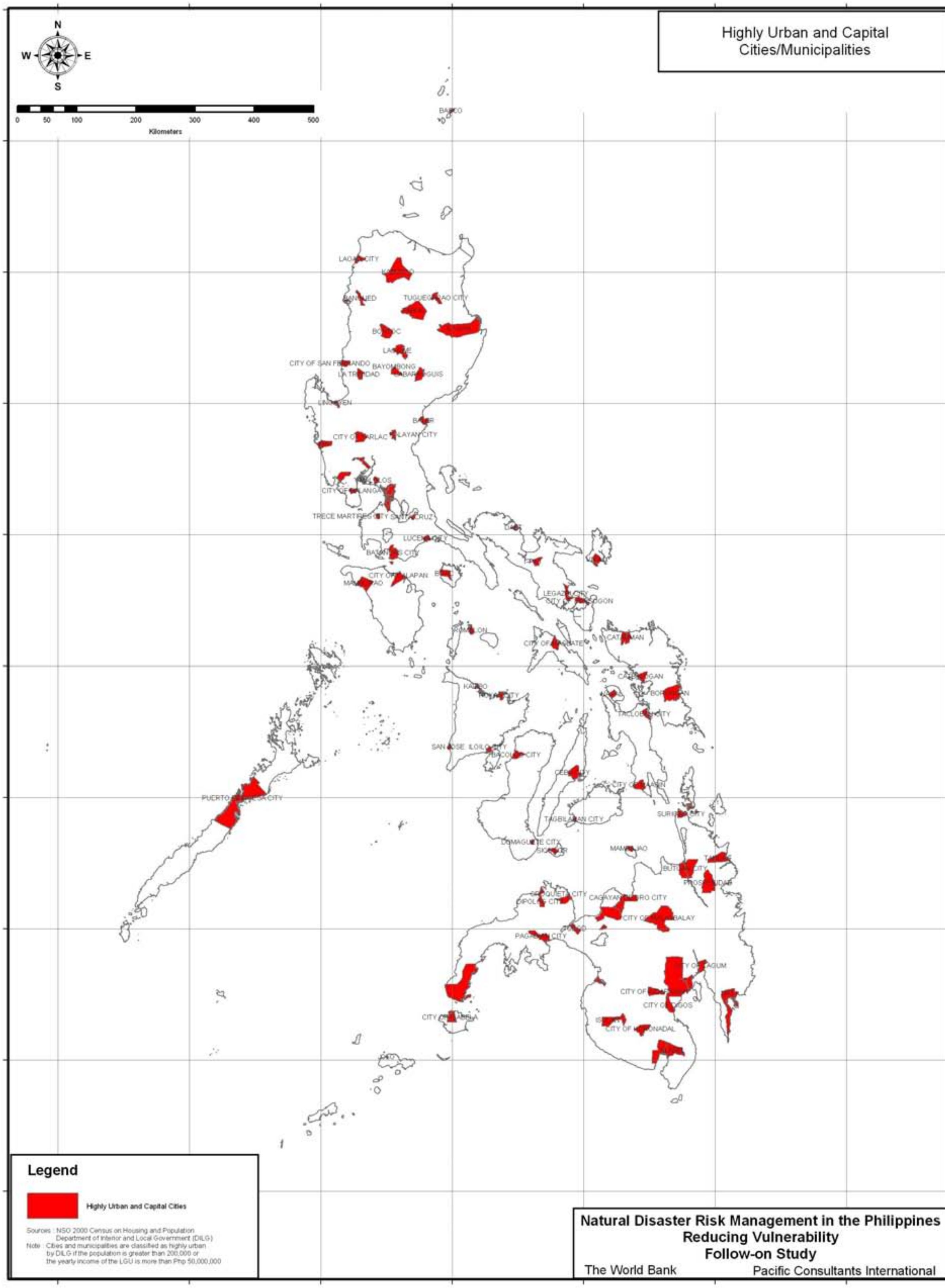


Figure 4.5 Highly Urban and Capital Cities/ Municipalities

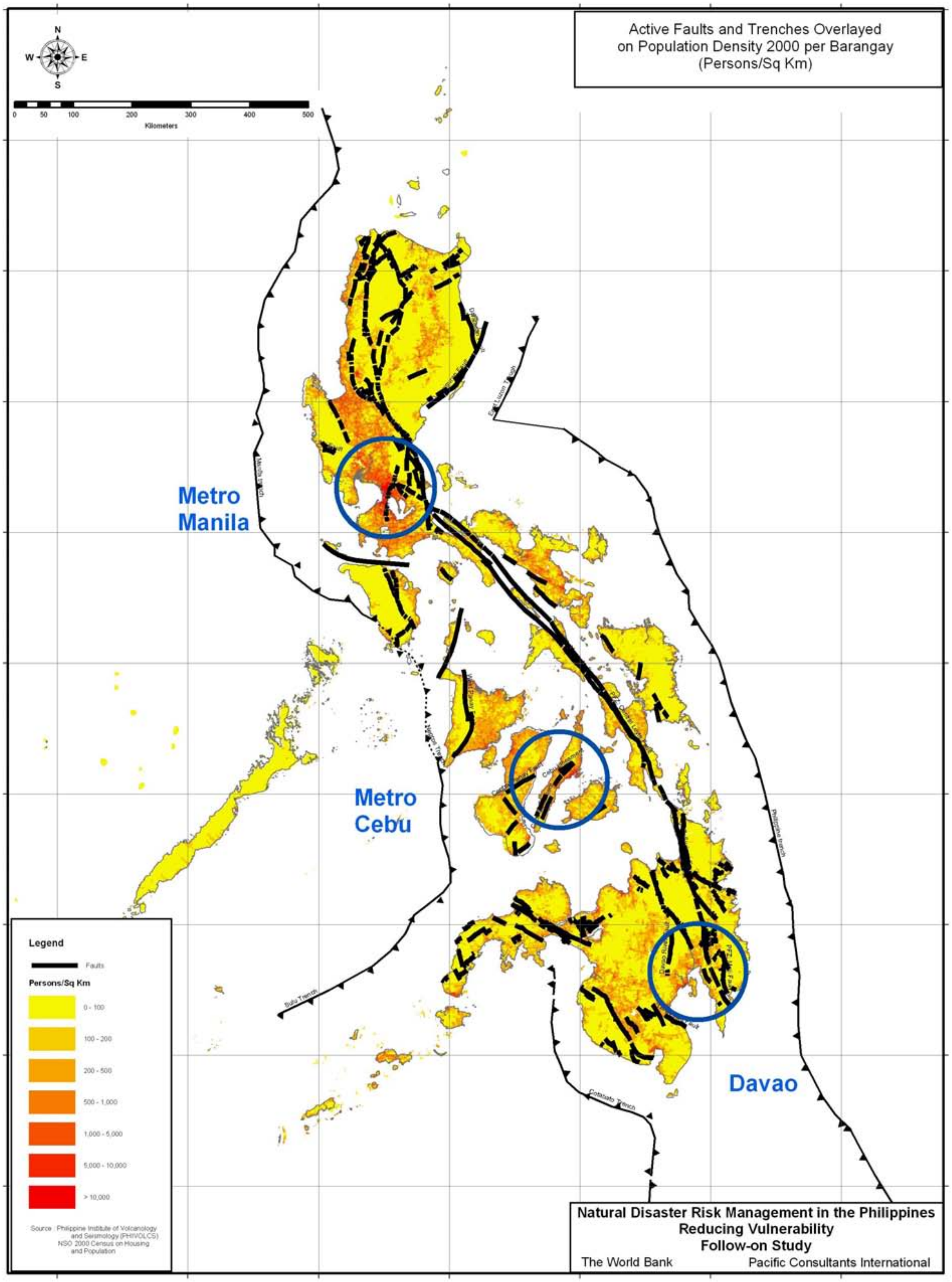


Figure 4.6 Active Faults and Population Density

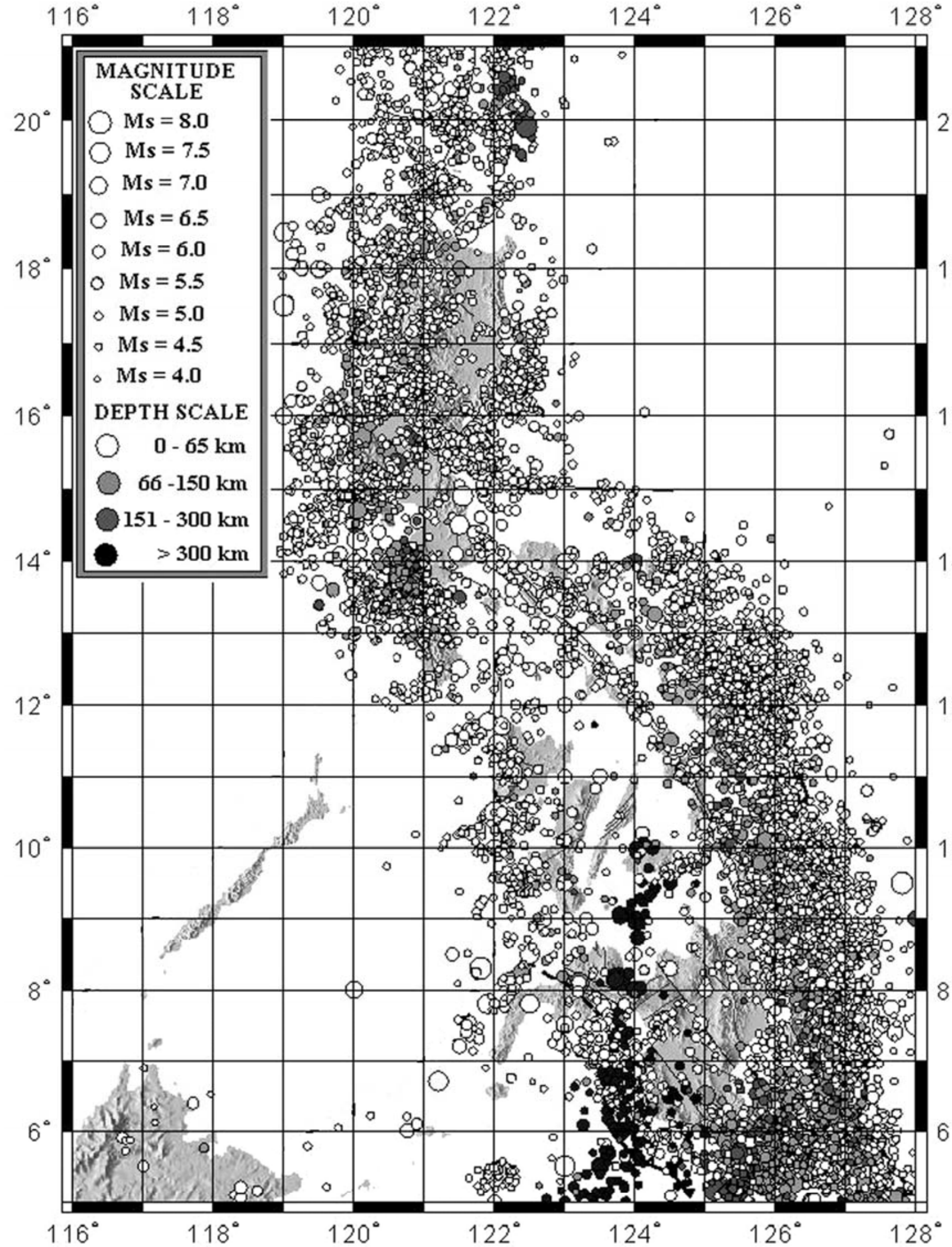


Figure 4.7 Spatial Distribution of Seismicity in the Philippine region from 1608 to 1999

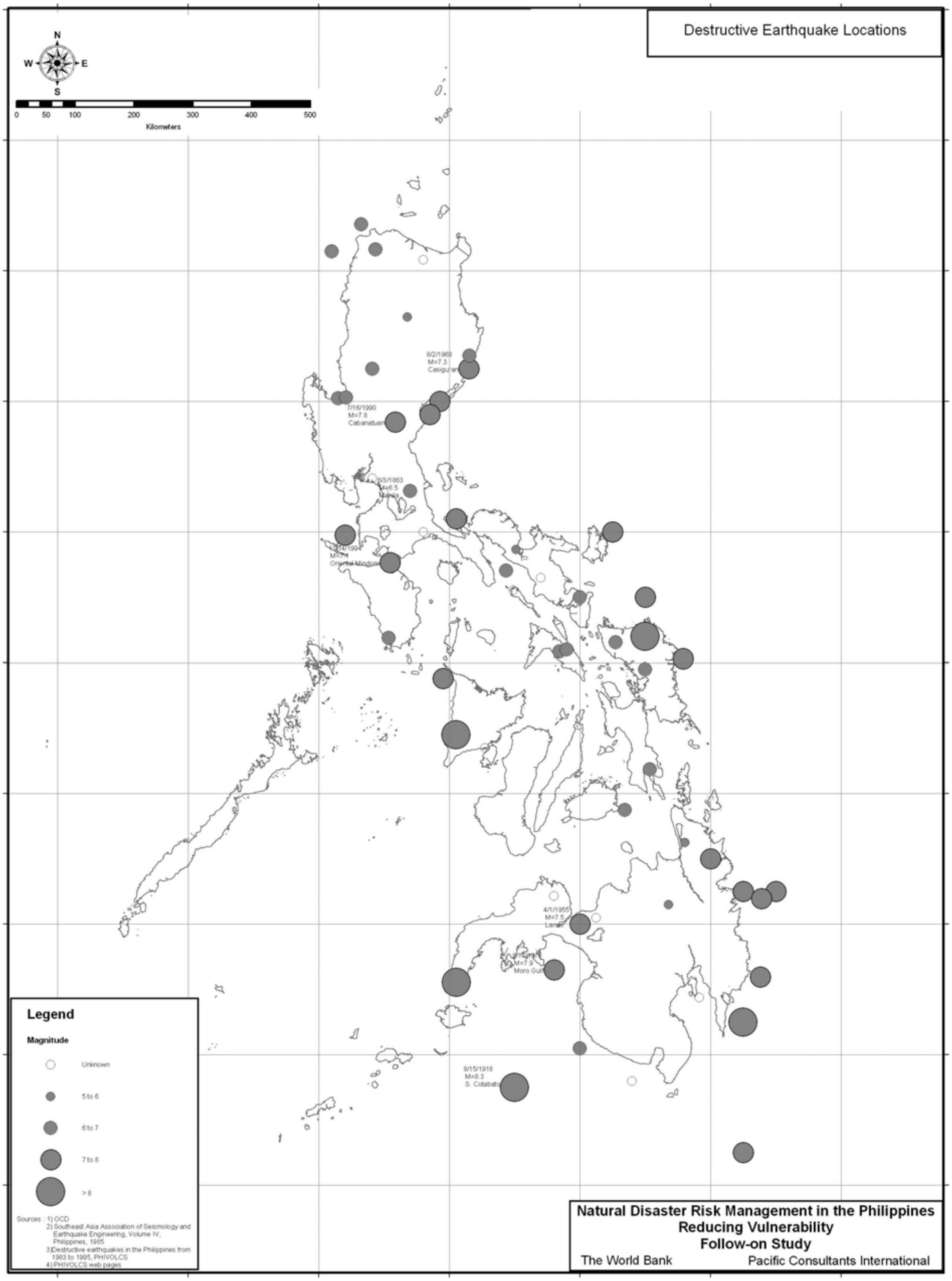
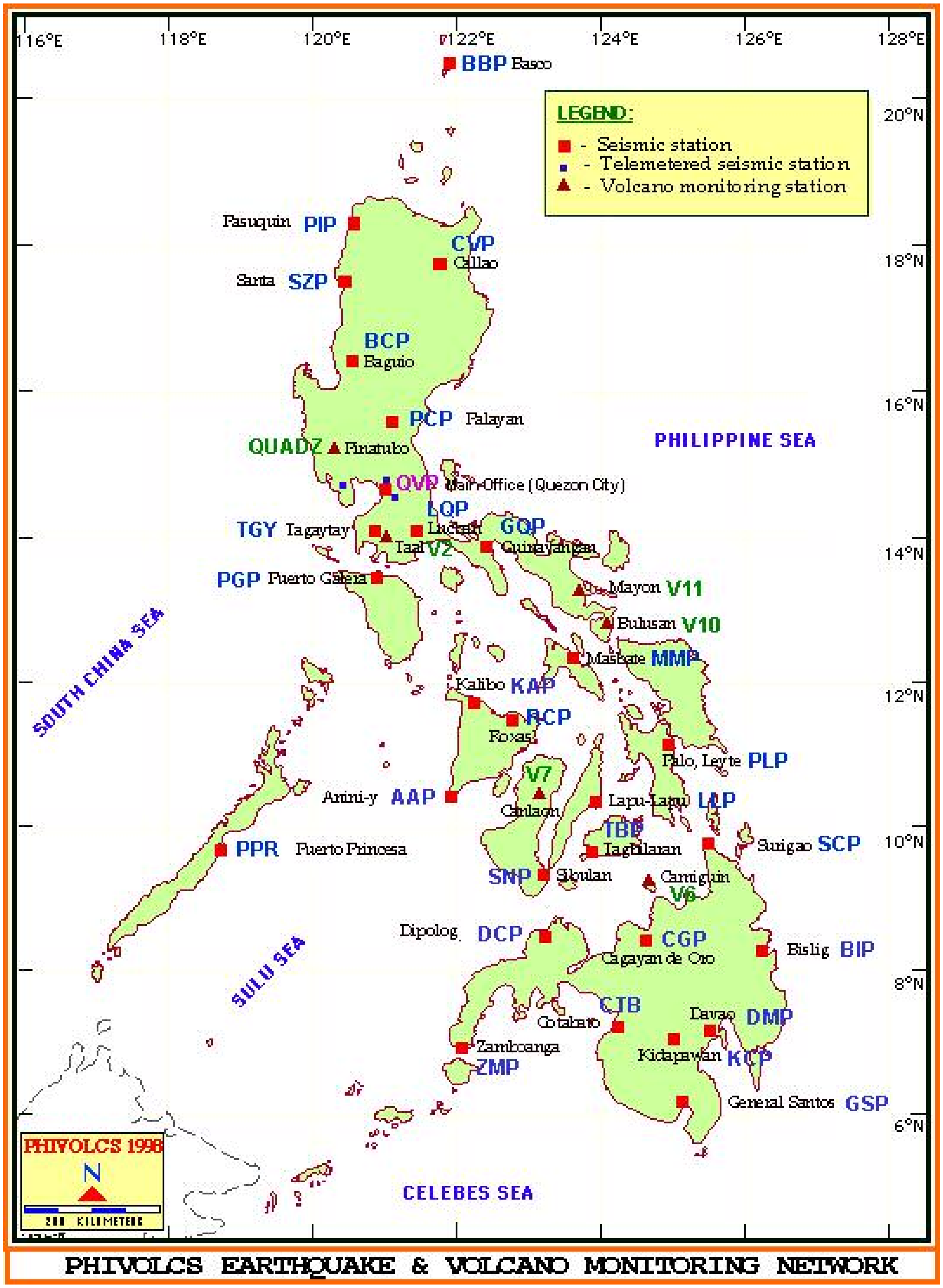
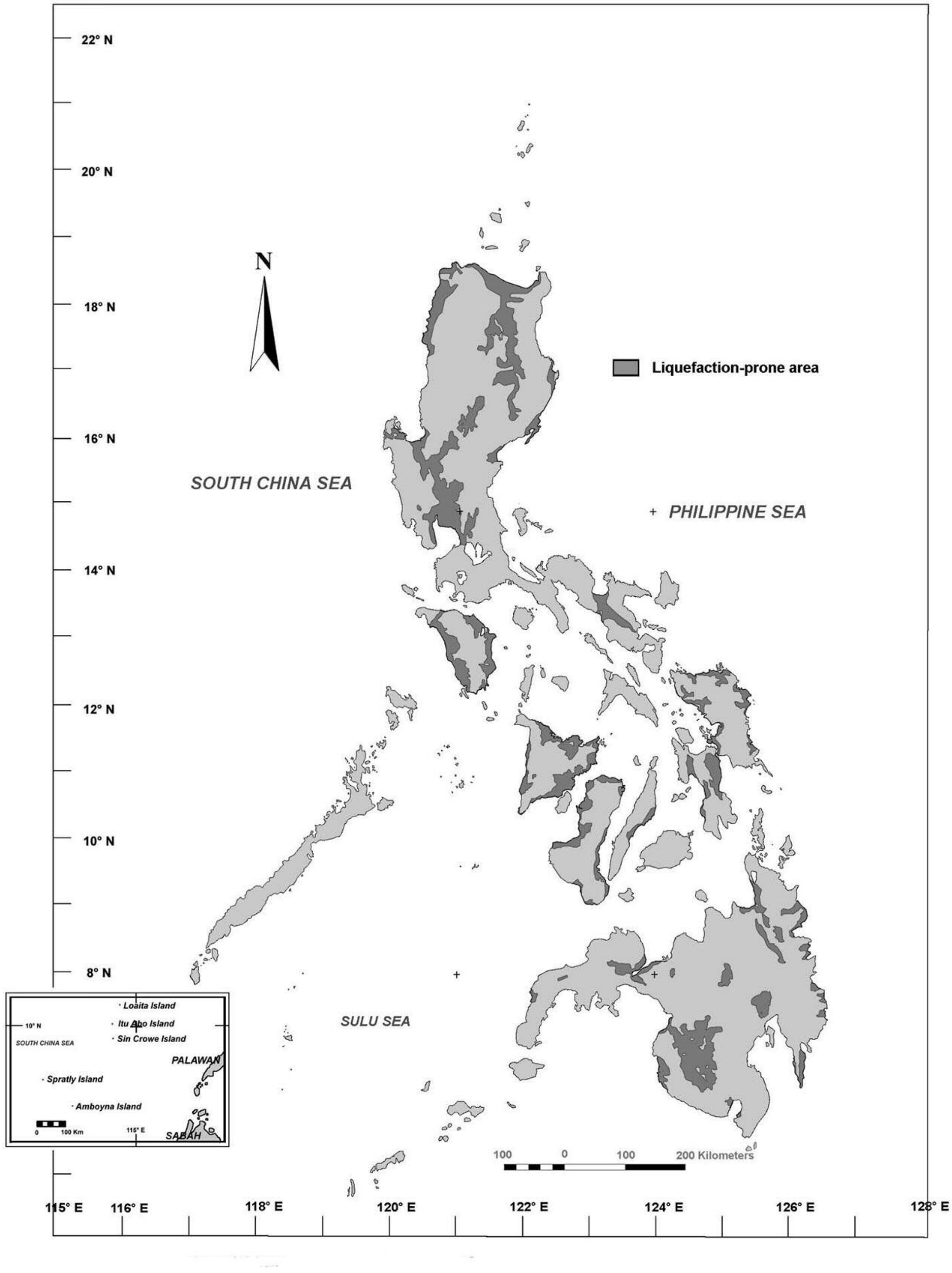


Figure 4.8 Destructive Earthquake Locations



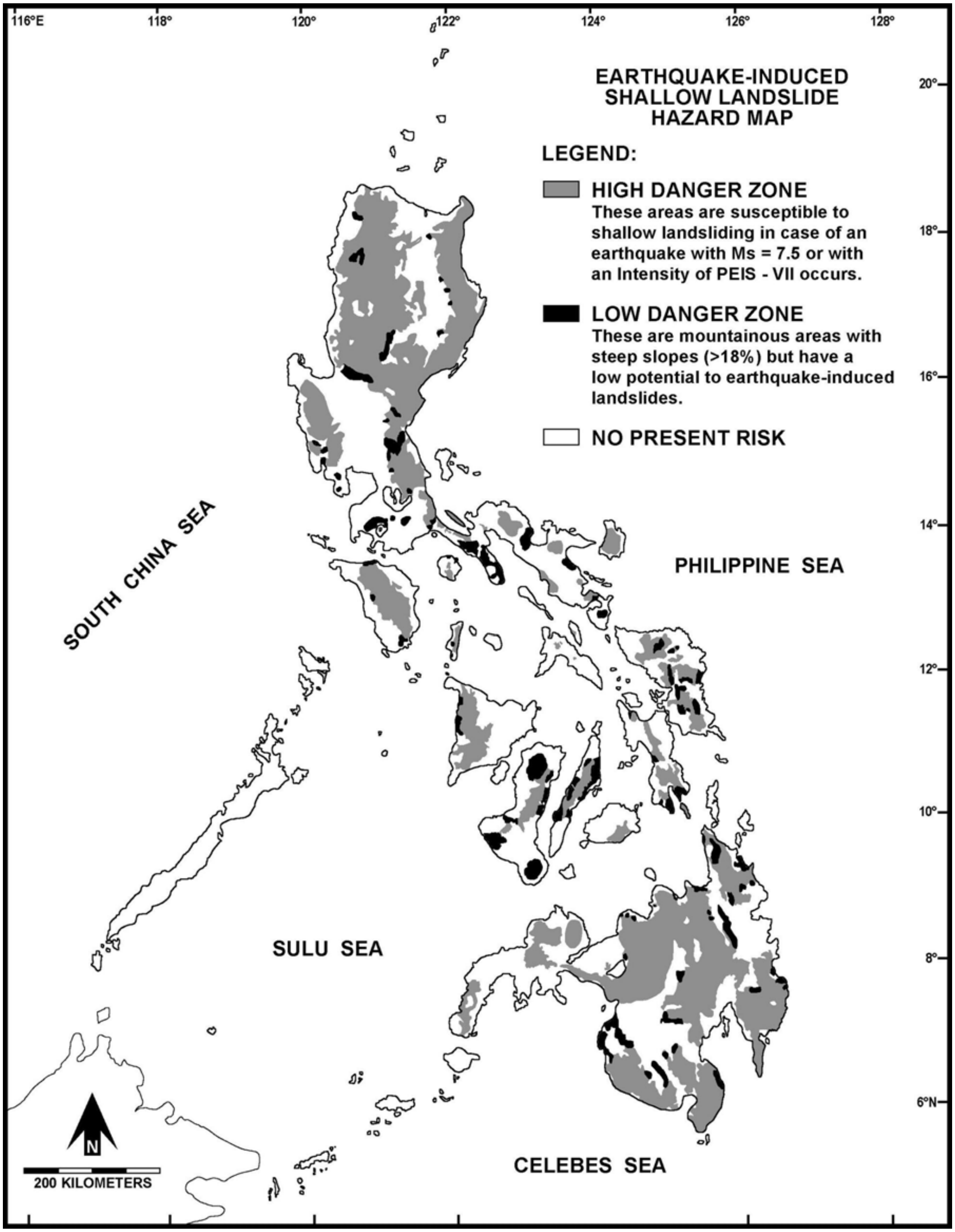
Source: PHIVOLCS home page, http://www.phivolcs.dost.gov.ph

Figure 4.9 Location of Existing Seismological and Volcanological Stations in the Philippines



Source: PHIVOLCS

Figure 4.10 Liquefaction Potential Map of PHIVOLCS



Source: PHIVOLCS

Figure 4.11 Earthquake Induced Landslide Hazard Map of PHIVOLCS

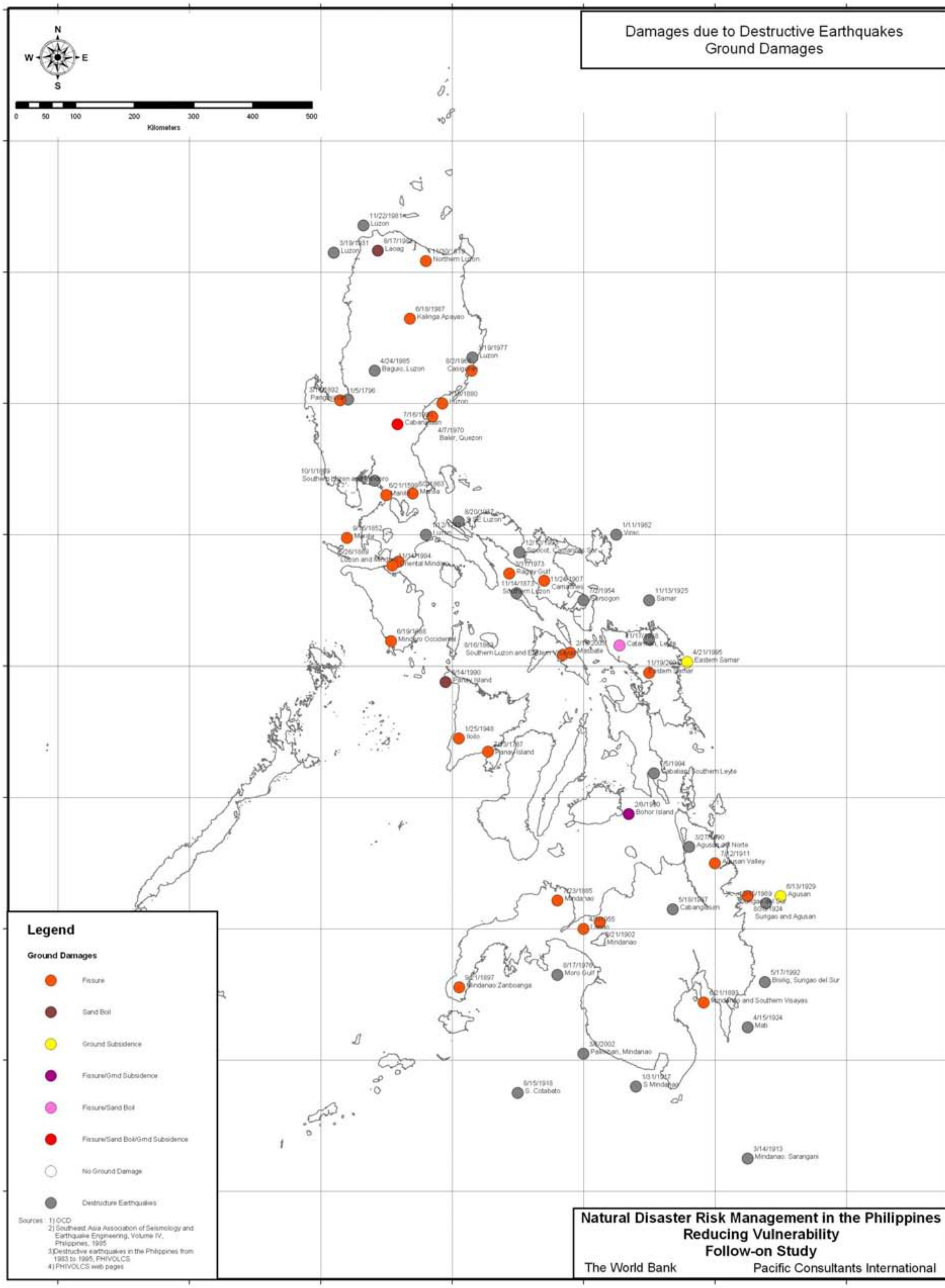


Figure 4.12 Damages due to Destructive Earthquakes – Ground Damages –

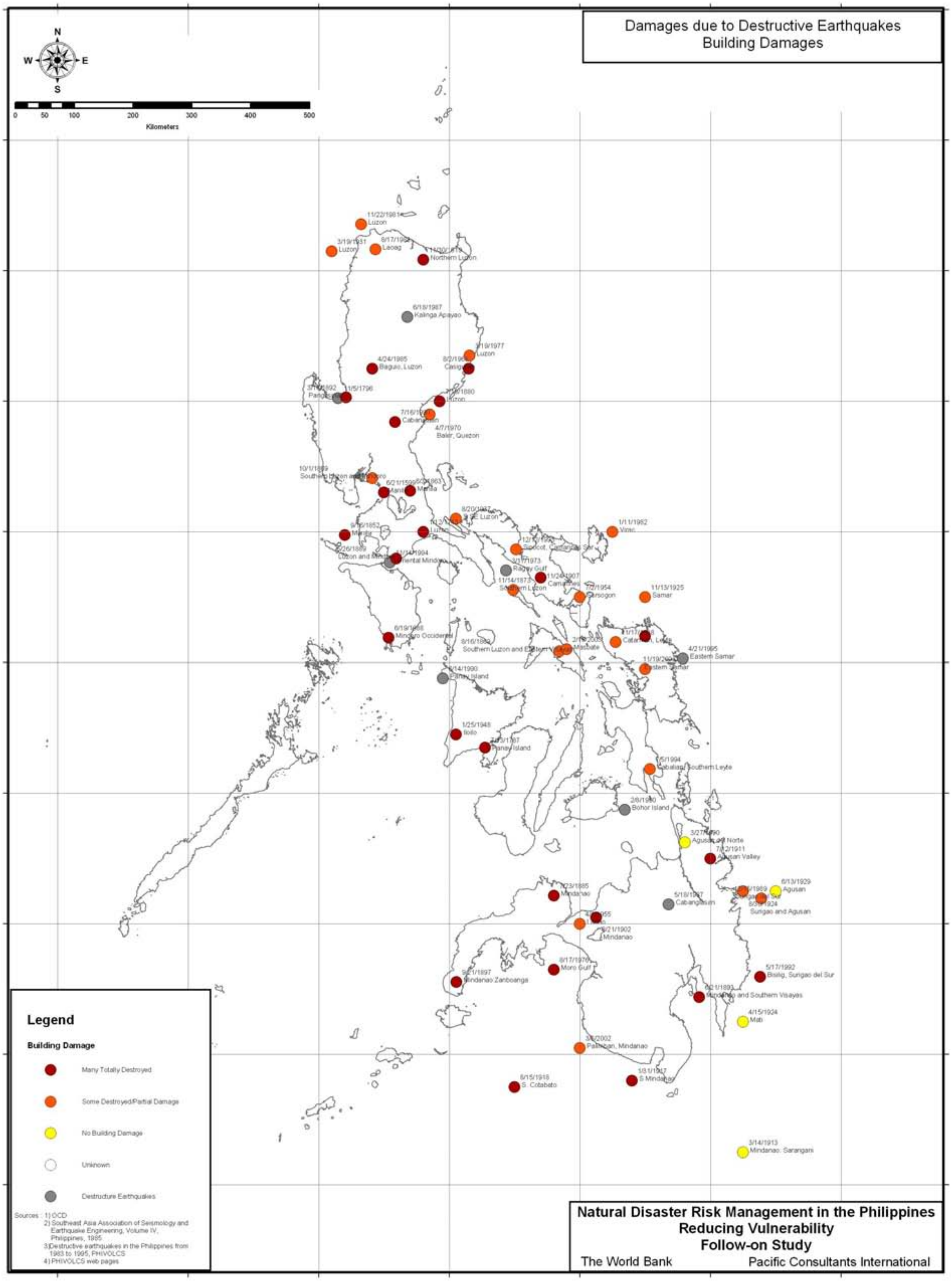


Figure 4.13 Damages due to Destructive Earthquakes – Building Damages –

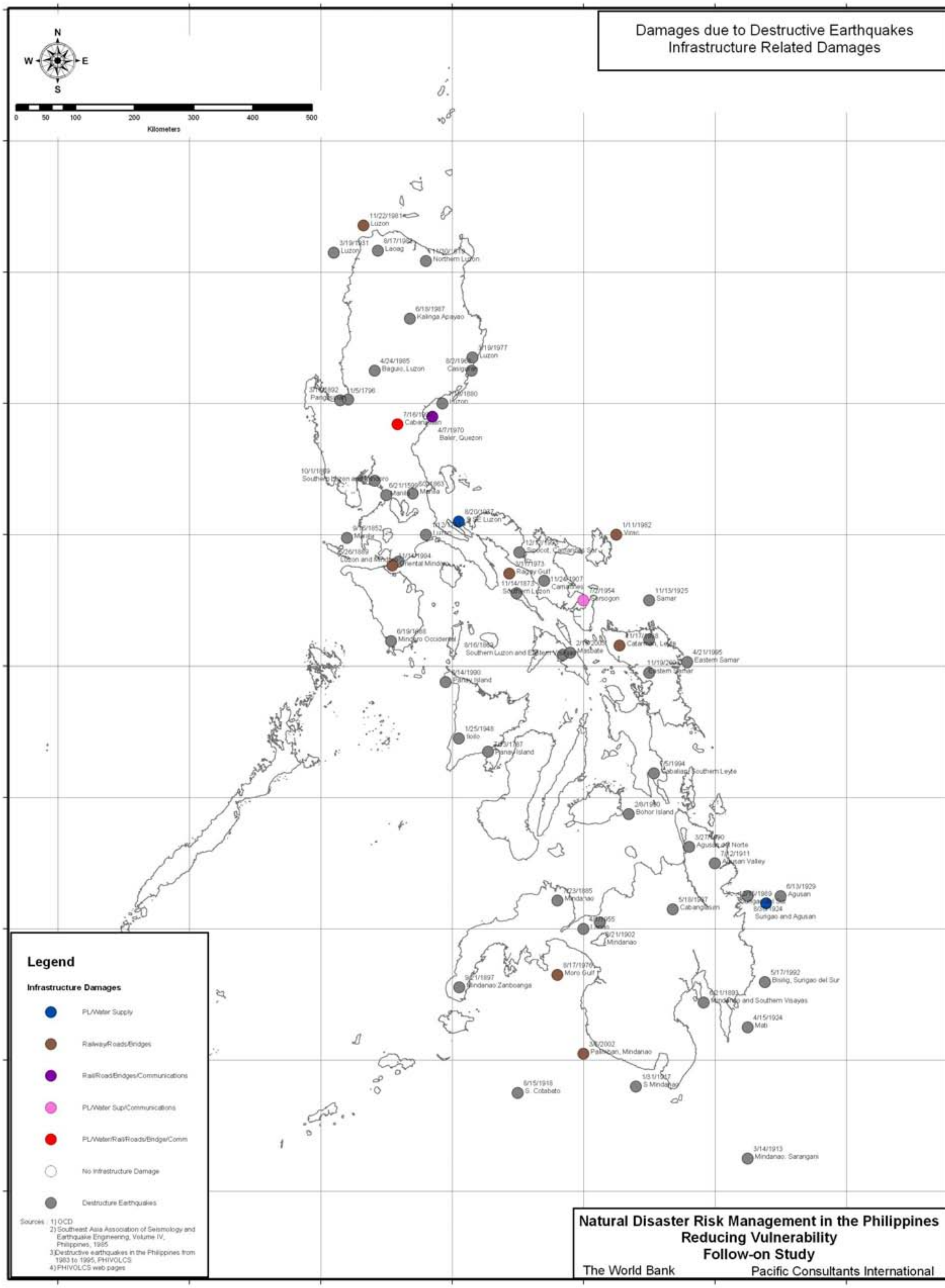


Figure 4.14 Damages due to Destructive Earthquakes – Infrastructure Related Damages –

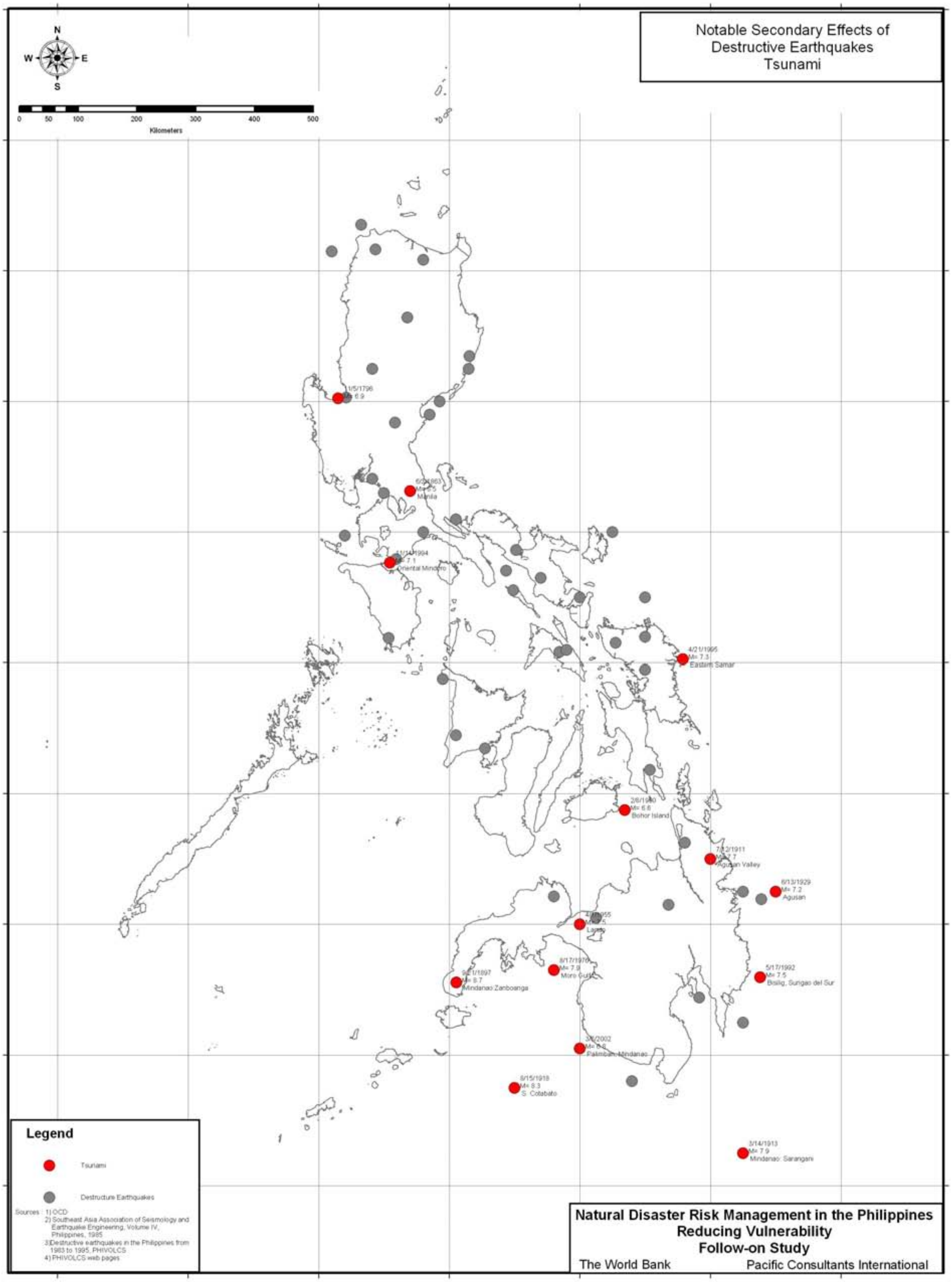


Figure 4.15 Notable Secondary Phenomenon of Destructive Earthquakes – Tsunami-

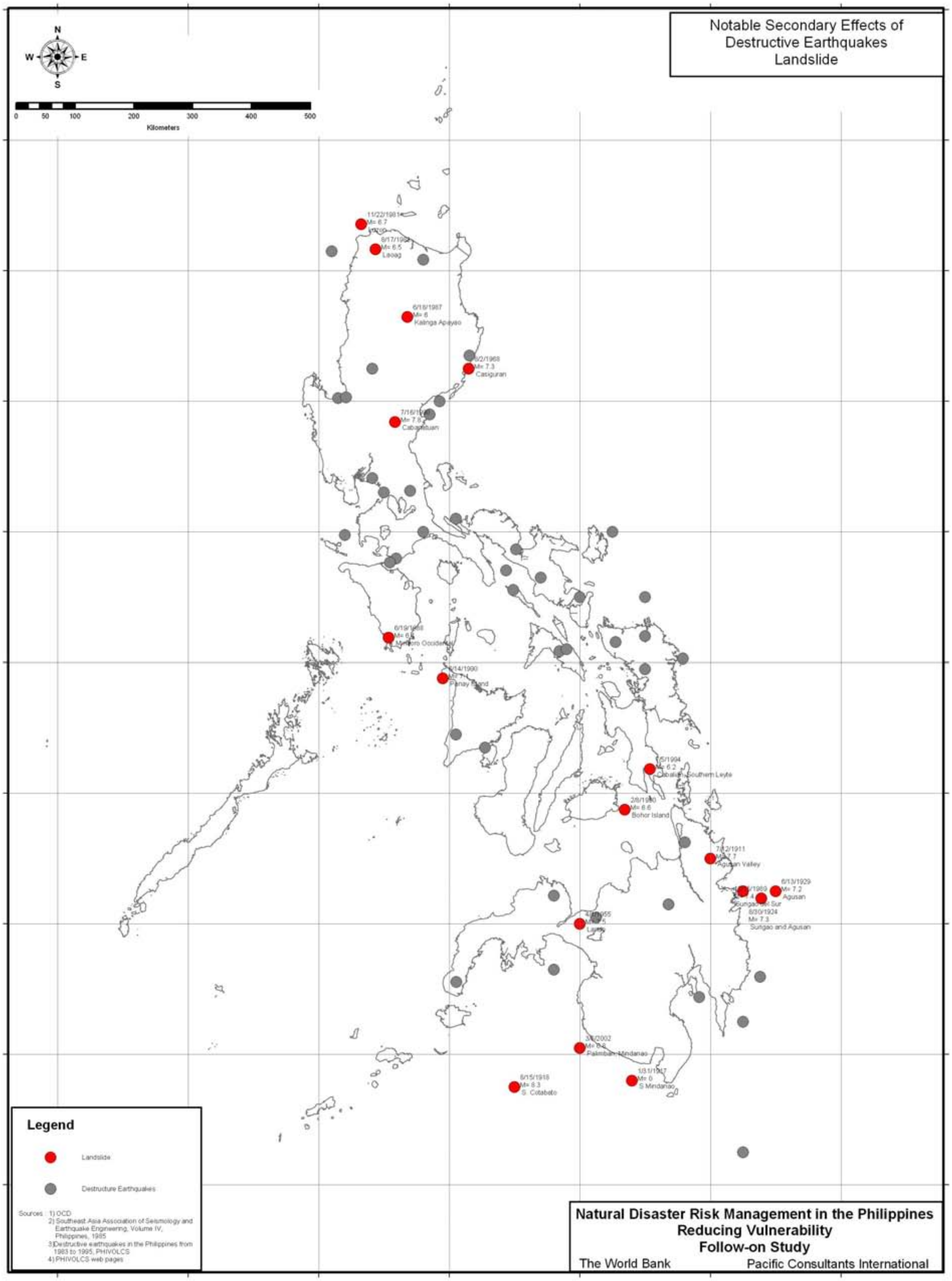


Figure 4.16 Notable Secondary Phenomenon of Destructive Earthquakes – Landslides-

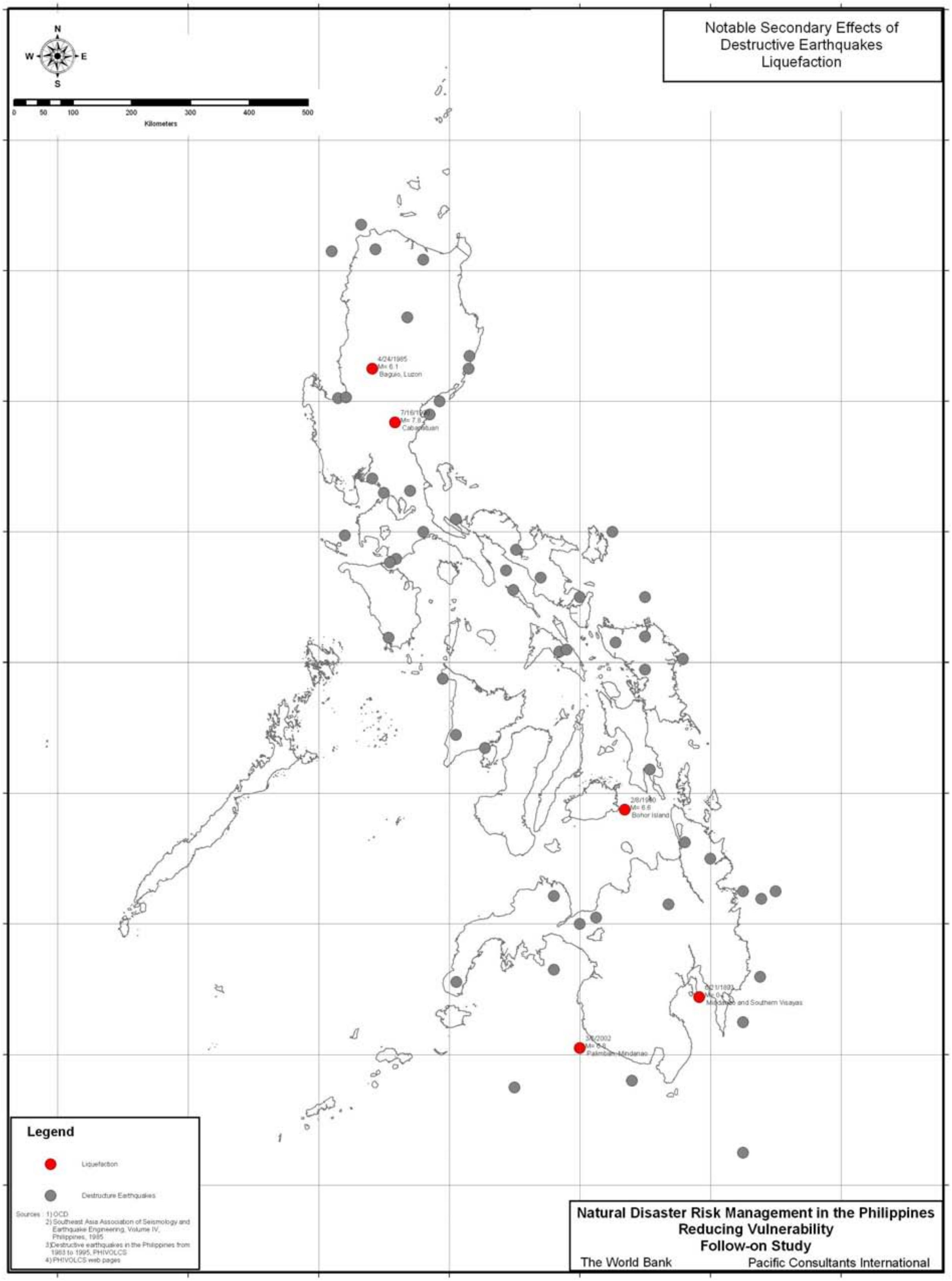


Figure 4.17 Notable Secondary Phenomenon of Destructive Earthquakes – Liquefaction-

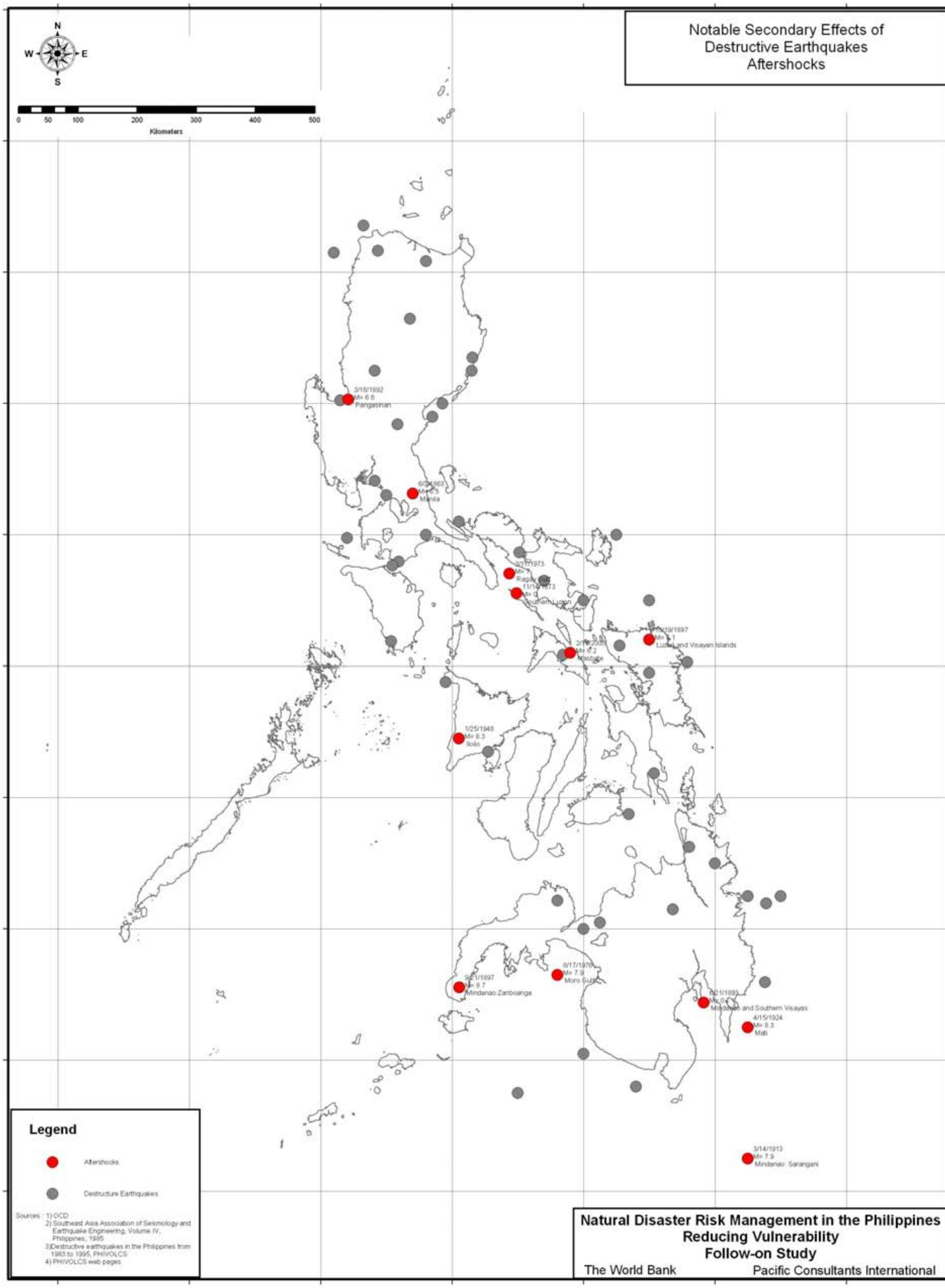


Figure 4.18 Notable Secondary Phenomenon of Destructive Earthquakes – Aftershocks-

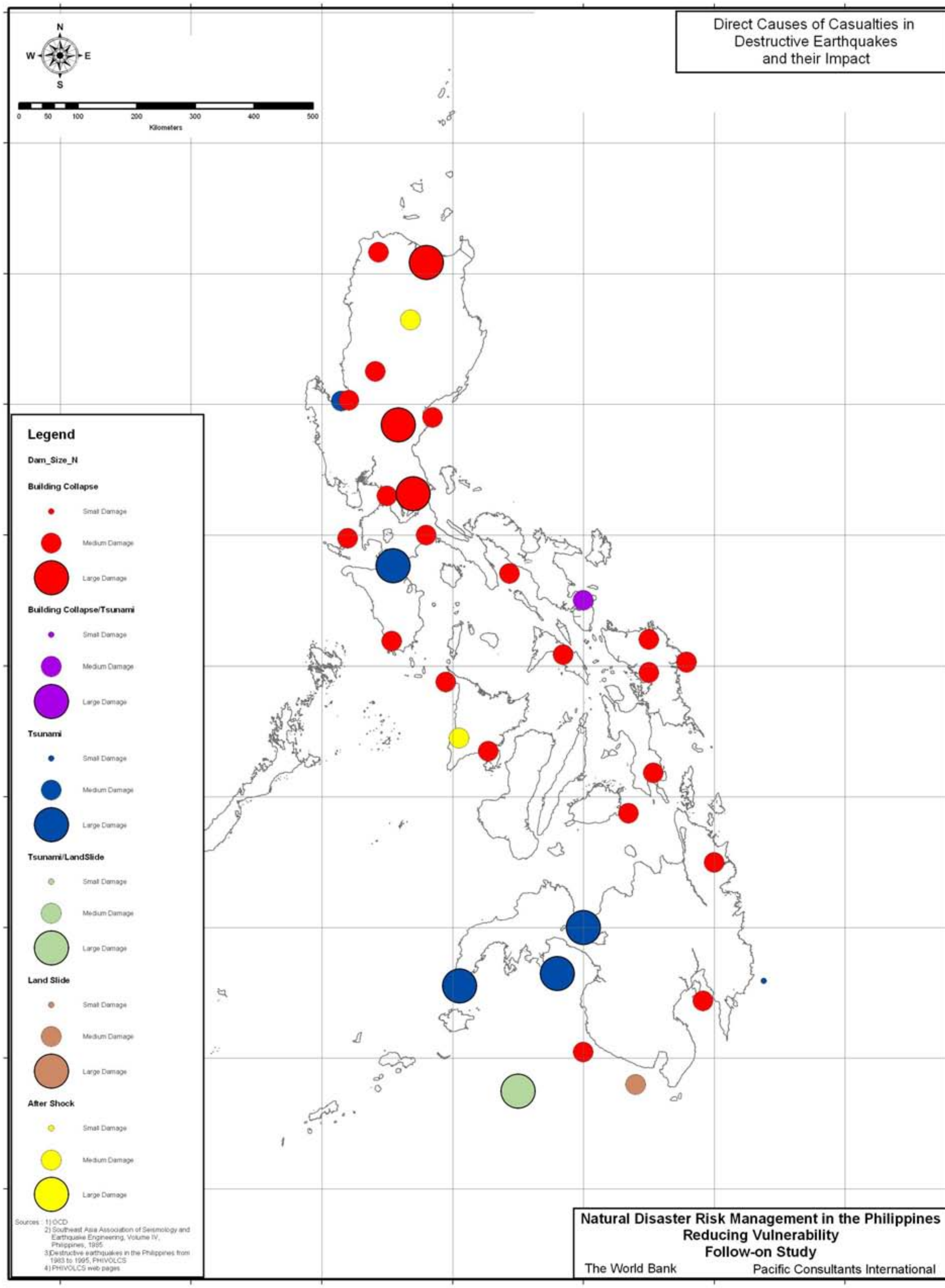


Figure 4.19 Direct Causes of Casualties in Destructive Earthquakes and their Impact

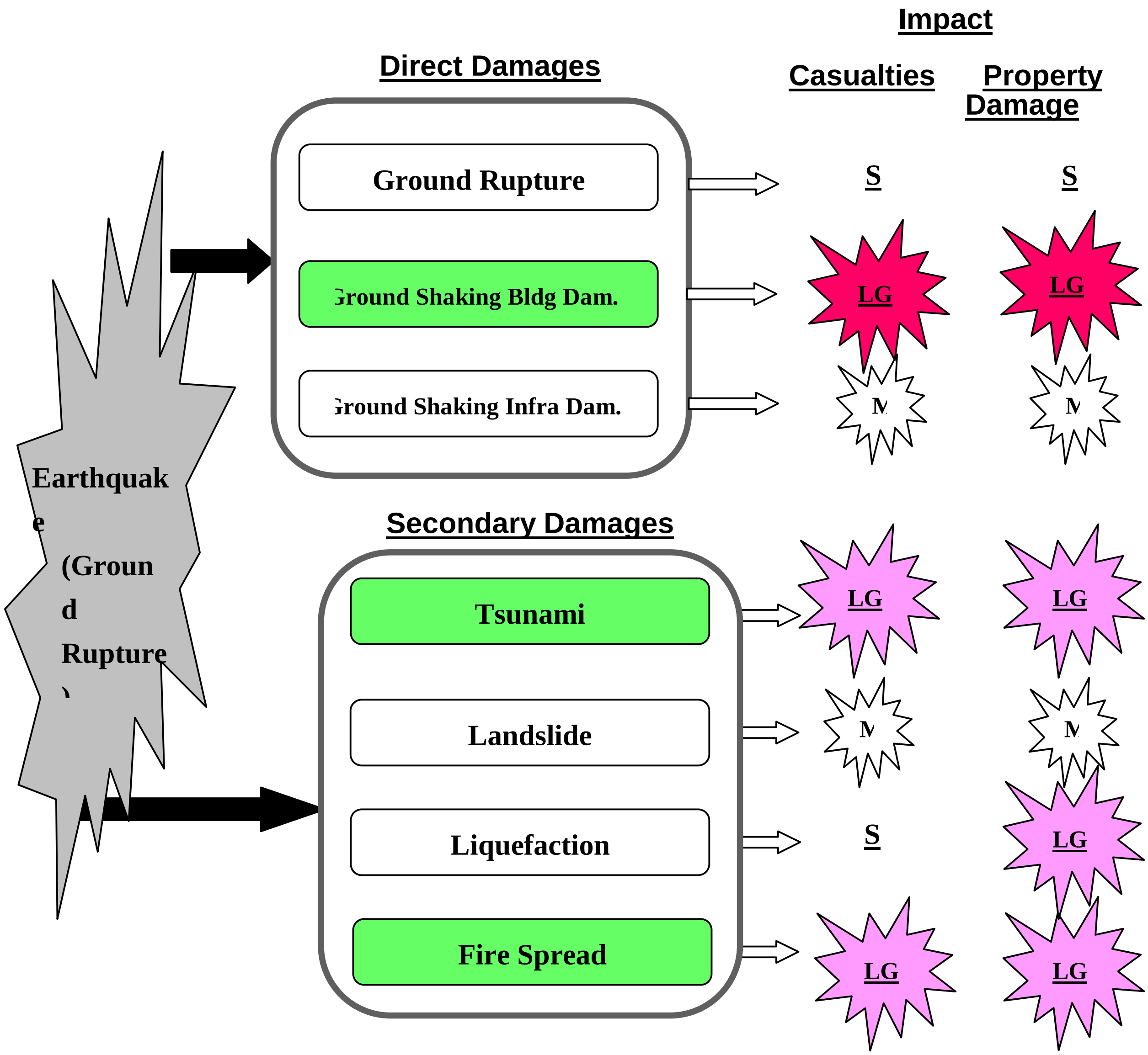


Figure 4.20 Earthquake Damage Mechanism in the Philippines

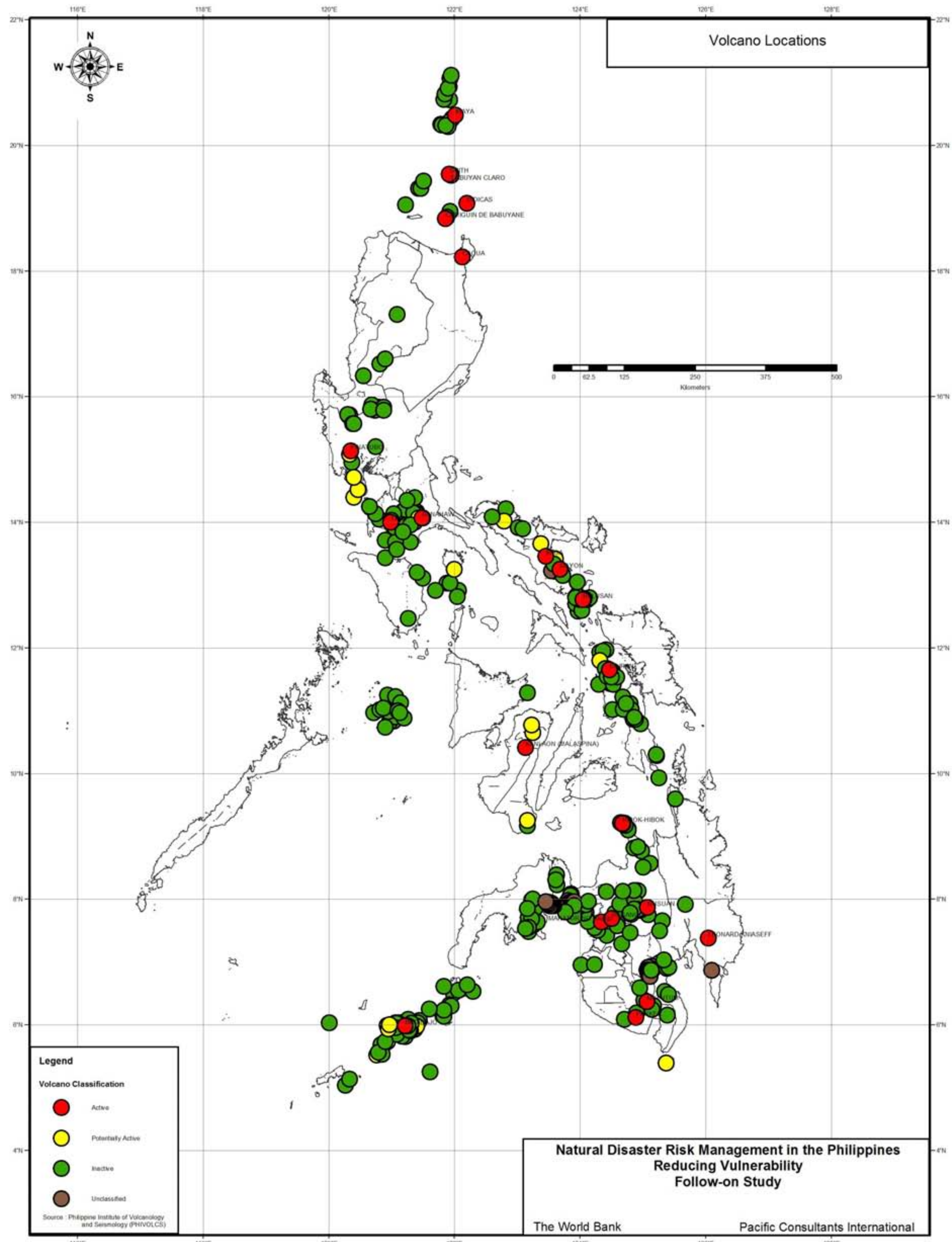


Figure 5.1 Location of the Volcanoes in the Philippines

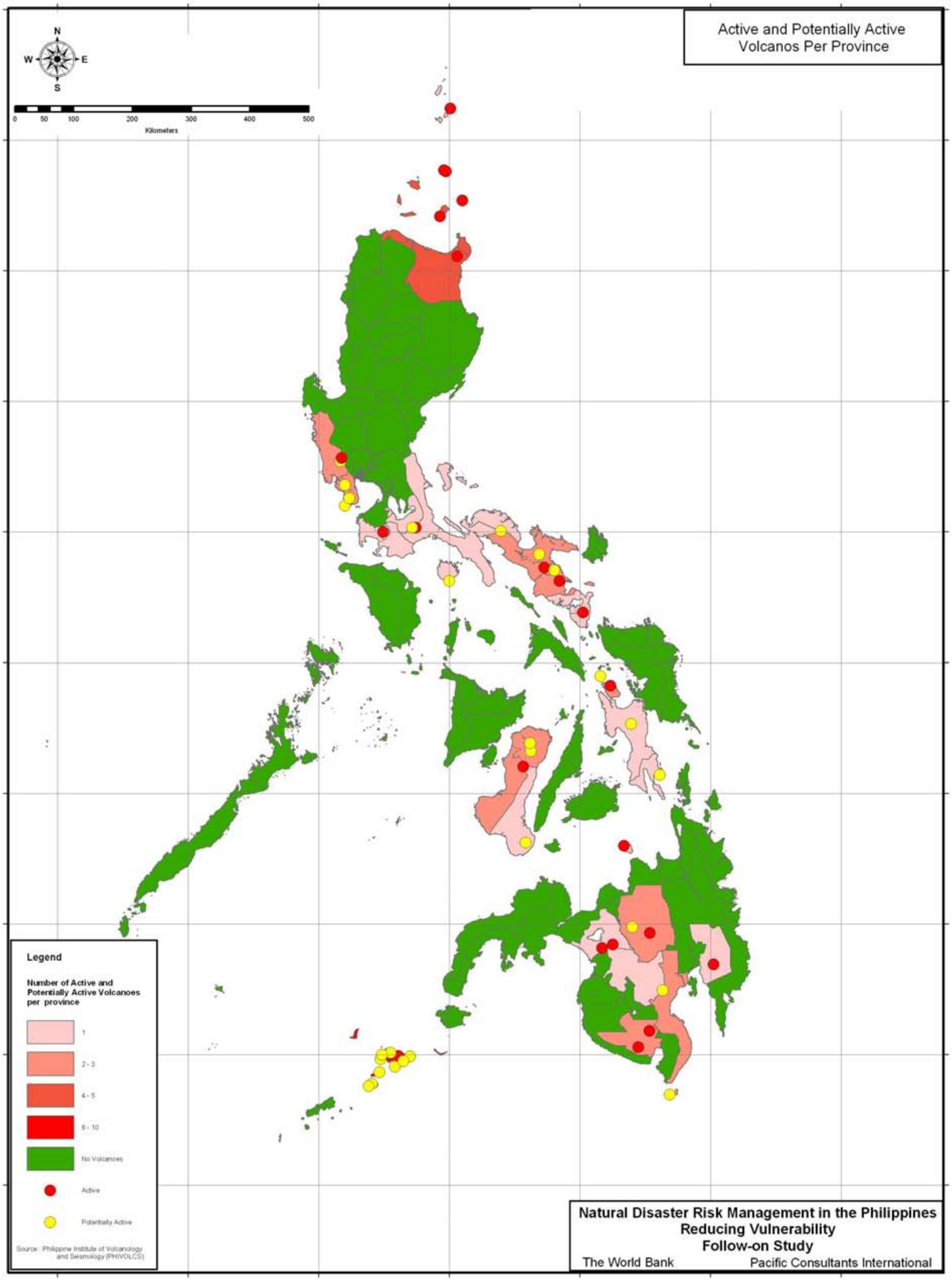


Figure 5.2 Number of Active and Potentially Active Volcanoes per Province

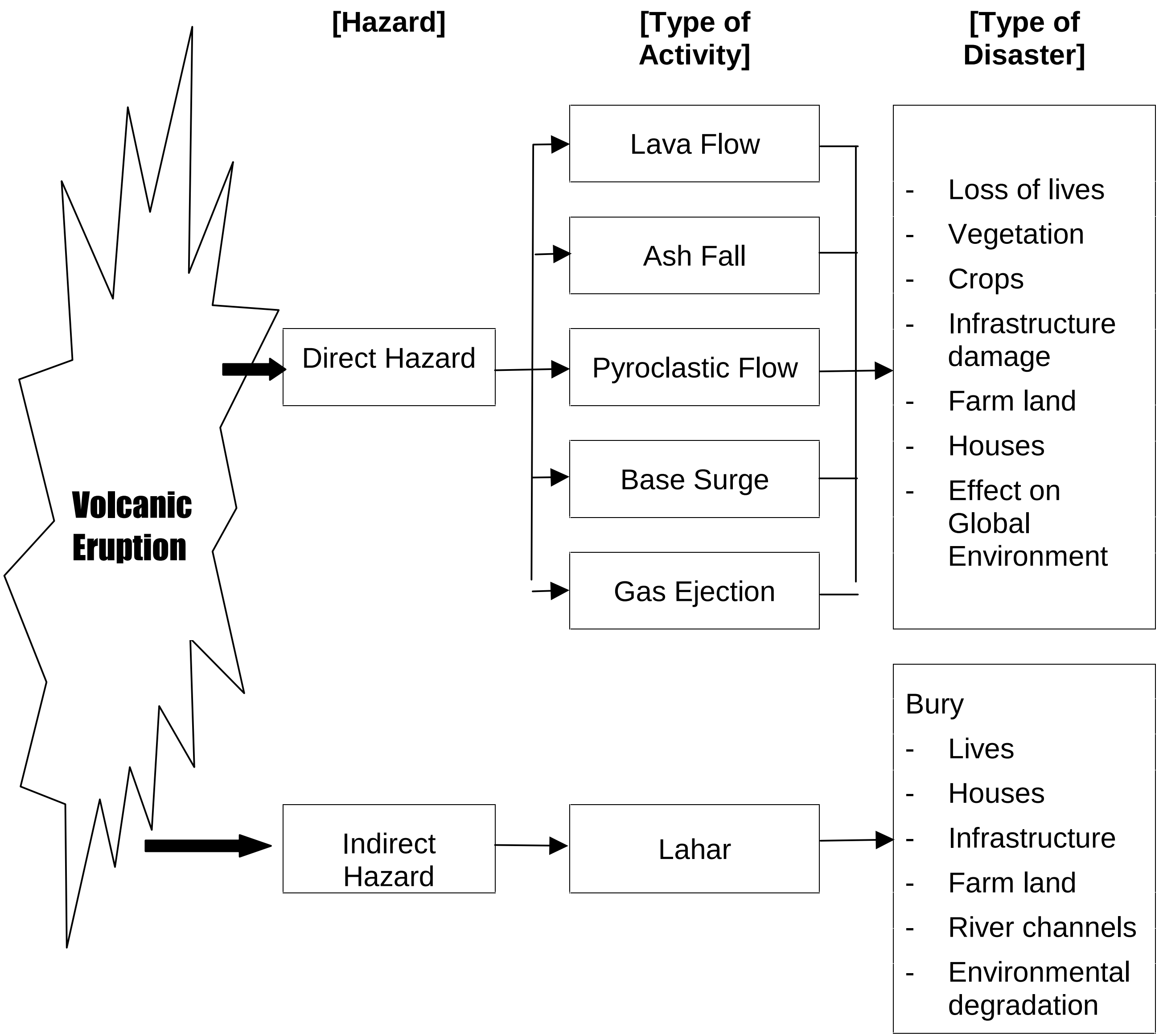


Figure 5.3 Mechanism of Volcanic Disaster

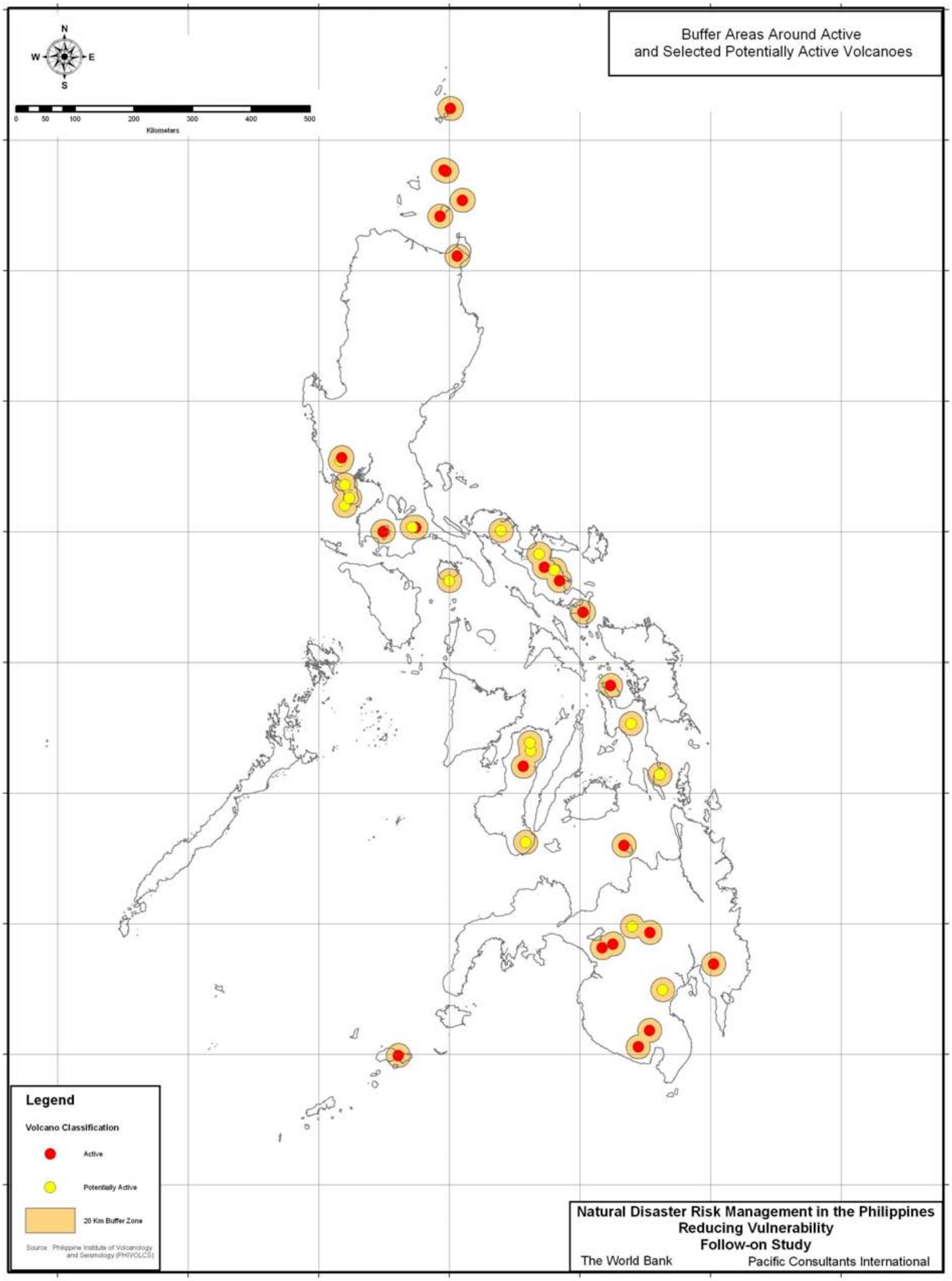


Figure 5.4 Problematic Areas of Volcanoes

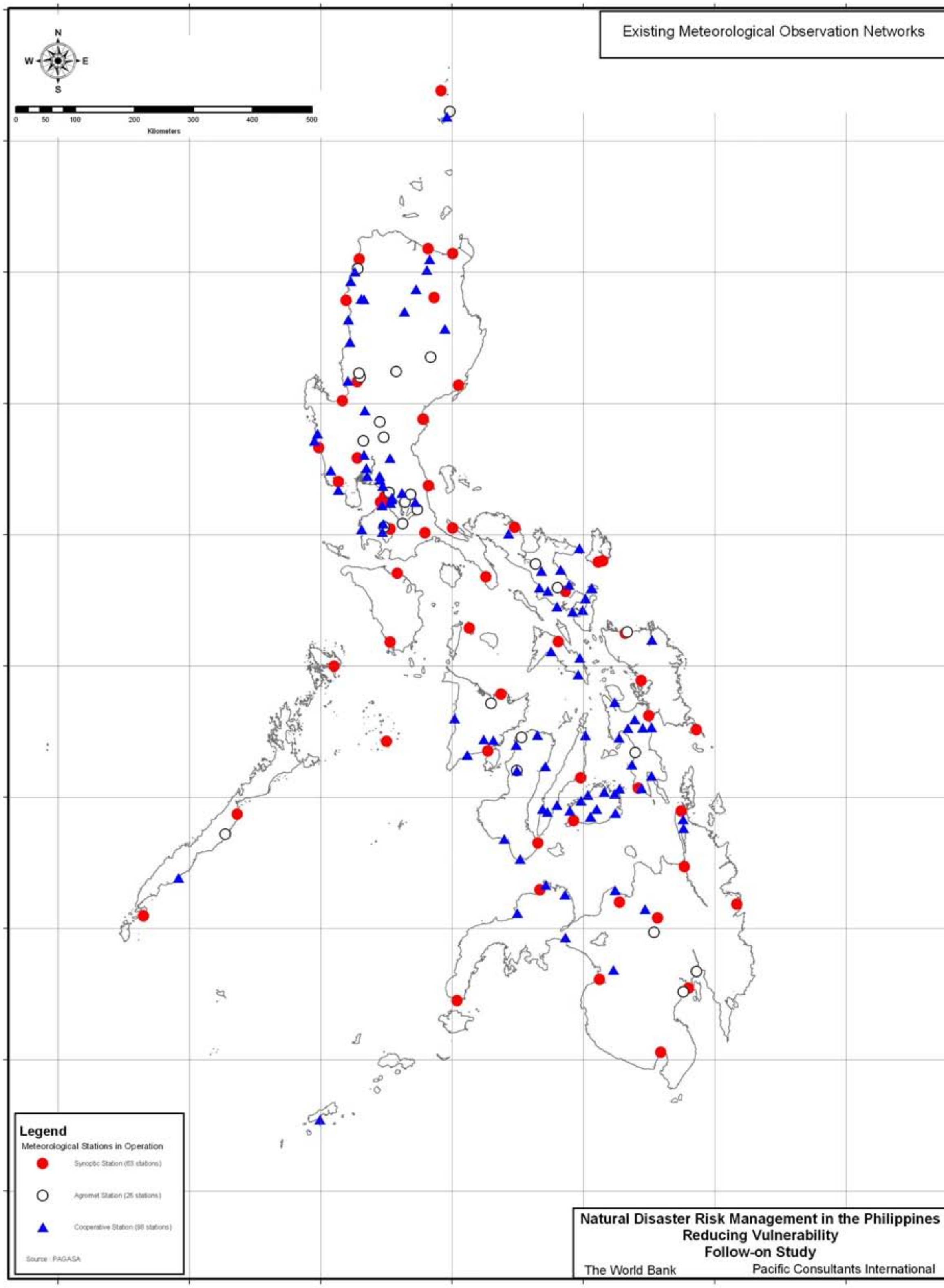


Figure 6.1 Existing Meteorological Observation Networks

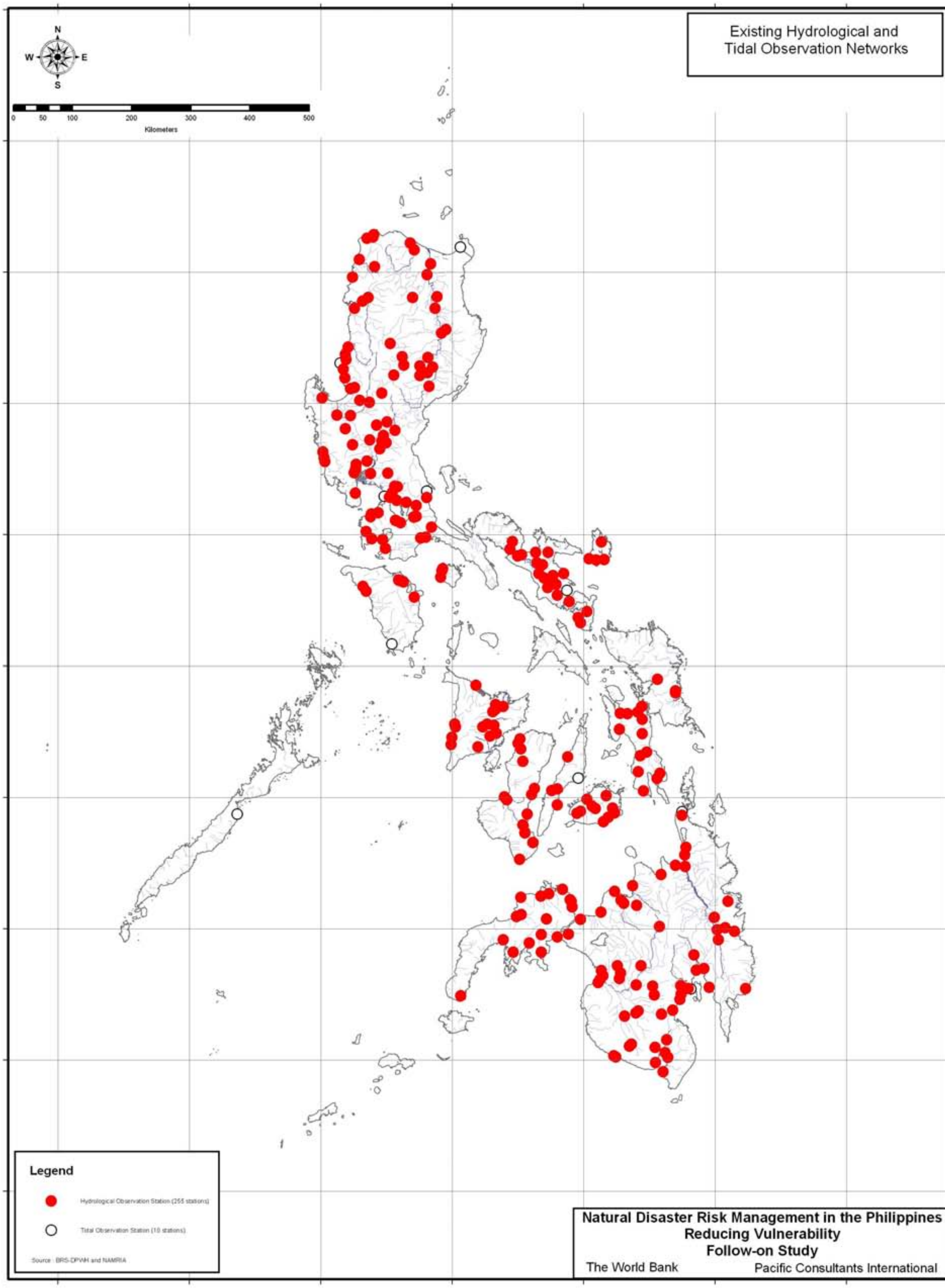
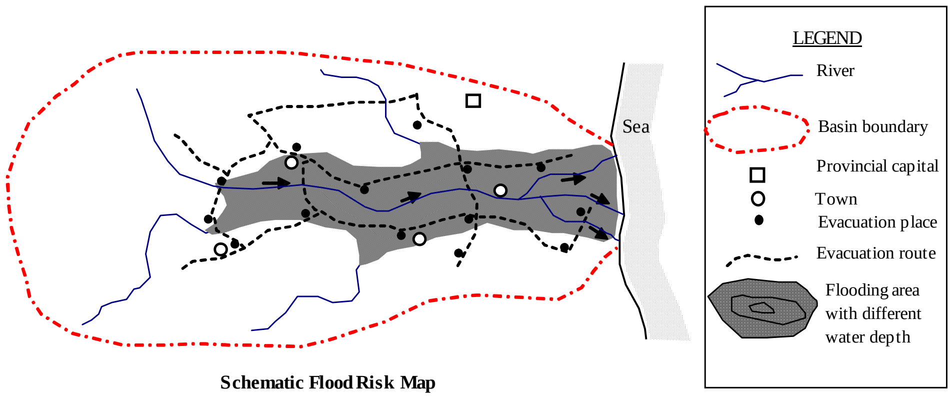


Figure 6.2 Existing Hydrological and Tidal Observation Networks

A. RIVER BASIN MODEL FOR FLOOD
- Most Basic Model for Damage Estimation



Schematic Flood Risk Map

A-1 Flood and Flood Damage Estimation based on Flood Survey **: Basically required**

A-1-1 Survey on Major Floods in Recent Years

Flood Survey
1) Major Floods
Flood 1 (Probability 1)
Flood 2 (Probability 2)
2) Average Floods
Flood 3 (Probability 3)

Survey Method
1) Site investigation
2) Flood mark survey
3) Interview to people
4) Information from LGUs
5) Others

To be Produced
1) Flood Risk Map

To be analyzed
1) Damage condition
2) Problems of evacuation
3) Problems of response
4) Problems of rehabilitation

A-1-2 Flood Damage Estimation in Monetary Terms based on Recorded Floods

Survey on Assets
1) Houses
2) Industries
3) Commercial & Trades
4) Infrastructure
5) Agriculture
6) Livestocks
7) Fishery
8) Others

Survey Method
1) Statistical data
2) Landuse map/data
3) Data of LGUs
4) Field sample survey

To be Analyzed
1) Damageable values
2) Damage rates
3) Damage estimation
4) Annual damage

A-2 Simulation of Floods and Flood Damage **: Necessary to assess damages of without and with structural mitigations measures**

Physical Model for Probable Floods

Rainfall Runoff Model for Basin
1) Input: Probable storm rainfall
2) Output: Rainfall runoff volume

Hydraulic Model for River
1) Probable flood water level
2) Probable flood discharge

Simulated Flooding Condition
1) Probable flooding areas
2) Flood depth and duration

Economic/Financial Model

Database of Assets

Probable Damage in Monetary Terms
- For each probable flood

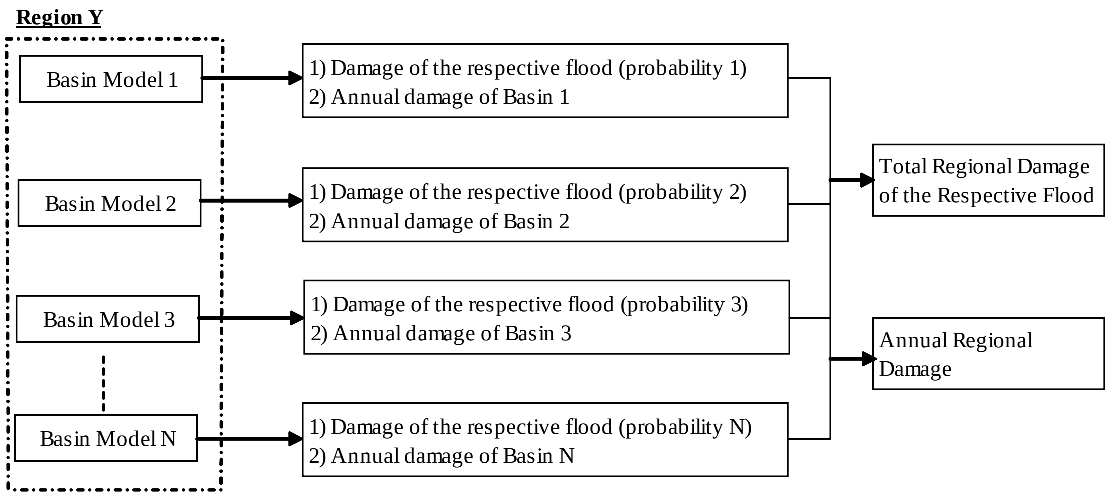
Annual Damage in Monetary Terms
- As expected value of probability analysis

Figure 6.3 (1) Proposed Flood Risk Model (1/2)

B. REGIONAL MODEL

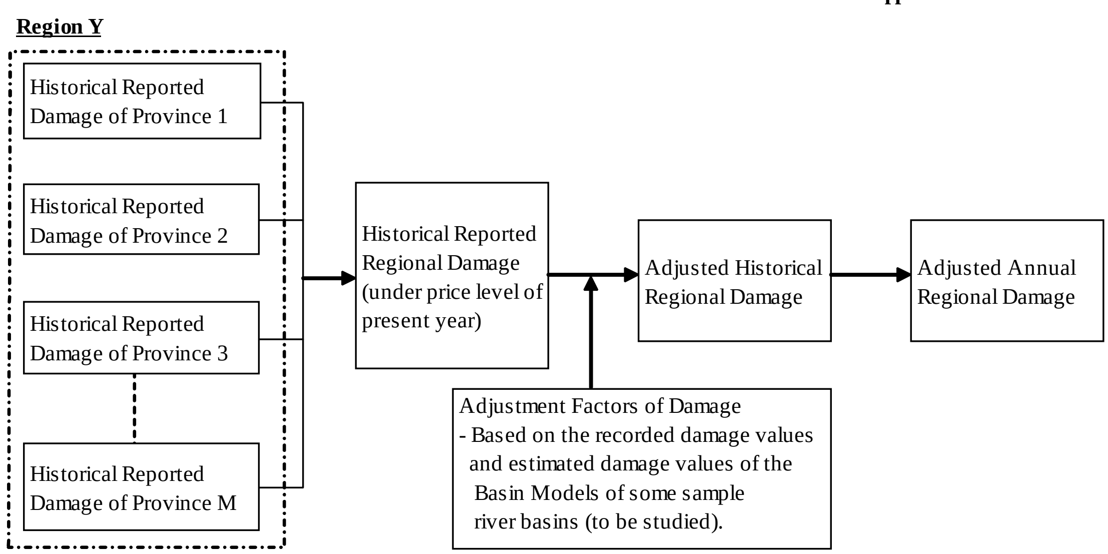
B-1 Regional Model for Monetary Damage based on Basin Model

: To be recommended



B-2 Provisional Regional Model for Monetary Damage based on the Reported Damages

: Only for provisional application

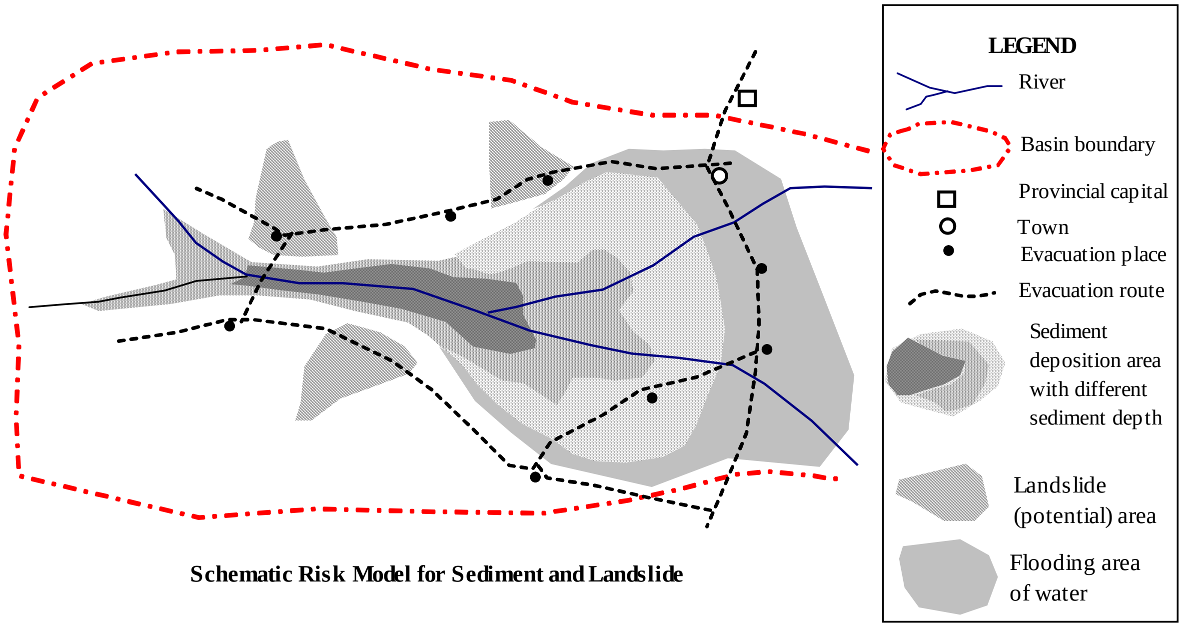


C. Matters to be improved

1) Improvement of topographic maps
2) Improvement of landuse maps
3) Strengthening of meteo-hydrological observation networks with improvement of data quality
4) Assets database of provinces and river basins
5) Improvement of accuracy of the reports on provincial property damages by DCCs

Figure 6.3 (2) Proposed Flood Risk Model

A. RIVER BASIN MODEL FOR SEDIMENT WITH FLOOD
- Most Basic Model for Damage Estimation



Schematic Risk Model for Sediment and Landslide

C-1 Sediment including Landslide Damage Estimation based on Survey **: Basically required**

C-1-1 Survey on Major Sediment including Landslide Damage in Recent Years

Survey
1) Major Sediment Damage
   Event 1 (Probability 1)
   Event 2 (Probability 2)
   Event 3 (Probability 3)

⇨

Survey Method
1) Site investigation
2) Sediment / Flood mark survey
3) Survey on slope failures and landslide
4) Survey on unstable sediment in the rivers
5) Interview to people
6) Information from LGUs

⇨

To be Produced
1) Sediment with Landslide Risk Map

To be analyzed
1) Damage condition
2) Problems of evacuation
3) Problems of response
4) Problems of rehabilitation

⇩

C-1-2 Sediment including Landslide Damage Estimation in Monetary Terms based on Recorded Events

Survey on Assets
1) Houses
2) Industries
3) Commercial & Trades
4) Infrastructure
5) Agriculture
6) Livestock
7) Fishery
8) Others

⇨

Survey Method
1) Statistical data
2) Landuse map/data
3) Data of LGUs
4) Field sample survey

⇨

To be Analyzed
1) Damageable values
2) Damage rates
3) Damage estimation
4) Annual damage

Figure 6.4 Proposed Sediment including Landslide Risk Model

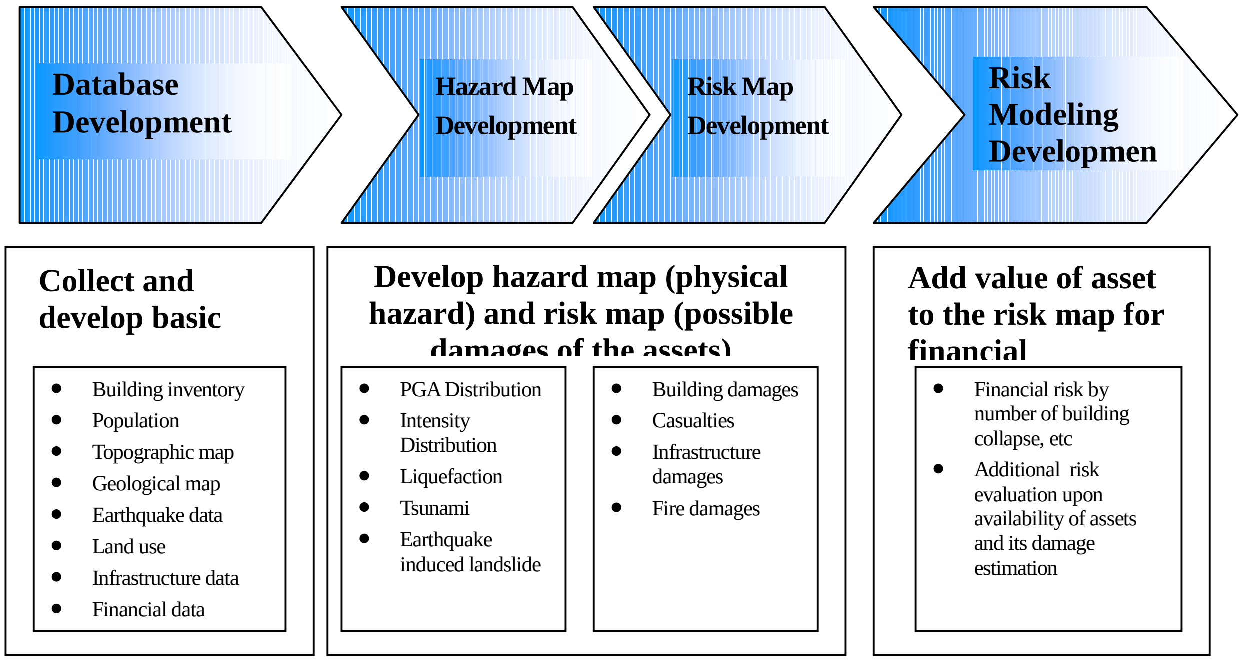


Figure 6.5 General Flow of the Database. Hazard and Risk Map, and Risk Modeling Development

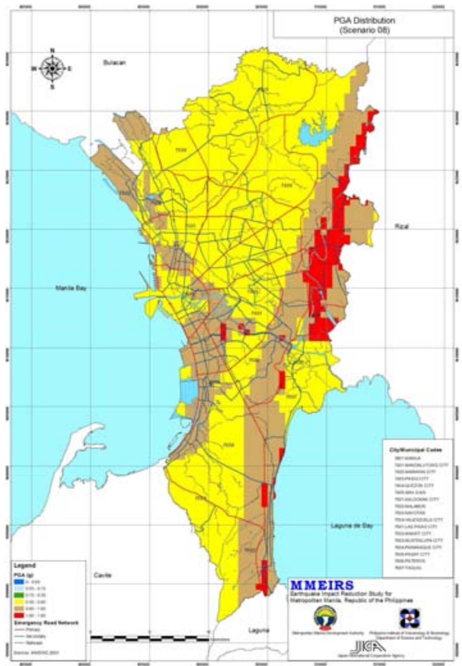


Figure 6.6 PGA Distribution

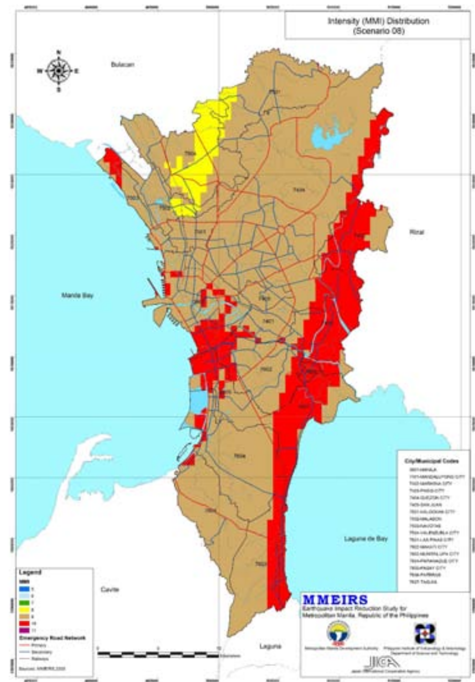


Figure 6.7 Intensity Distribution

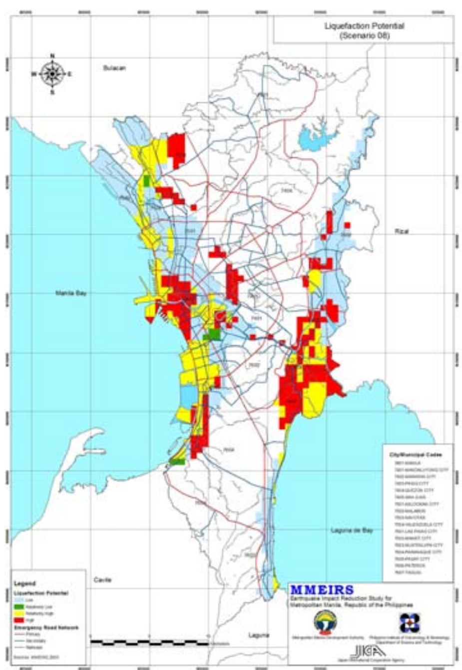


Figure 6.8 Liquefaction

Source: MMEIRS, 2003, JICA

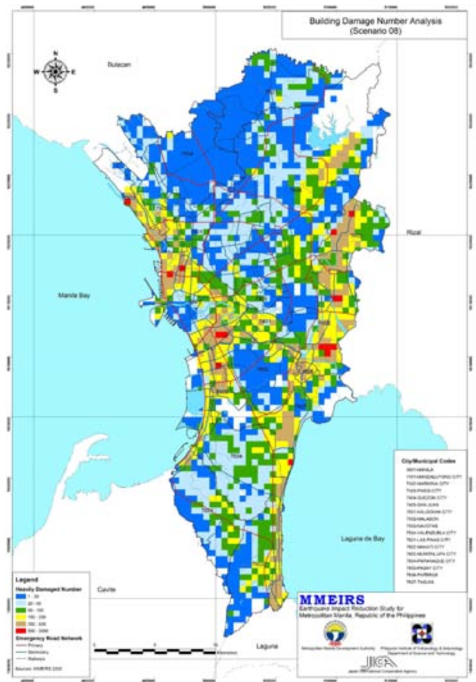


Figure 6.9 Building Damages (Number of Heavily Damaged Buildings)

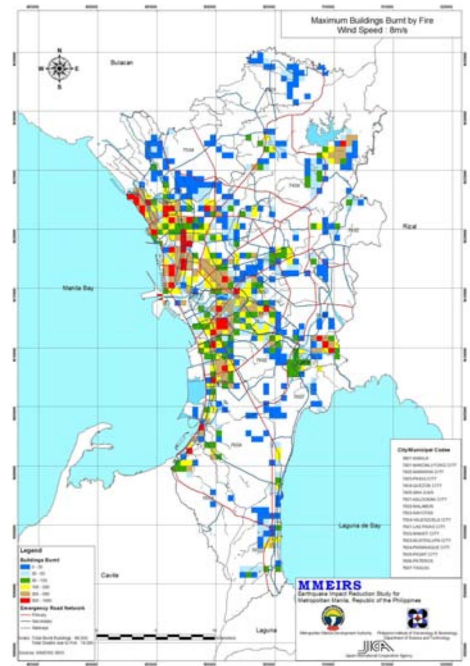


Figure 6.10 Maximum Burnt Buildings by Fire

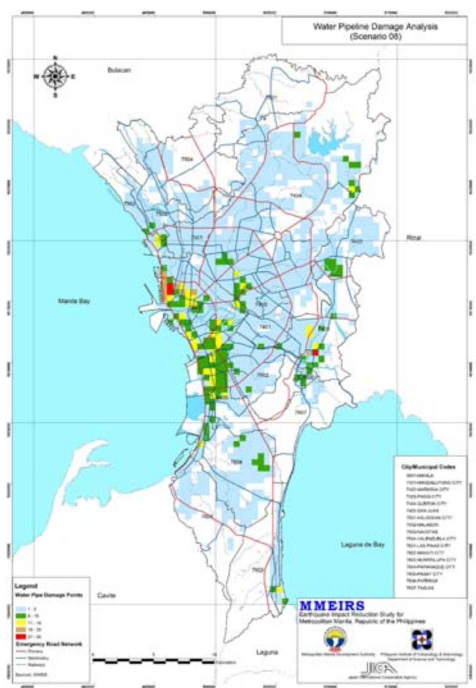


Figure 6.11 Distribution of Water Pipeline Damage

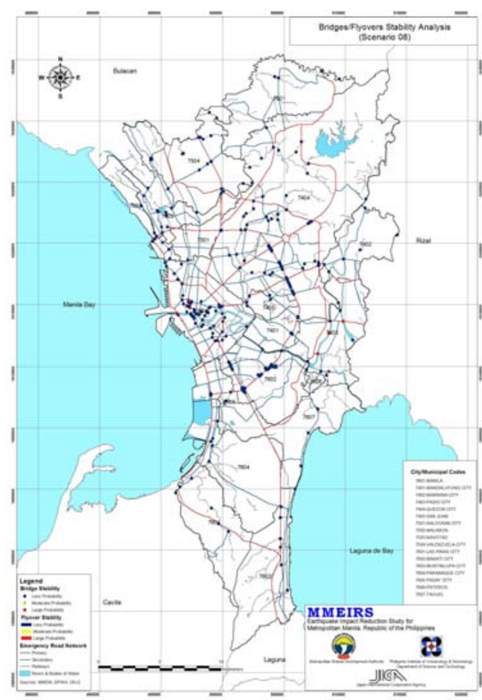


Figure 6.12 Result of Bridges and Flyovers Stability Analysis

Source: MMEIRS, 2003, JICA

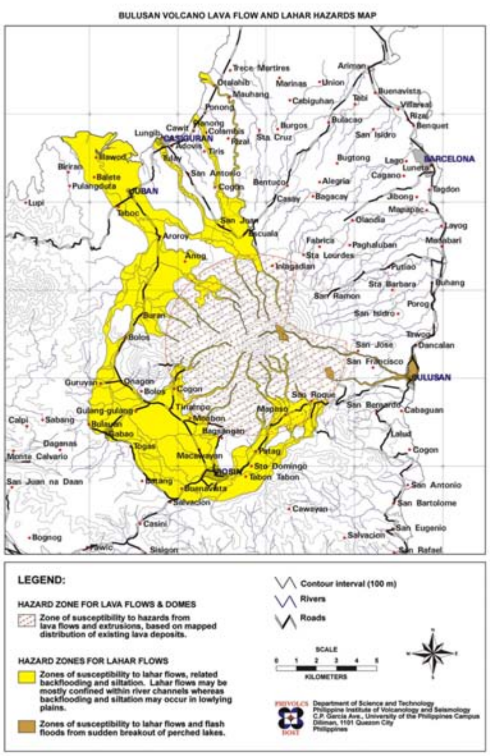


Figure 6.13 Bulasan Lava-Lahar Hazard Map

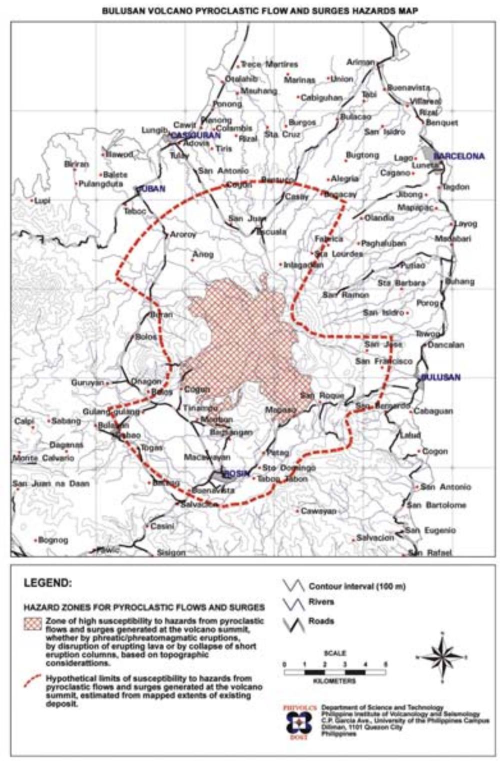


Figure 6.14 Bulasan Pyroclastic Flow Hazard Map

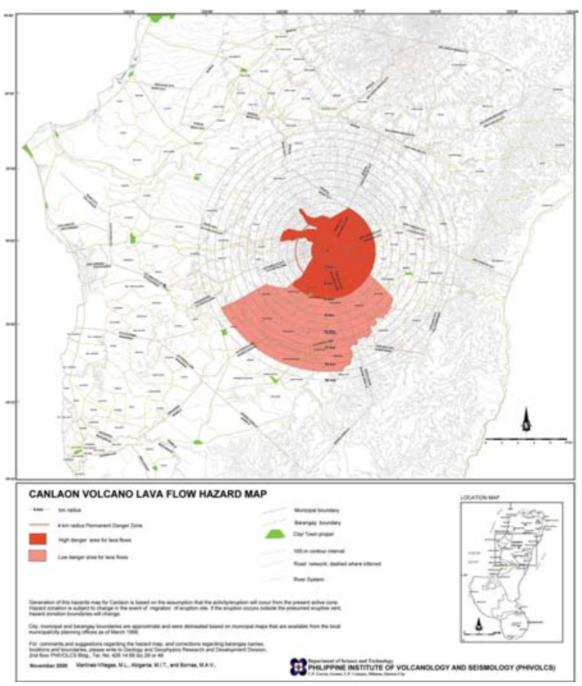


Figure 6.15 Canlaon Lava Flow Hazard Map

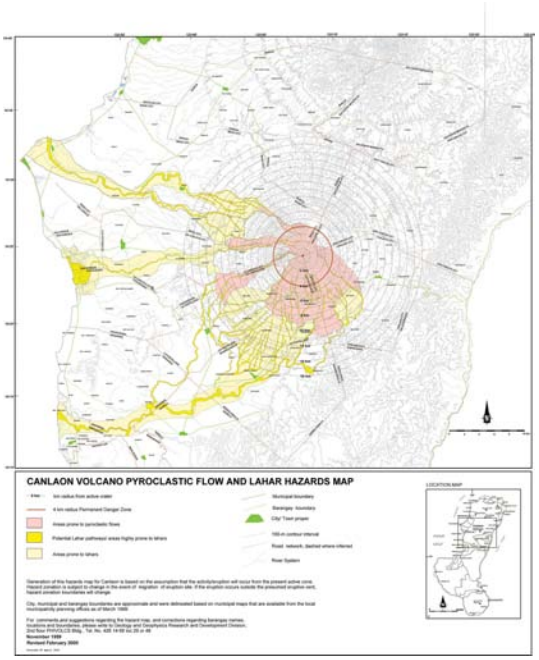


Figure 6.16 Canlaon Volcanic Pyroclasic Flow and Lahar Hazard Map

Source: PHIVOLCS

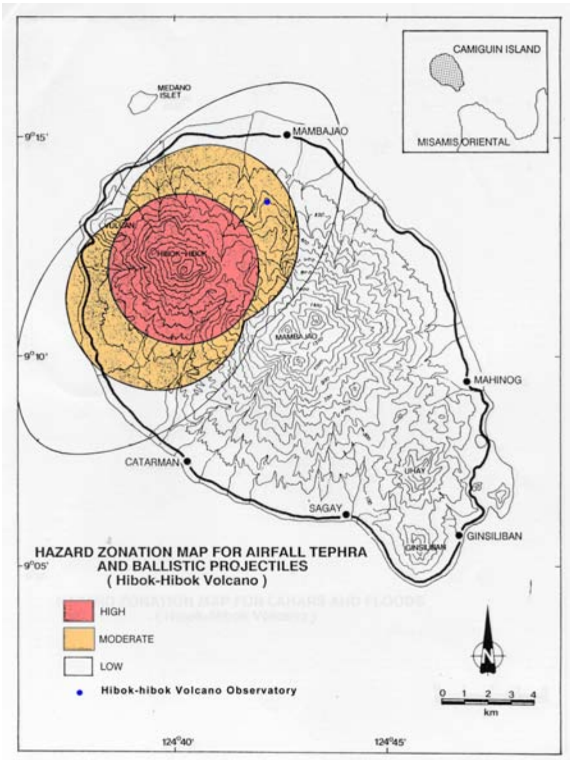


Figure 6.17 Hazard Zonation Map for Airfall Tephra and Ballistic Projects, Hibok-hibok

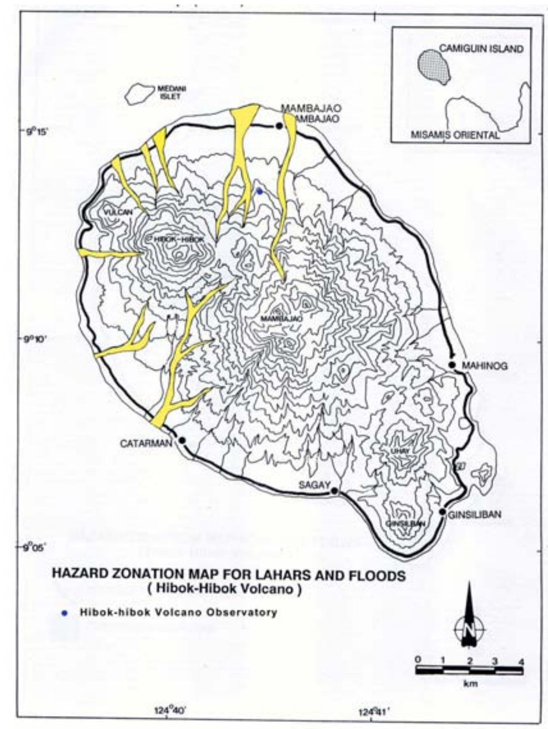


Figure 6.18Hazard Zonation Map for Lahar and Floods, Hibok-hibok

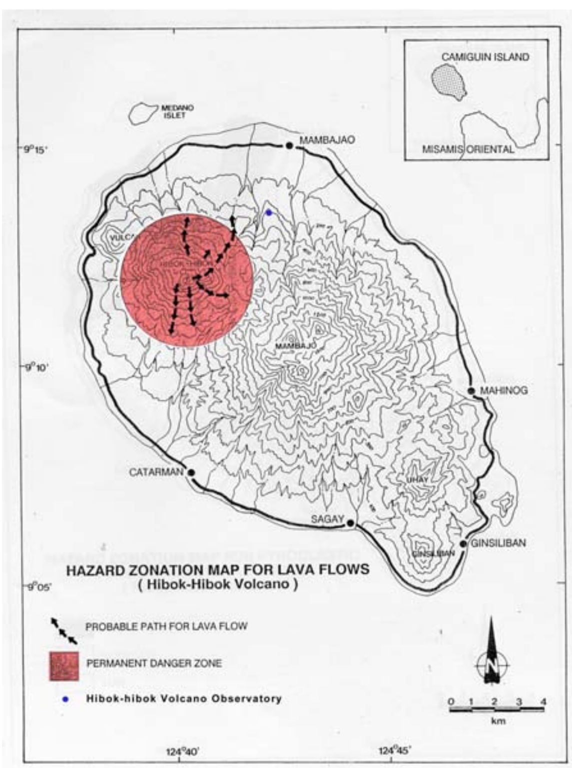


Figure 6.19 Hazard Zonation Map for Lava Flows, Hibok-hibok

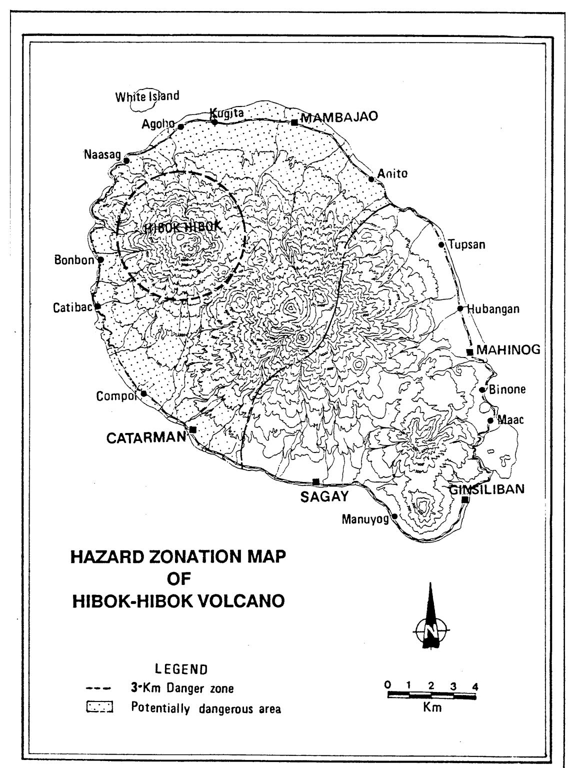


Figure 6.20 Hazard Zonation Map for Hibok-hibok

Source: PHIVOLCS

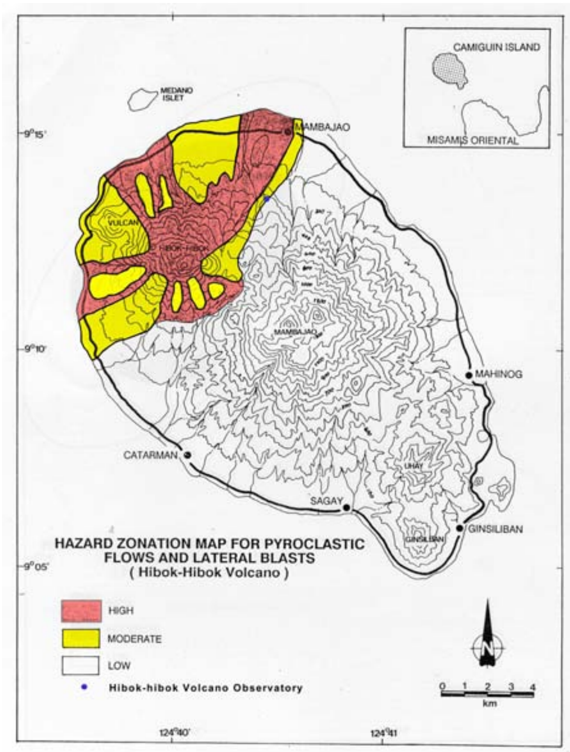


Figure 6.21 Hazard Zonation Map for Pyroclastic Flows and Lateral Blasts, Hibok-hibok

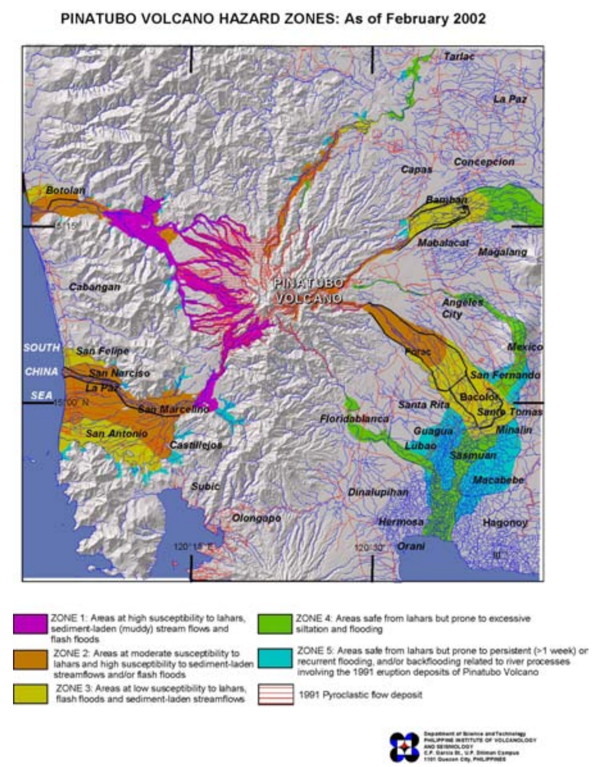


Figure 6.22 Pinatubo Volcano Hazard Zones

Source: PHIVOLCS

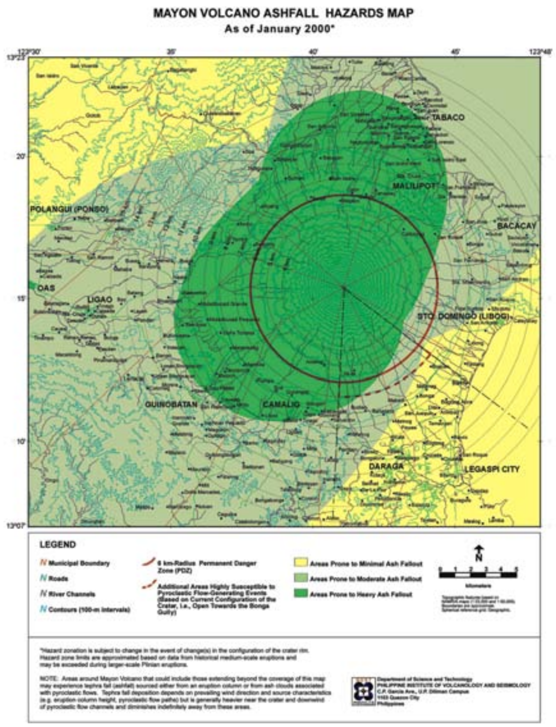


Figure 6.23 Mayon Volcano Ashfall Hazard Map

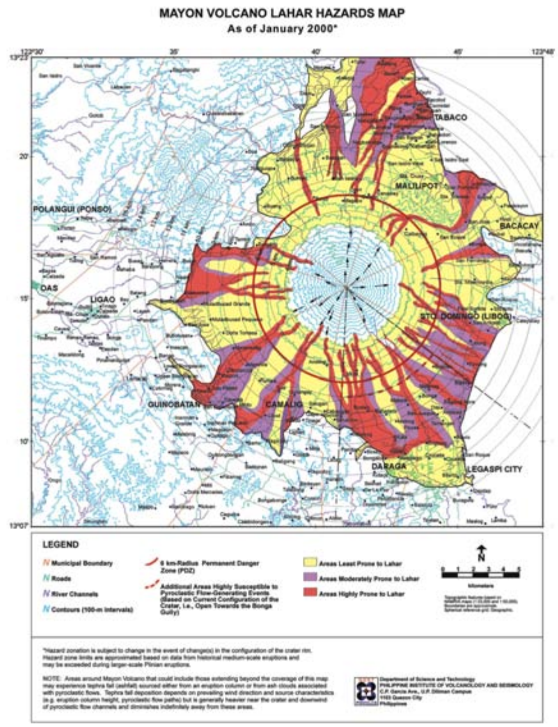


Figure 6.24 Mayon Volcano Lahar Hazard Map

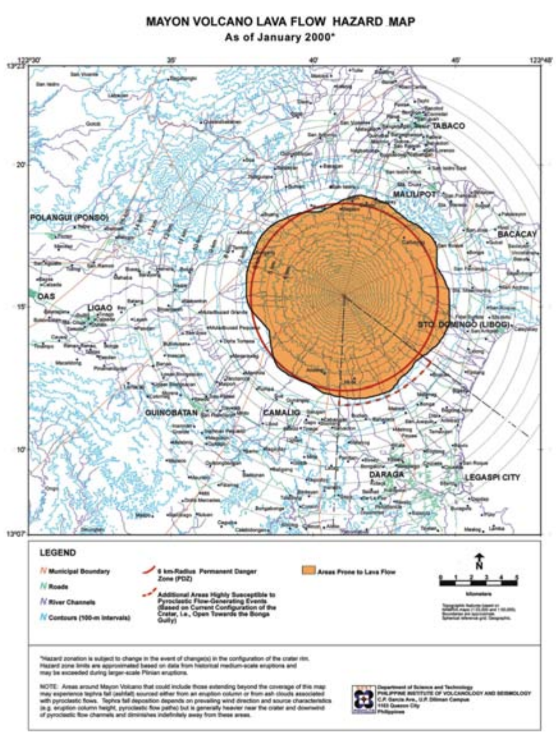


Figure 6.25 Mayon Volcano Lava Flow Hazard Map

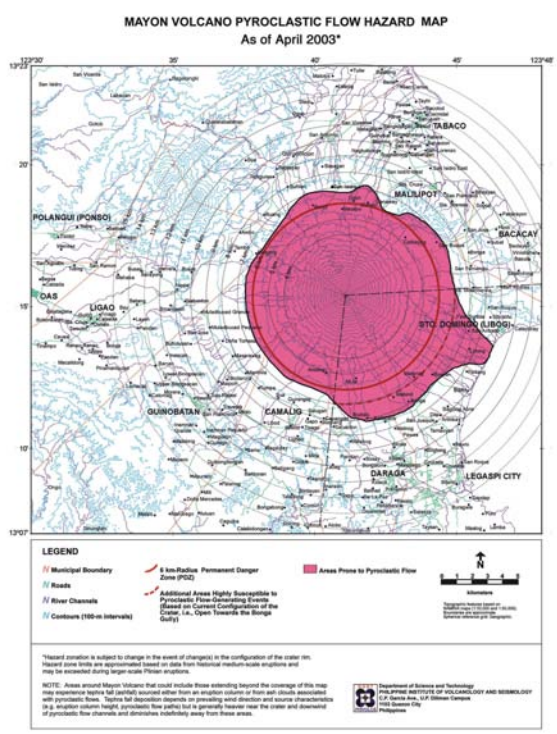


Figure 6.26 Mayon Volcano Pyroclastic Flow Hazard Map

Source: PHIVOLCS

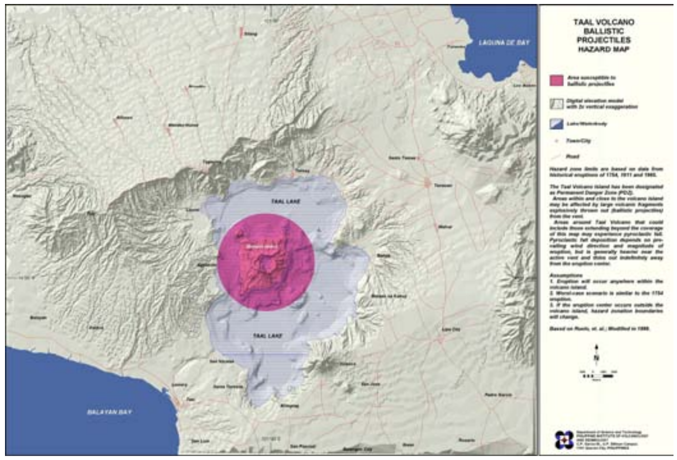


Figure 6.27 Taal Volcano Ballistic Projectiles Hazard Map

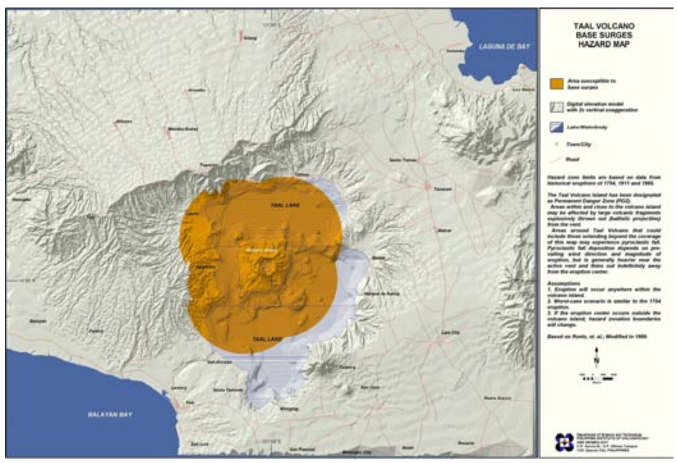


Figure 6.28 Taal Volcano Base Surge Hazard Map

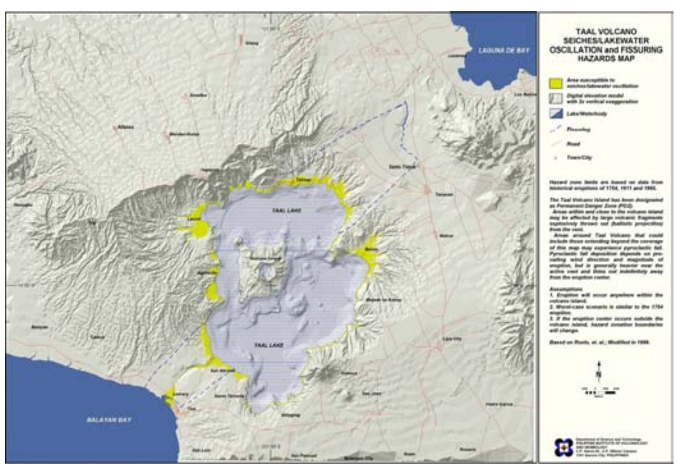


Figure 6.29 Taal Volcano Seiches/ Lake water Oscillation and Fisshering Hazard Map

Source: PHIVOLCS

S o u r c e : P H I V O L C S

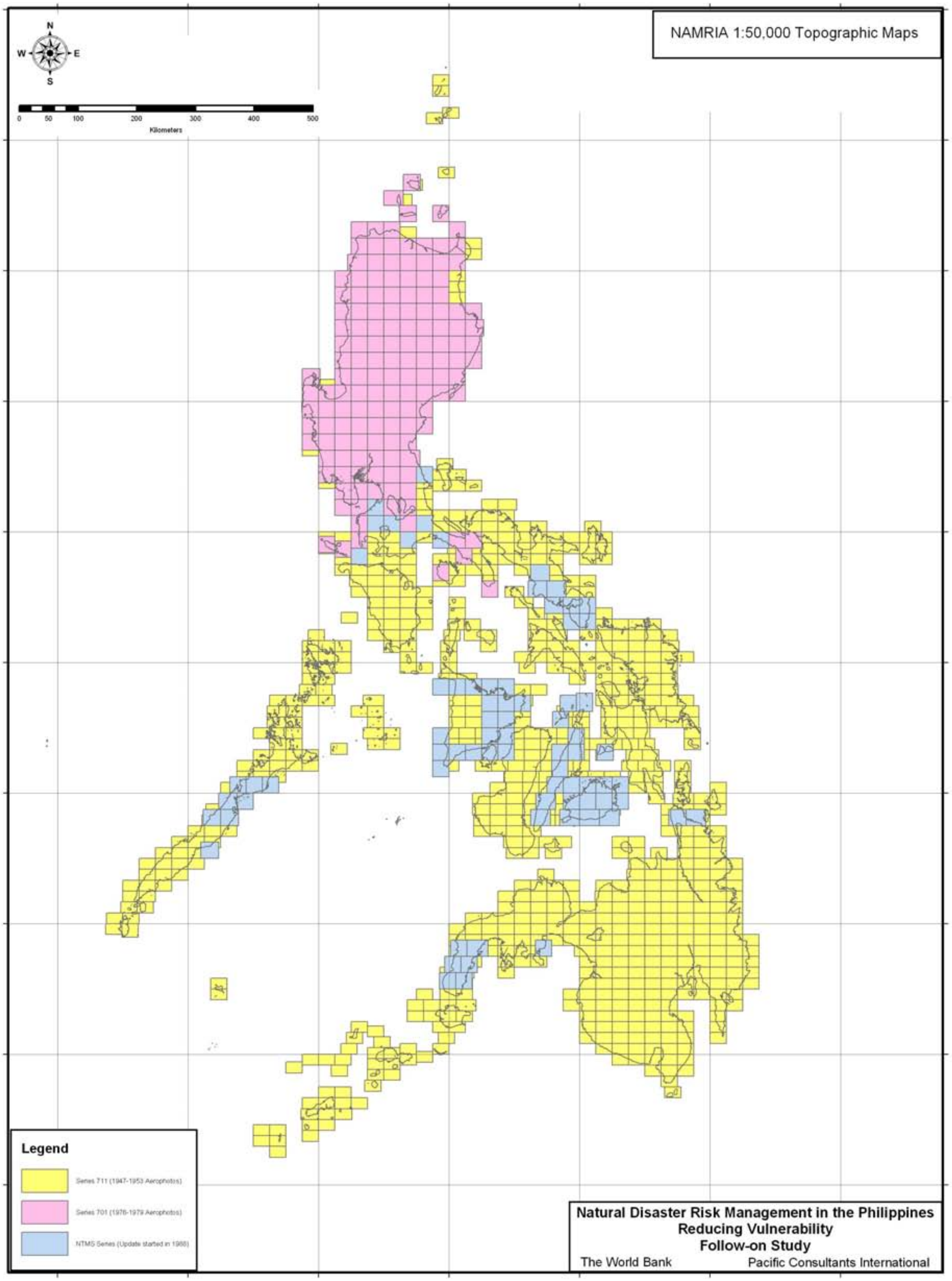


Figure 7.1 Index of Existing 1:50,000 scale maps at NAMRIA

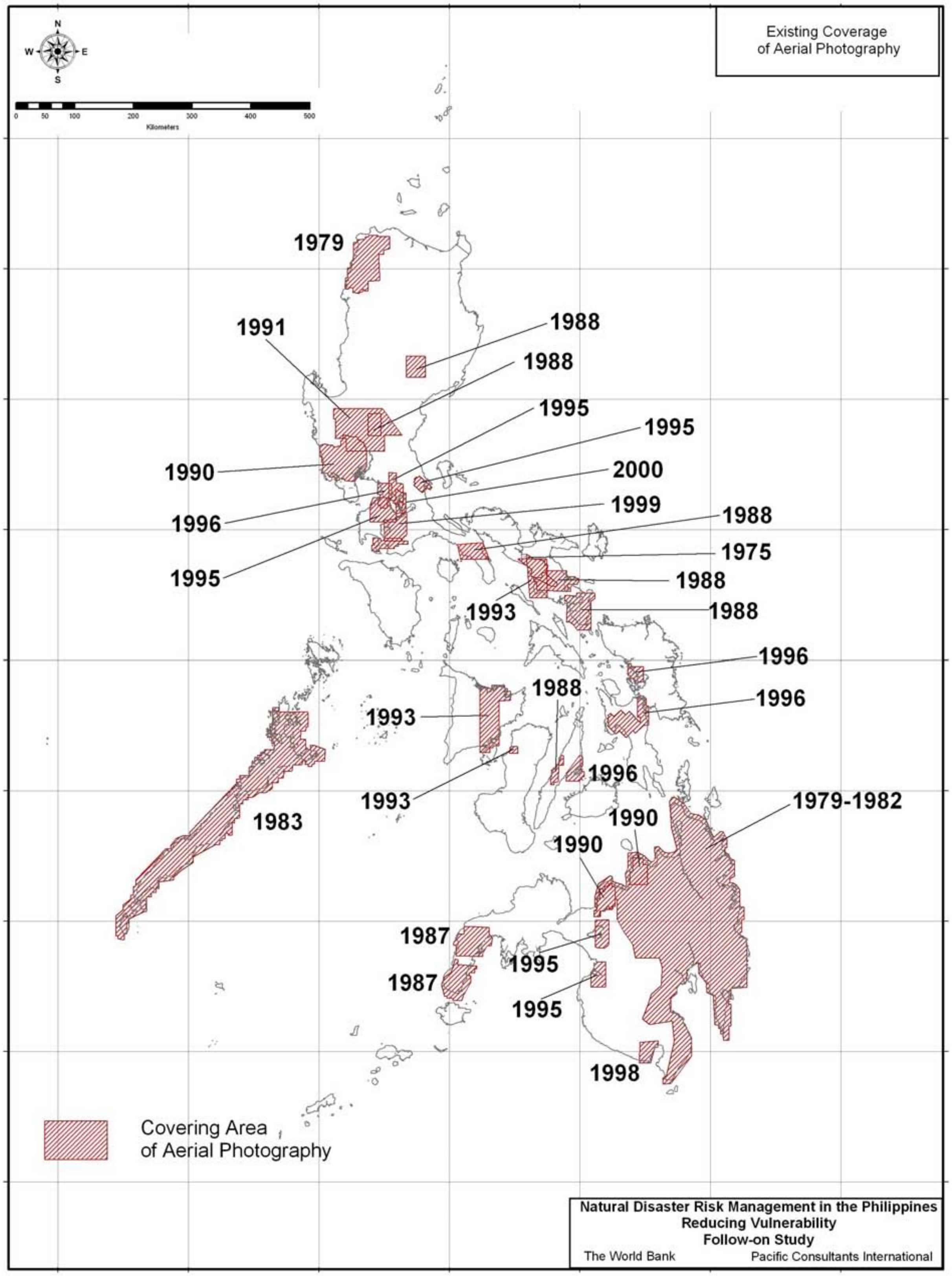


Figure 7.2 Existing Coverage of Aerial Photography

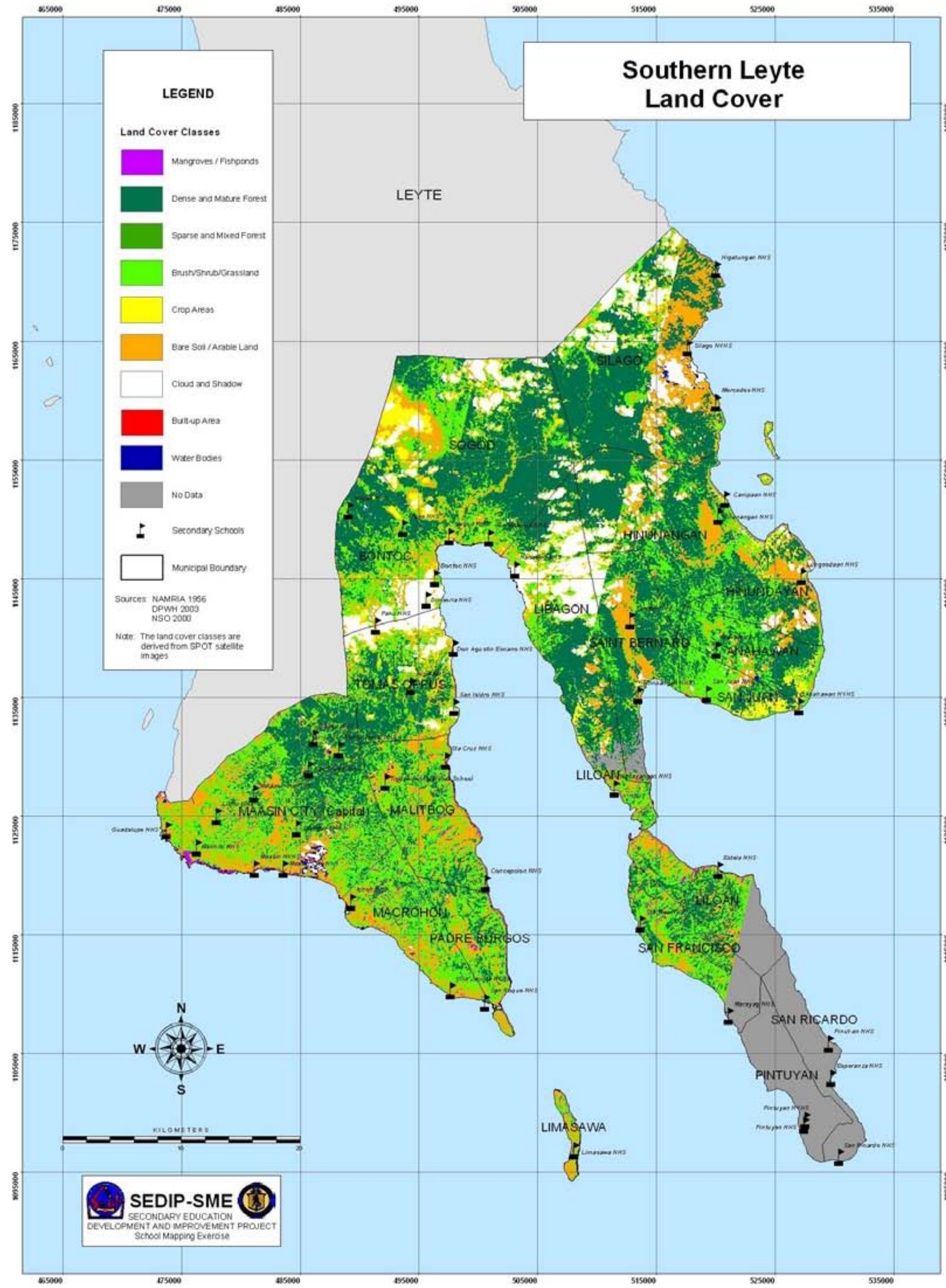


Figure 7.3 Land Cover map for Southern Leyte

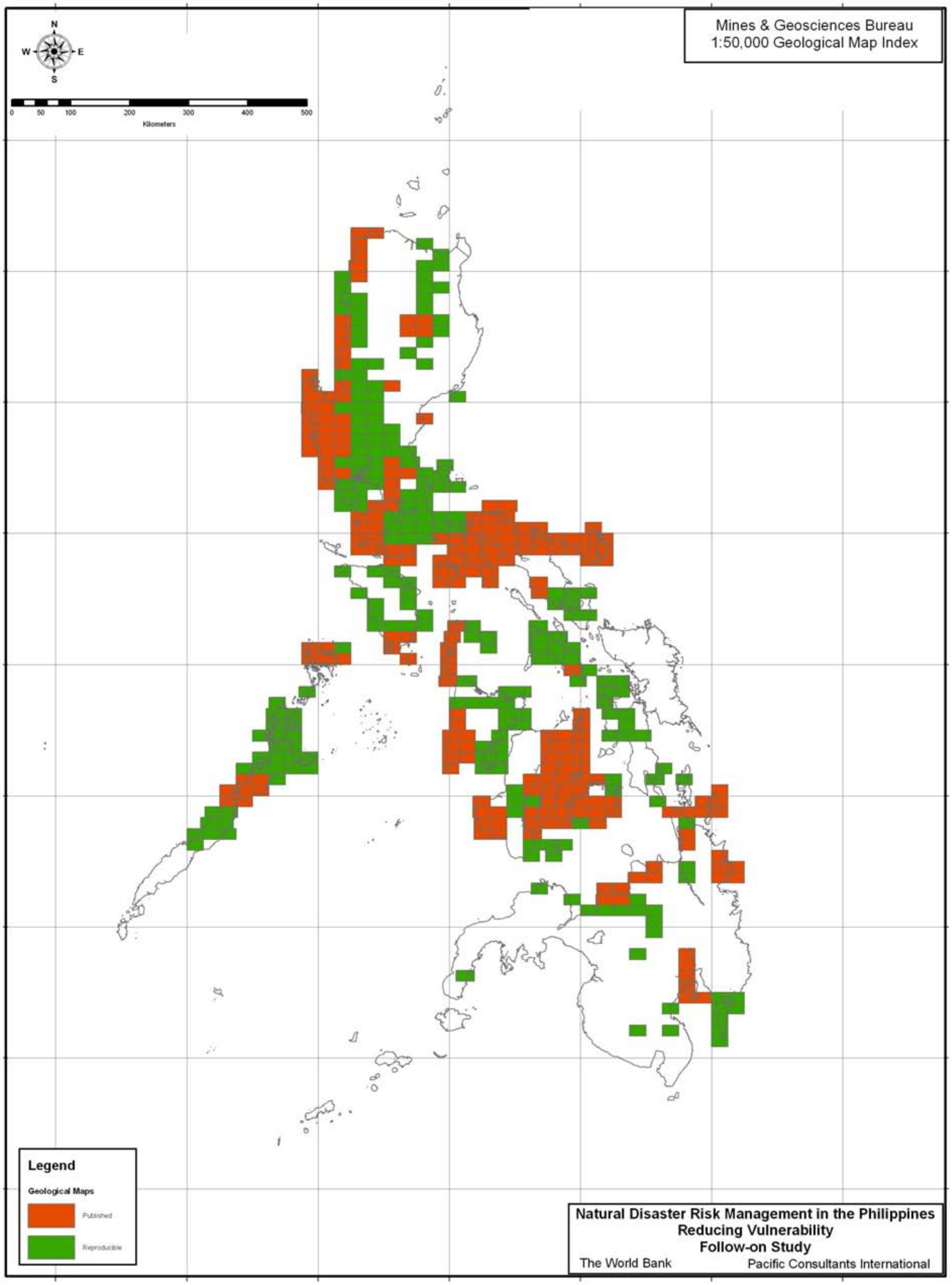


Figure 7.4 Available geological maps at scale 1:50,000 at the MGB

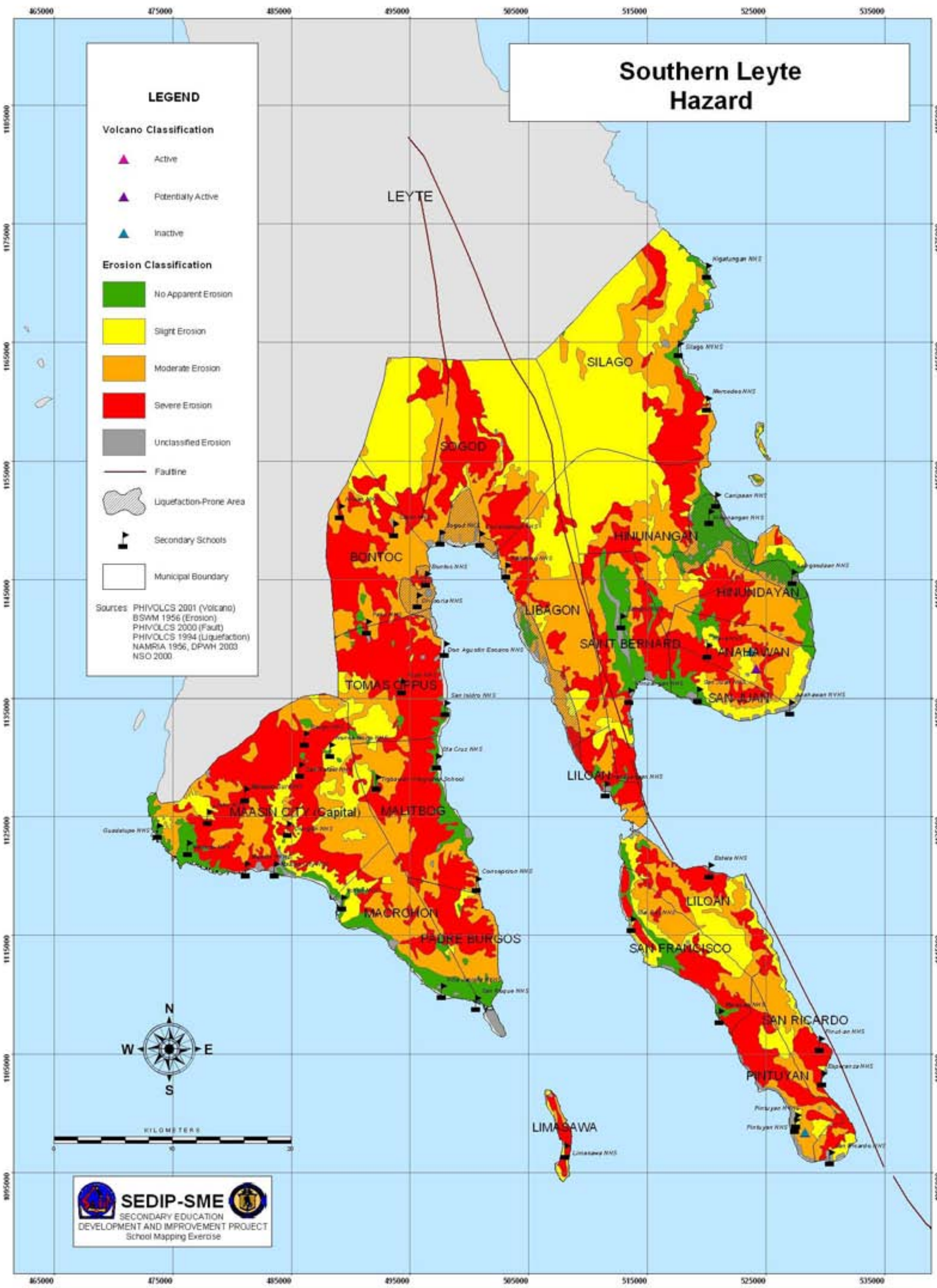


Figure 7.5 Erosion Map for Southern Leyte

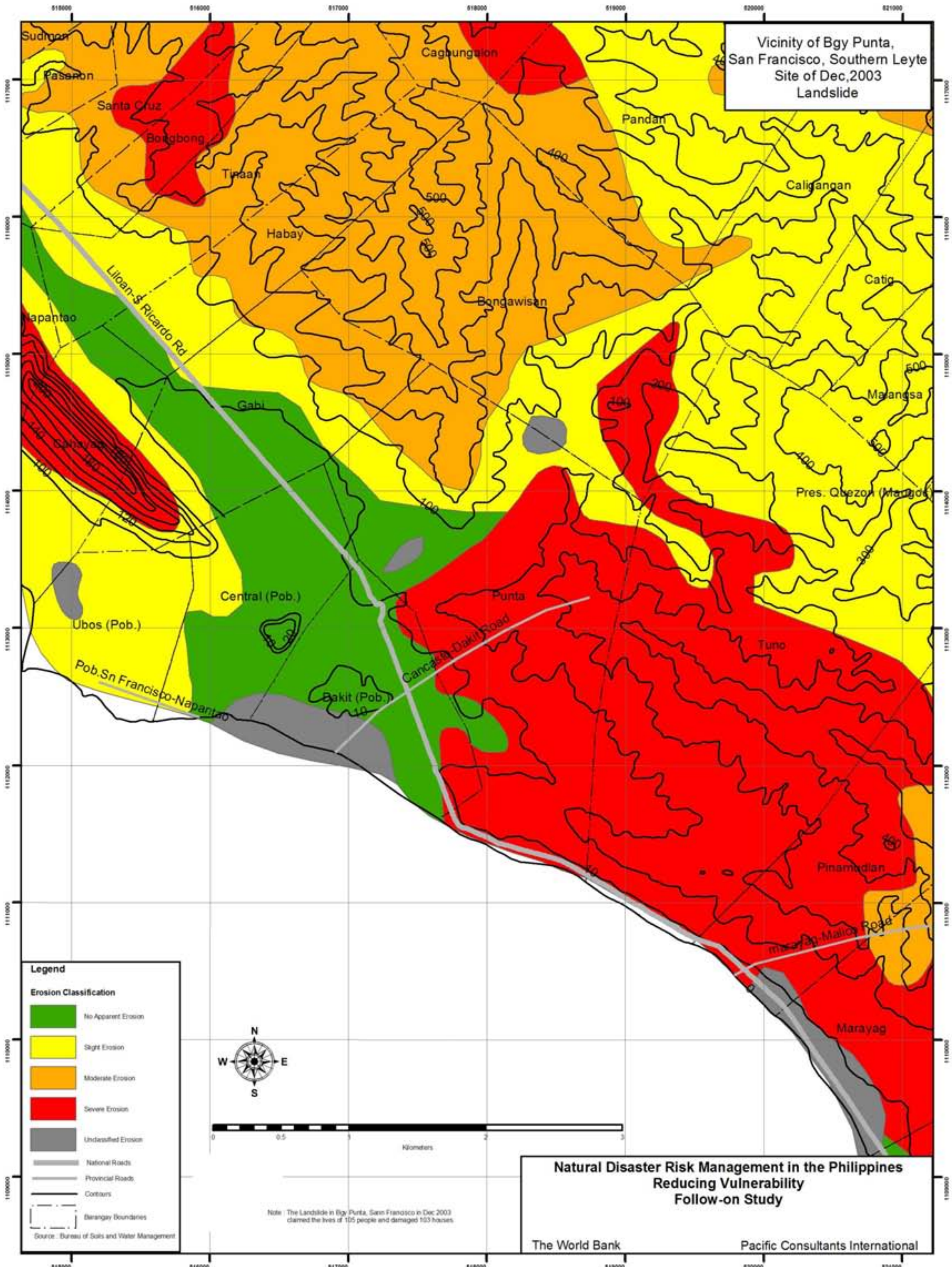


Figure 7.6 Vicinity of Bgy Punta, San Francisco, Southern Leyte, Site of Dec 2003 Landslide

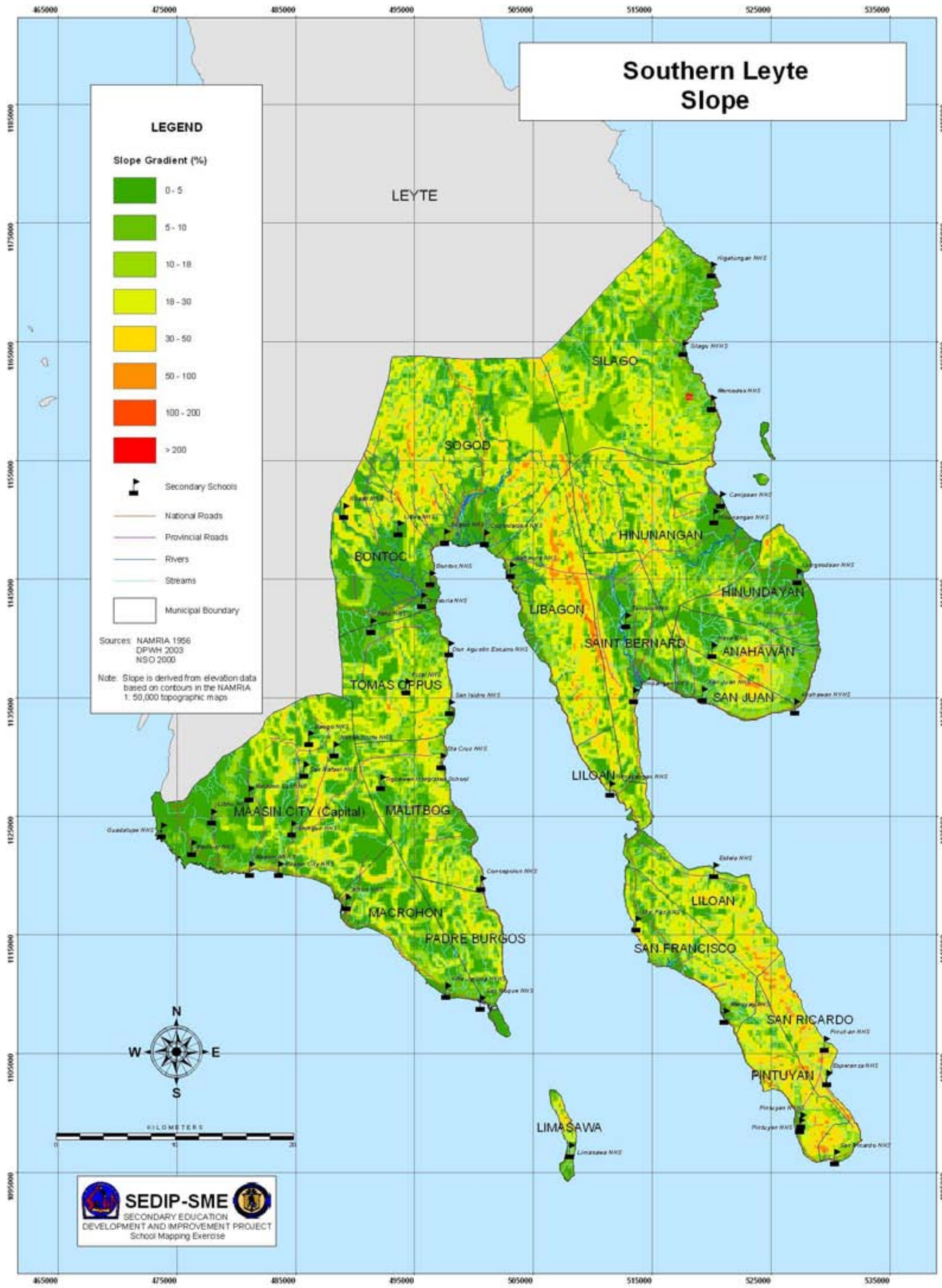


Figure 7.7 Slope Map for Southern Leyte

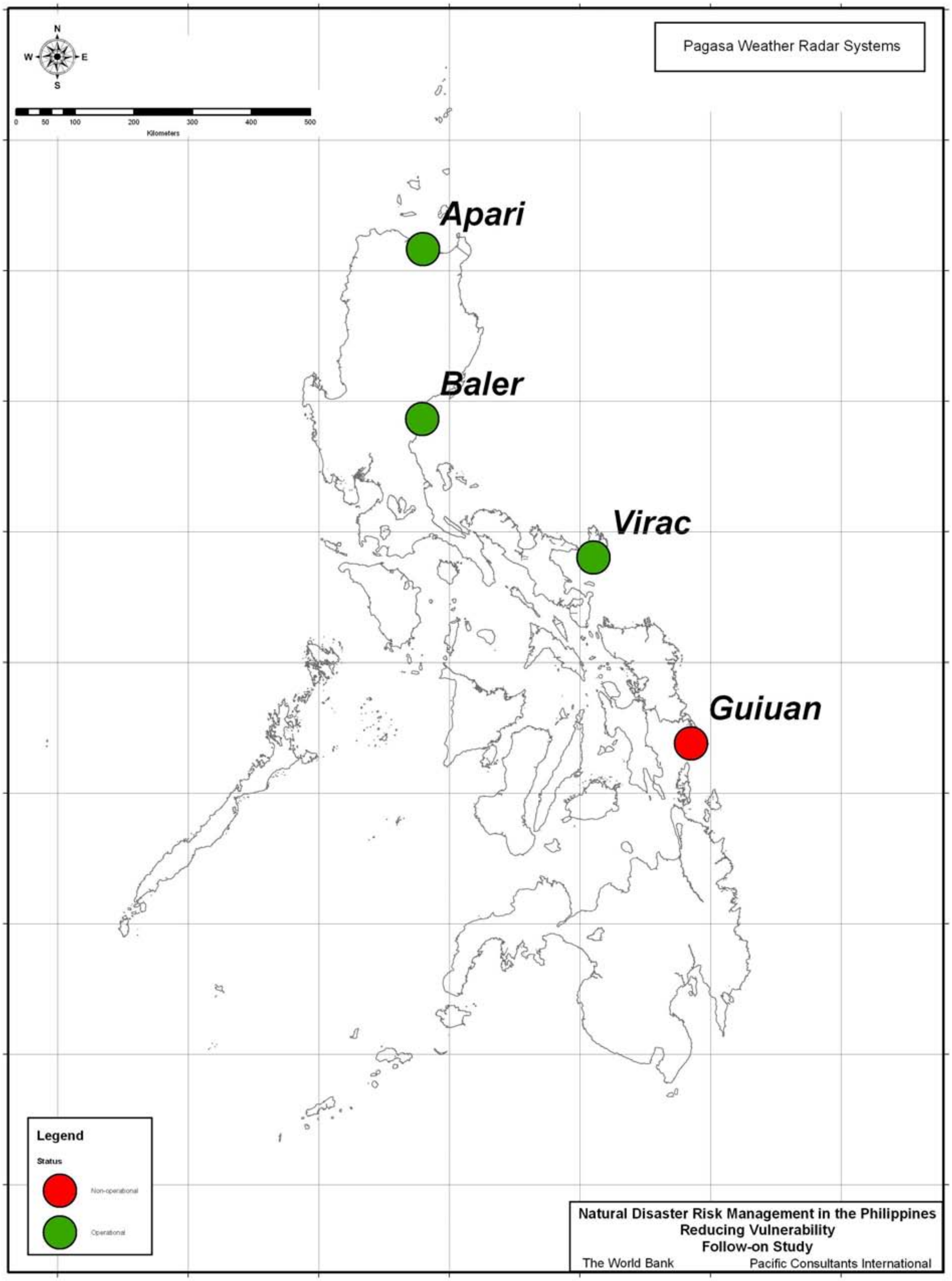


Figure 7.8 Existing Weather Surveillance Radar

Appendix

List of Destructive Earthquake with its Damages

DATE	MAGNI	Intensity	Location	Casualties				Damages									Notable Secondary effects				Direct cause of casualties						Assumed size of Damage (In terms of casualty and building damages)		
								Ground damages			Building damages			Infra related damages															
				Death	Injuries	Missing	Total	Fissures	Sand boils	Ground subsidence	Many destroyed totally	Some destroyed/ Partial damages	No big damage	PL/ water supplies	Railway/ roads/ bridges	Communication	Tsunami (Wave of lake incl)	Land slide	Liquefaction	After shocks	Building Collapse	Tsunami (Wave of lake incl)	Land slide	After shock	Others (Elec shock/heart attack)	None or not clarified	Large	Med	Small
1599/6/21	NA	8	Manila					x			x										x							x	
1619/11/30	NA	10	Northern Luzon	Many	many		Many	x			x										x							x	
1743/1/12	NA	10	Luzon	some	Several		several				x										x							x	
1787/7/13	NA	10	Panay Island	15+	many		many	x			x										x							x	
1796/11/5	6.9	10					NA	x									x					x							x
1852/9/16	7.6	9	Manila				NA	x			x										x							x	
1863/6/3	6.5	10	Manila	876+	387+		1263+	x			x						x			x	x	x					x		
1869/8/16	6.6	9	Eastern Visayas				NA	x				x									x								x
1869/10/1	NA	9	Mindoro				NA					x														x			x
1873/11/14	NA	8	Southern Luzon				NA					x								x						x			x
1880/7/18	7.6	10	Luzon				NA	x			x										x							x	
1885/7/23	NA	10	Mindanao				NA	x			x										x							x	
1889/5/26	NA	8	Luzon and Mindoro				NA	x			x										x								x
1892/3/16	6.6	9	Pangasinan				NA				x									x	x			x				x	
1893/6/21	NA	10	Southern Visayas				NA	x			x								x	x	x			x				x	
1897/9/21	8.7	9	a				NA	x			x						x			x		x						x	
1897/10/19	8.1	9	Islands				NA				x									x	x			x				x	
08/21/1902	NA	10	Mindanao				NA	x			x										x							x	
11/24/1907	NA	10	Camarines				NA	x			x										x							x	
07/12/1911	7.7	10	Agusan Valley				NA	x			x						x	x			x		x					x	
03/14/1913	7.9	9	Sarangani				NA						x				x			x						x			x
01/31/1917	NA	9	S Mindanao				NA				x							x					x					x	
08/15/1918	8.3	10	S. Cotabato	100			NA				x						x	x				x	x				x		
04/15/1924	8.3	9	Mati				NA						x							x						x			x
08/30/1924	7.3	9	Surigao and Agusan				NA	x				x						x								x			x
11/13/1925	7.3	8	Samar				NA					x														x			x
06/13/1929	7.2	10	Agusan				NA			x			x				x	x								x			x
03/19/1931	6.9	8	Luzon				NA					x									x								x
08/20/1937	7.5	8	S SE Luzon				NA					x		x							x								x
01/25/1948	8.3	9	Illoilo	27			NA	x			x									x	x			x				x	
07/02/1954	6.75	9	Sorsogon	13	101		114					x		x		x					x	x		x				x	
04/01/1955	7.5	10	Lanao	291	713		1004	x				x					x	x			x	x					x		
08/02/1968	7.3	9	Casiguran	270	600		870	x			x							x			x						x		
04/07/1970	7.3	9	Baler, Quezon	15	200		215	x				x			x	x					x			x				x	
03/17/1973	7	11	Ragay Gulf	14	100+		114+	x							x					x	x			x				x	
08/17/1976	7.9	10	Moro Gulf	4791	9928	2288	17007				x				x		x			x	x	x					x		
03/19/1977	7	8	Luzon	1	8		9					x													x				x
11/22/1981	6.7	8	Luzon				NA					x			x			x								x			x
01/11/1982	7.1	8	Virac				NA					x			x											x			x
08/17/1983	6.5	8	Laoag	16	47	0	63		x			x						x			x		x					x	
04/24/1985	6.1	8	Baguio, Luzon	6	11		17				x								x		x			x				x	
06/18/1987	6	5	Kalinga Apayao	8	5		13	x										x					x						x
06/19/1988	6.4	7	Mindoro Occidental	1	4		5	x			x							x			x							x	x
11/17/1988	6.6	6	Catarman, Leyte	0	29		29	x	x			x			x											x			x
12/15/1989	7.4	7	Surigao del Sur	2	1		3					x		x				x								x			x
02/08/1990	6.6	8	Bohor Island	6	200		206	x		x							x	x	x		x		x					x	
03/27/1990	5.5	5	Agusan del Norte	1	2		3						x													x			x
06/14/1990	7.1	7	Panay Island	15	72		87		x									x			x							x	

List of Destructive Earthquake with its Damages

DATE	MAGNI	Intensity	Location	Casualties				Damages: Ground damages			Damages: Building damages			Damages: Infra related damages			Notable Secondary effects				Direct cause of casualties						Assumed size of Damage (In terms of casualty and building damages)		
				Death	Injuries	Missing	Total	Fissures	Sand boils	Ground subsidence	Many destroyed totally	Some destroyed/ Partial damages	No big damage	PL/ water supplies	Railway/ roads/ bridges	Communication	Tsunami (Wave of lake incl)	Land slide	Liquefaction	After shocks	Building Collapse	Tsunami (Wave of lake incl)	Land slide	After shock	Others (Elec shock/heart attack)	None or not clarified	Large	Med	Small
07/16/1990	7.8	8	Cabanatuan	1283	2786	321	4390	x	x	x	x			x	x	x		x	x		x		x	x			x		
05/17/1992	7.5	6	Sur	0	0		NA				x						x					x							x
12/12/1993	5.3	3	Sur	0	0		NA					x														x			x
07/05/1994	6.2	7	Leyte	28	0		28					x						x			x							x	
11/14/1994	7.1	7	Oriental Mindoro	83	430	8	521	x							x		x				x	x					x		
04/21/1995	7.3	7	Eastern Samar				67			x							x				x							x	
02/08/1996	6.8	8	Tagbilaran city	6	200+		206+	x		x		x					x			x	x							x	
12/12/1999	6.8	6	Manila	5	40		45					x								x					x				x
03/06/2002	6.8	7	Palimban, Mindanao	8	39		47					x			x		x	x	x		x							x	
02/15/2003	6.2	8	Masbate				NA	x				x								x						x			x
11/19/2003	6.6	6	Eastern Samar	1	26		27	x				x									x							x	

Note: Intensity: 1599-1983, MMI scale, 1985-2003 Rossi-Forel Intensity scale

Source: Created from available data of the followings:

1) OCD, 2) Southeast Asia Association of Seismology and Earthquake Engineering, Volume IV, Philippines, 1985, 3)Destructivee earthquakes in the Philippines from 1983 to 1995, PHIVOLCS, 4) PHIVOLCS web pages

Appendix 3-1 List of Synoptic Stations (1/2)

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Elevation	Start	Last
1	325	Dagupan City	Pangasinan	I	16	2	36	120	20	0	2.4	1951	Present
2	223	Laoag	Ilocos Norte	I	18	12	0	120	35	30	5.0	1951	Present
3	222	Vigan	Ilocos Sur	I	17	34	30	120	23	12	33.0	1951	Present
4	232	Aparri	Cagayan	II	18	21	30	121	38	12	3.0	1951	Present
5	135	Basco	Batanes	II	20	27	0	121	58	12	11.0	1951	2000
6	134	Basco Radar	Batanes	II	20	27	0	121	58	12	167.0	2000	Present
7	133	Calayan	Cagayan	II	19	15	48	121	28	0	13.0	1951	Present
8	132	Itabayat	Batanes	II	20	46	0	121	50	0	124.0	1965	Present
9	233	Tuguegarao	Cagayan	II	17	36	48	121	43	42	62.0	1951	Present
10	321	Baguio City (Radar)	Benguet	CAR	16	20	12	120	33	36	2256.0	1973	Present
11	328	Baguio City	Benguet	CAR	16	24	36	120	36	0	1500.0	1951	Present
12	330	Cabanatuan	Nueva Ecija	III	15	29	18	120	57	42	28.4	1951	Present
13	327	Clark Airport	Pampanga	III	15	10	18	120	33	42	154.8	1994	Present
14	329	Clsu Munoz	Nueva Ecija	III	15	43	0	120	54	6	76.0	1982	Present
15	426	Cubi Pt.	Zambales	III	14	48	30	120	16	30	19.1	1992	Present
16	324	Iba	Zambales	III	15	19	48	119	58	30	5.4	1910	Present
17	334	Baler Radar	Aurora	III	15	45	0	121	38	0	178.2	1951	Present
18	336	Casiguran	Aurora	III	16	16	48	122	7	24	4.0	1951	Present
19	429	NAIA(MIA),Pasay City	NCR	NCR	14	31	0	121	1	0	21.1	1951	Present
20	425	Port Area(MCO), Manila	NCR	NCR	14	35	8	120	58	7	15.0	1951	Present
21	430	Science Garden, Quezon City	NCR	NCR	14	38	41	121	2	31	42.0	1961	Present
22	435	Alabat	Quezon	IV-A	14	6	12	122	0	36	5.0	1951	Present
23	432	Ambulong	Batangas	IV-A	14	5	30	15	45	42	10.6	1951	Present
24	333	Baler	Aurora	IV-A	15	45	42	121	33	42	6.0	1951	Present
25	434	Infanta	Quezon	IV-A	14	45	0	121	38	48	7.0	1951	Present
26	433	Lucena City	Quezon	IV-A	13	56	12	121	36	42	0.0	1951	1970
27	536	Romblon	Romblon	IV-A	12	34	36	122	16	6	47.0	1951	Present
28	437	San Francisco	Quezon	IV-A	-	-	-	122	31	0	45.0	1951	Present
29	428	Sangley Point	Cative	IV-A	14	29	54	120	54	54	3.0	1974	Present
30	433	Tanay (Radar)	Rizal	IV-A	14	30	0	121	17	0	650.0	1951	Present
31	427	Tayabas	Quezon	IV-A	14	1	42	121	35	18	157.7	1970	Present
32	712	Bugsuk	Palawan	IV-B	8	11	42	117	18	12	3.0	1983	Present
33	431	Calapan	Ori. Mindoro	IV-B	13	24	48	121	10	12	40.5	1951	Present
34	526	Coron	Palawan	IV-B	11	59	54	120	12	12	14.0	1951	Present
35	630	Cuyo	Palawan	IV-B	10	51	12	121	0	24	4.0	1951	Present
36	602	Pagasa Island	Palawan	IV-B	-	-	-	-	-	-	-	1974	Present
37	618	Puerto Princesa	Palawan	IV-B	9	44	30	118	44	0	16.0	1951	Present
38	531	San Jose	Occ. Mindoro	IV-B	13	17	18	121	21	6	0.3	1981	Present
39	440	Daet	Camarines Norte	V	14	6	48	122	57	12	4.0	1951	Present
40	444	Legaspi City	Albay	V	13	8	18	123	44	0	17.0	1951	Present
41	543	Masbate	Masbate	V	12	22	12	123	37	6	10.0	1951	Present
42	442	Pili	Camarines Sur	V	13	33	18	123	16	12	0.0	1992	Present
43	447	Virac Radar	Cataduanes	V	13	36	18	124	17	48	233.0	1968	Present
44	446	Virac Synop.	Cataduanes	V	13	35	6	124	13	48	40.0	1951	Present
45	637	Iloilo City	Iloilo	VI	10	42	30	122	33	0	6.2	1951	Present
46	538	Roxas City	Capiz	VI	11	16	42	122	27	24	4.0	1951	Present
47	645	Cebu City	Cebu	VII	10	18	0	123	54	12	3.5	1951	1983
48	642	Dumaguete City	Negros Ori.	VII	9	18	6	123	18	24	8.0	1951	Present
49	646	Mactan Int'l Air Port	Cebu	VII	10	17	48	123	57	48	12.0	1972	Present
50	644	Tagbilaran City	Bohol	VII	9	38	36	123	51	18	8.0	1961	Present
51	553	Borongan	Eastern Samar	VIII	11	36	30	125	26	0	2.4	1951	1987
52	546	Catarman	Northern Samar	VIII	12	30	0	124	38	18	6.6	1951	Present
53	548	Catbalogan	Samar	VIII	11	46	42	124	52	48	5.0	1951	Present

Appendix 3-1 List of Synoptic Stations (2/2)

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Elevation	Start	Last
54	558	Guiuan	Eastern Samar	. VIII	11	1	54	125	43	30	60.0	1973	Present
55	648	Maasin	Southern Leyte	VIII	10	8	12	124	50	12	72.0	1972	Present
56	550	Tacloban City	Leyte	VIII	11	14	42	125	0	0	2.7	1951	Present
57	815	Cagayan de Tawitawi	Tawi Tawi	IX	6	59	0	118	32	0	0.0	1975	1982
58	741	Dipolog	Zam. del Norte	ARMM	8	35	30	123	20	18	3.7	1951	Present
59	830	Jolo	Sulu	IX	6	3	12	120	59	54	6.0	1951	1985
60	836	Zamboanga	Zam. del Sur	IX	6	54	18	122	4	30	6.9	1951	Present
61	748	Cagayan de Oro	Misamis Ori.	X	8	29	12	124	38	0	6.0	1951	2000
62	747	Lumbia Airport	Misamis Ori.	X	8	24	12	124	33	18	182.0	1971	Present
63	751	Malaybalay	Bukidnon	X	8	9	12	125	4	36	609.3	1951	Present
64	753	Davao City	Davao del Sur	XI	7	18	0	125	50	0	18.0	1951	Present
65	851	General Santos	South Cotabato	XII	6	7	0	125	11	0	15.0	1951	Present
66	752	Butuan City	Agusan del Norte	XIII	8	56	48	125	32	36	17.7	1981	Present
67	653	Surigao	Surigao del Norte	XIII	9	47	30	125	29	30	39.3	1951	Present
68	755	Hinatuan	Surigao del Sur	XIII	8	22	12	126	20	12	3.0	1951	Present
69	746	Cotabato City	Maguindanao	ARMM	7	13	42	124	14	48	44.9	1951	Present

Appendix 3-2 List of Agromet Stations

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Elevation	Start	Last
1	002	Basco Agromet Station	Batangas	I	20	27	0	121	58	12	-	1995	Present
2	006	MMSU, Batac	Ilocos Norte	I	18	3	18	120	33	48	12.1	1975	Present
3	004	DMMMU, Bacnotan	La Union	I	16	43	12	120	21	0	-	1992	1999
4	011	ISU, Echague	Isabela	II	16	42	24	121	40	24	83.2	1976	Present
5	019	NVSIT, Bayombong	Nueva Viscaya	II	16	29	12	121	9	6	-	1993	Present
6	012	periment Station, Bagu	Benguet	CAR	16	24	0	120	36	0	1317.4	1972	Present
7	014	SU (MSAC) La Trinid	Benguet	CAR	16	27	48	120	35	12	1317.4	1976	Present
8	018	TCA, Camiling	Tarlac	III	15	42	0	120	24	6	-	1992	-
9	017	CLSU, Munoz	Nueva Ecija	III	15	43	0	120	54	6	76.0	1973	Present
10	016	cienda Luisita, San Mig	Tarlac	III	15	25	48	120	39	6	32.0	1967	Present
11	020	Magalang	Pampanga	III	15	13	0	120	39	30	-	1988	1995
12	329	atuan Synop-Agromet	Nueva Ecija	III	15	29	18	120	57	42	-	1989	Present
13	021	al Agromet Research	NCR	NCR	14	38	41	121	2	31	42.0	1971	Present
14	023	ricultural Stn, Cuyamb	Rizal	IV-A	14	30	0	121	17	0	-	1991	Present
15	022	u of Soil, Cuyambay,	Rizal	IV-A	14	36	42	121	22	6	-	1969	Present
16	151	UPLB, Los Banos	Laguna	IV-A	14	10	0	121	15	0	21.7	1977	Present
17	153	Pakil	Laguna	IV-A	14	22	54	121	28	36	-	1992	Present
18	424	Tagaytay	Cavite	IV-A	14	7	18	120	58	0	-	1996	Present
19	034	PNAC, Aborlan	Palawan	IV-B	9	26	12	118	33	0	6.8	1975	Present
20	027	BUCAF, Guinobatan	Albay	V	13	11	33	123	36	26	65.9	1990	Present
21	028	CSSAC, Pili	Camarines Sur	V	13	33	18	123	16	12	35.0	1975	Present
22	026	Parapoto, Malinao	Albay	V	13	23	54	123	42	12	-	1972	1990
23	056	La Granja, La Carlota	Negros Occ.	VI	10	24	24	122	59	6	96.0	1975	Present
24	051	PSPC, Mambusao	Capiz	VI	11	26	0	122	35	42	-	1978	Present
25	058	ictorias Milling Co. In	Negros Occ.	VI	10	54	54	123	3	30	-	1988	Present
26	050	Saba, Basin, Tacloban	Leyte	VIII	11	8	0	124	53	0	-	1974	1989
27	041	UEP, Catarman	Samar	VIII	12	31	0	124	40	0	3.5	1975	Present
28	055	VISCA, Baybay	Leyte	VIII	10	40	48	124	47	30	7.0	1975	Present
29	076	CMU, Musuan	Bukidnon	X	7	56	36	125	4	36	-	1978	Present
30	074	aponan Prip-Nia, Vale	Bukidnon	X	7	57	0	125	2	48	-	1976	1984
31	082	., Bago Oshiro, Davao	Davao del Sur	XI	7	2	12	125	31	18	-	1976	Present
32	191	TRRC, Tagum	Davao	XI	7	20	48	125	43	30	21.7	1976	Present
33	081	USM, Kabacan	North Cotabato	XII	7	7	36	124	49	0	-	1969	1994
34	077	Cabitic, San miguel	Surigao del Sur	XIII	8	55	30	126	6	30	-	1978	1990
35	071	MSU, Marawi City	Lanao del Sur	ARMM	8	0	0	124	18	0	-	1969	-

Appendix 3-3 List of Cooperative Stations (1/5)

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Type	Start	Last
1	0111	VSS Gaang Port, Curi	Ilocos Norte	I	18	0	48	120	30	54	VSS	1971	Present
2	0112	San Roque, Santiago	Ilocos Sur	I	17	16	42	120	25	12	VSS	1971	Present
3	0113	Sinait	Ilocos Sur	I	17	52	0	120	27	18	OR	1972	Present
4	0114	Tagudin	Ilocos Sur	I	16	56	12	120	26	36	OR	1971	Present
5	0115	Mamat-Ing, Naguilian	La Union	I	16	34	48	120	24	30	CC	1956	1977
6	0116	Masalep, Tubao	La Union	I	16	20	54	120	24	42	OR	1956	Present
7	0117	Balungao	Pangasinan	I	15	53	54	120	40	18	OR	1971	Present
8	0118	Barrio Binalonan	Pangasinan	I	16	2	48	120	35	30	OR	1972	1999
9	0119	Mabini	Pangasinan	I	16	4	18	119	56	18	OR	1967	1990
10	0122	Manleluag Ref., Mang	Pangasinan	I	15	47	0	120	17	30	OR	1956	1956
11	0217	Ivana	Batanes	II	20	22	15	121	55	10	-	-	Present
12	0201	Aggunetan Lasam, Ga	Cagayan	II	18	2	3	121	36	54	OR	1966	Present
13	0202	Cagumitan Tuao	Cagayan	II	17	44	23	121	26	50	OR	1967	Present
14	0203	Caritan Centro, Tugue	Cagayan	II	17	31	0	121	43	0	OR	1977	1991
15	0204	Claveria	Cagayan	II	18	36	42	121	5	6	OR	1956	1980
16	0205	Lallo	Cagayan	II	18	12	12	121	39	30	OR	1972	Present
17	0215	Lagawe	Ifugao	II	16	48	36	121	6	24	OR	1968	1982
18	0206	Naumulditan, Lagawe	Ifugao	II	16	48	0	121	7	0	CR	1968	1982
19	0207	Nayon Lamut	Ifugao	II	16	38	48	121	13	36	CR	1968	1981
20	0208	Cullalabo, Burgos	Isabela	II	17	6	18	121	41	36	OR	1983	1991
21	0209	Ilagan	Isabela	II	17	8	30	121	53	12	OR	1966	Present
22	0216	Luna Mountain	Apayao	II	18	18	24	121	21	0	OR	1965	1965
23	0210	Naneng, Tabuk, Kalin	Apayao	II	17	24	12	121	16	12	OR	1956	Present
24	0211	Barat Bambang	Nueva Viscaya	II	16	22	42	121	2	42	OR	1969	1981
25	0212	Consuelo, Sta. Fe	Nueva Viscaya	II	16	10	0	120	56	6	OR	1967	1980
26	0213	Dupax	Nueva Viscaya	II	16	8	41	121	6	16	OR	1969	1981
27	0214	Solano	Nueva Viscaya	II	16	30	49	121	10	35	OR	1967	1979
28	0101	Bangued	Abra	CAR	17	35	54	120	36	54	OR	1974	Present
29	0102	Cosili, Bangued	Abra	CAR	17	35	24	120	39	24	OR	1980	Present
30	0104	Divine World Coll, Ba	Abra	CAR	17	34	54	120	33	54	CC	1971	1998
31	0103	Langangilang	Abra	CAR	17	36	48	120	40	0	CC	1956	1974
32	0105	Mudeng, La Paz	Abra	CAR	17	40	0	120	41	0	CC	1971	1981
33	0123	Agno River, Buguias	Benguet	CAR	16	44	1	120	47	38	OR	1966	1978
34	0106	Ambuklao, Bokod	Benguet	CAR	16	28	48	120	44	48	CR	1969	1985
35	0107	Atok	Benguet	CAR	16	34	48	120	40	48	CR	1968	1979
36	0108	Balatoc Mines, Itogon	Benguet	CAR	16	21	58	120	40	51	CR	1956	1996
37	0120	Binga Plant, Itogon M	Benguet	CAR	16	21	54	120	40	36	OR	1956	1965
38	0109	Bobok, Bokod	Benguet	CAR	16	26	25	120	49	37	CR	1956	1986
39	0110	Kabayan	Benguet	CAR	16	38	42	120	49	48	CR	1968	1976
40	0121	Kabugao	Mt. Province	CAR	18	1	6	121	12	54	OR	1956	1965
41	0301	Morong	Bataan	III	14	40	57	120	16	10	OR	1987	Present
42	0302	Borol, Balagtas	Bulacan	III	14	50	20	120	54	10	OR	1971	Present
43	0303	Catmon, Malolos	Bulacan	III	14	50	44	120	48	35	OR	1969	2000
44	0304	Makinabang, Baliwag	Bulacan	III	14	53	35	120	53	35	OR	1969	Present
45	0305	Marungko, Angat	Bulacan	III	14	57	17	121	1	25	OR	1969	1998
46	0306	Obando	Bulacan	III	14	42	45	120	56	10	OR	1969	1986
47	0307	Paombong	Bulacan	III	14	50	18	120	47	6	OR	1981	1990
48	0309	San Agustin, Hagonoy	Bulacan	III	14	50	29	120	44	30	OR	1971	1992
49	0310	Sibul Spring, San Mig	Bulacan	III	15	10	6	121	3	18	OR	1988	Present
50	0311	San Isidro	Nueva Ecija	III	15	27	11	120	47	55	OR	1973	1992
51	0312	Bai Magalang	Pampanga	III	15	13	0	120	39	30	CR	1977	Present
52	0313	Juliana Subd, San Fer	Pampanga	III	15	0	54	120	41	30	OR	1970	Present
53	0314	Masantol	Pampanga	III	14	53	52	120	42	12	OR	1969	Present

Appendix 3-3 List of Cooperative Stations (2/5)

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Type	Start	Last
54	0315	Camiling	Tarlac	III	15	42	0	120	24	0	OR	1976	1990
55	0316	Mayantoc	Tarlac	III	15	37	24	120	23	12	OR	1972	1990
56	0317	Bolawon, Sta Cruz	Zambales	III	15	45	41	119	54	34	OR	1975	1996
57	0318	Palawig	Zambales	III	15	25	57	119	54	0	OR	1975	Present
58	0319	San Felipe	Zambales	III	15	4	6	120	3	57	OR	1975	1990
59	0320	Sta Rita Elem. Sch. Ca	Zambales	III	15	10	57	120	2	24	OR	1975	1995
60	0321	Sta Rita, Masinloc	Zambales	III	15	32	20	119	56	58	OR	1975	Present
61	0322	Wstrn Luz. Agri Coll.,	Zambales	III	14	58	42	120	9	9	OR	1975	Present
62	1301	Bagumbayan, Taguig,	NCR	NCR	14	29	9	121	3	30	OR	1975	Present
63	1307	Balara Filters, Quezon	NCR	NCR	14	37	0	121	5	0	OR	1956	1965
64	1302	Camarin, Caloocan Ci	NCR	NCR	14	46	4	121	2	9	OR	1974	1991
65	1303	Conception Elem. Sch	NCR	NCR	14	40	0	121	5	0	OR	1975	1993
66	1304	NPP Research, Bu. Of	NCR	NCR	14	23	0	121	1	0	OR	1971	1997
67	1305	Pasig Elem. School, P	NCR	NCR	14	34	0	121	5	0	OR	1975	Present
68	1308	SHN Novaliches, Que	NCR	NCR	14	44	36	121	4	11	OR	1956	1965
69	1306	Tipas, Taguig, MM	NCR	NCR	14	32	37	121	4	41	OR	1975	Present
70	1309	Polo, Valenzuela, MM	NCR	NCR	14	44	36	120	56	42	OR	1974	Present
71	0401	Gulod, Laurel	Batangas	IV-A	14	2	27	120	56	24	OR	1973	Present
72	0402	Lipa City	Batangas	IV-A	13	56	30	121	9	48	CR	1981	1996
73	0403	Lobo	Batangas	IV-A	13	38	48	121	12	36	OR	1969	1999
74	0404	Mabini	Batangas	IV-A	13	45	6	120	56	24	OR	1969	1999
75	0405	Wawa, Nasugbu	Batangas	IV-A	14	5	6	120	37	18	VSS	1971	Present
76	0406	Barrio Maitim, Amade	Cavite	IV-A	14	10	18	120	57	0	OR	1971	Present
77	0407	Mabolo Elem. School	Cavite	IV-A	14	27	0	120	56	0	OR	1975	Present
78	0420	Caliraya Cavinte	Laguna	IV-A	14	15	42	121	29	42	OR	1956	1965
79	0421	Lumot Cavinte	Laguna	IV-A	14	16	6	121	30	36	OR	1956	1965
80	0418	Macasipac, Sta Maria	Laguna	IV-A	14	30	0	121	26	18	OR	1993	Present
81	0408	San Pedro	Laguna	IV-A	14	22	0	121	2	18	OR	1971	1999
82	0409	Sta. Cruz	Laguna	IV-A	14	16	53	121	24	48	OR	1956	-
83	0419	UPLB	Laguna	IV-A	14	11	0	121	13	21		1966	1976
84	0410	Boac, Tanza, Marindu	Marinduque	IV-A	13	27	0	121	50	24	OR	1969	1992
85	0422	Sta. Cruz	Marinduque	IV-A	13	28	42	122	1	30	OR	1956	1965
86	0415	Boso-Boso, Antipolo	Rizal	IV-A	14	38	30	121	14	18	OR	1972	Present
87	0416	Juan Sumulong Elem.	Rizal	IV-A	14	25	0	121	5	0	OR	1971	1991
88	0417	Sito Tabak, Montalbar	Rizal	IV-A	14	46	0	121	11	0	OR	1976	1996
89	0411	Pob. San Jose	Occ. Mindoro	IV-B	12	22	0	121	2	0	OR	1971	1981
90	0412	Tilik, Lubang	Occ. Mindoro	IV-B	13	49	6	120	12	0	OR	1956	1998
91	0413	Brooke's Point	Palawan	IV-B	8	46	30	117	50	0	OR	1956	Present
92	0414	Calawit, Busuanga	Palawan	IV-B	12	17	0	119	56	0	OR	1977	1992
93	0501	Epi Exp. Stn. Buang, (	Albay	V	13	21	42	123	43	42	CR	1981	1994
94	0502	Central Libon	Albay	V	13	17	48	123	26	18	OC	1971	1990
95	0503	Centro Rapu-Rapu	Albay	V	13	11	18	124	7	42	OC	1972	Present
96	0504	Guinobatan	Albay	V	13	11	33	123	36	26	OR	1967	1983
97	0505	Joroan, Tiwi	Albay	V	13	29	24	123	37	6	OR	1967	2000
98	0506	Malama, Ligao	Albay	V	13	8	48	123	27	12	OC	1971	Present
99	0507	Naglagbong, Tiwi	Albay	V	13	28	0	123	39	0	OC	1971	Present
100	0508	Pantao, Libon	Albay	V	13	11	42	123	19	36	OC	1971	Present
101	0509	Pier Site, Tabaco	Albay	V	13	21	42	123	43	42	VSS	1971	1988
102	0539	Pio Duran	Albay	V	13	1	58	123	26	25	OR	1956	1965
103	0510	Pob. Manito	Albay	V	13	7	36	123	52	6	OR	1966	1987
104	0511	Pob. Tiwi	Albay	V	13	27	30	123	40	36	OC	1971	1991
105	0512	San Ramon, Tabaco	Albay	V	13	21	0	123	43	0	OR	1971	1997
106	0513	Sto Domingo	Albay	V	13	14	21	123	46	35	OR	1966	Present

Appendix 3-3 List of Cooperative Stations (3/5)

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Type	Start	Last
107	0514	Villa-Hermosa, Rapu-	Albay	V	13	11	0	124	7	0	OC	1971	Present
108	0516	Jose Panganiban	Camarines Norte	V	14	17	30	122	41	30	OR	1971	1976
109	0517	Paracale	Camarines Norte	V	14	16	54	122	47	12	OR	1974	1995
110	0518	San Felipe, Basud	Camarines Norte	V	14	4	40	122	57	35	OR	1974	1988
111	0515	San Lorenzo Ruiz	Camarines Norte	V	14	1	4	122	51	30	OR	1974	Present
112	0519	Sta Elena	Camarines Norte	V	14	8	0	122	58	0	OR	1974	1991
113	0520	Tulayna Lupa, Labo	Camarines Norte	V	14	6	28	122	46	44	OR	1974	1992
114	0521	Caramoan	Camarines Sur	V	13	47	48	123	56	24	OR	1972	Present
115	0522	Mabalodbalod, Tigaor	Camarines Sur	V	13	35	18	123	27	18	OR	1977	2000
116	0523	Pob. Pasacao	Camarines Sur	V	13	30	54	123	2	36	OR	1969	1997
117	0524	Sabang, Sipocot	Camarines Sur	V	13	46	12	122	58	24	OR	1969	1991
118	0525	Sta Cruz, San Nichola	Camarines Sur	V	13	27	6	123	21	36	OR	1969	Present
119	0540	Yabo Farm, Naga City	Camarines Sur	V	13	37	30	123	11	0	OR	1956	1965
120	0526	Aroroy	Masbate	V	12	30	48	123	23	48	OR	1981	1989
121	0527	Milagros	Masbate	V	12	31	6	123	30	30	OR	1956	Present
122	0528	Nipa, Palanas	Masbate	V	12	7	36	123	56	30	OR	1956	Present
123	0529	Placer	Masbate	V	11	52	12	123	55	1	VSS	1972	Present
124	0530	Bulusan	Sorsogon	V	12	45	12	124	8	0	OR	1972	1998
125	0541	Castilla	Sorsogon	V	12	57	0	123	52	42	OR	1956	1965
126	0531	Donsol	Sorsogon	V	12	54	24	123	35	36	OR	1972	Present
127	0532	Gubat	Sorsogon	V	12	55	18	124	7	24	OR	1972	1988
128	0533	Juban, Mapili	Sorsogon	V	12	51	6	123	59	18	OR	1956	Present
129	0534	Magallanes	Sorsogon	V	12	49	42	123	50	6	OR	1972	Present
130	0535	Pier Bulan	Sorsogon	V	12	40	6	123	52	24	VSS	1971	1992
131	0536	Prieto Diaz	Sorsogon	V	13	2	30	124	11	36	OR	1972	2000
132	0537	San Roque, Bacon	Sorsogon	V	13	1	42	124	1	36	OR	1972	Present
133	0538	Sorsogon	Sorsogon	V	12	58	12	124	0	12	OR	1972	1972
134	0601	Balete	Aklan	VI	11	33	6	122	22	30	OR	1956	1987
135	0602	Kalibo	Aklan	VI	22	42	42	122	21	48	HYDRO	1970	Present
136	0603	Barbaza	Antique	VI	11	11	57	122	2	18	OR	1956	Present
137	0604	Pandan	Antique	VI	11	43	18	122	5	36	OR	1975	1986
138	0605	Valderrama	Antique	VI	11	0	6	122	7	42	OR	1956	1998
139	0606	Culasi	Capiz	VI	11	25	36	122	3	18	OR	1971	1988
140	0622	Pilar Sugar Central, Pi	Capiz	VI	11	26	1	122	55	35	OR	1956	1966
141	0607	Barotac Viejo	Iloilo	VI	11	2	42	122	51	0	OR	1971	1999
142	0608	Cabatuan	Iloilo	VI	10	53	0	122	28	48	OR	1971	Present
143	0609	Donsol, Pototan	Iloilo	VI	10	52	12	122	37	36	HYDRO	1983	Present
144	0610	Miagao	Iloilo	VI	10	38	48	122	14	0	OR	1971	Present
145	0611	A. Bonifacio, Sagay	Negros Occ.	VI	10	57	0	123	18	0	OR	1974	Present
146	0621	Calapanagan La Caste	Negros Occ.	VI	10	25	0	123	3	0	OR	1956	1966
147	0612	Kabankalan	Negros Occ.	VI	9	59	24	122	48	42	OR	1971	1990
148	0613	La Granija Exp. Stn. I	Negros Occ.	VI	10	24	26	122	59	6	CR	1956	Present
149	0620	Maao Central Bago	Negros Occ.	VI	10	28	36	122	57	12	OR	1957	1965
150	0623	Manapla Mallsite	Negros Occ.	VI	10	57	36	123	7	12	OR	1957	1975
151	0614	Pulupandan	Negros Occ.	VI	10	31	0	122	48	3	VSS	1971	1987
152	0615	San Carlos City	Negros Occ.	VI	10	28	42	123	25	1	OR	1971	Present
153	0619	Siaton	Negros Occ.	VI	9	3	48	123	2	0	OR	1956	1965
154	0616	Silay Hawaiian Centra	Negros Occ.	VI	10	48	1	122	58	24	CC	1951	Present
155	0617	Sipalay	Negros Occ.	VI	9	45	6	122	24	12	OR	1971	1997
156	0618	Victorias	Negros Occ.	VI	10	54	18	123	3	30	CC	1971	1997
157	0705	Bes Ubay	Bohol	VII	10	3	6	124	28	18	CR	1978	Present
158	0701	Central Carmen	Bohol	VII	9	49	30	124	12	0	OR	1975	Present
159	0702	Dagohoy	Bohol	VII	9	42	0	124	6	0	OR	1966	Present

Appendix 3-3 List of Cooperative Stations (4/5)

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Type	Start	Last
160	0703	Guindulman	Bohol	VII	9	45	48	124	29	12	OR	1975	Present
161	0704	Las Salinas	Bohol	VII	9	36	18	124	2	48	OR	1975	1994
162	0706	Pob. Bilar	Bohol	VII	9	42	30	124	6	24	OR	1982	Present
163	0707	Pob. Ilaud	Bohol	VII	10	2	18	124	3	48	OR	1975	Present
164	0708	Pob. Loon	Bohol	VII	9	48	0	123	47	30	OR	1975	Present
165	0710	Pob. Trinidad	Bohol	VII	10	5	0	124	19	0	OR	1975	Present
166	0711	Pob. Ubay	Bohol	VII	10	3	6	124	28	18	OR	1975	Present
167	0712	Pres. Carlos P. Garcia	Bohol	VII	10	8	0	124	33	0	OR	1975	Present
168	0713	Tinangnan, Tubigon	Bohol	VII	9	57	12	123	57	48	OR	1956	Present
169	0714	Bogo, Medellin Millin	Cebu	VII	11	3	12	124	40	36	CC	1966	Present
170	0715	Talaga, Argao	Cebu	VII	9	53	6	123	35	48	OR	1978	Present
171	0723	Champ7 Minglanilla	Cebu	VII	10	14	42	123	47	24	OR	1956	1965
172	0716	Kal-Anan, Tabogon	Cebu	VII	10	56	30	124	1	48	OR	1980	Present
173	0717	Mantalongon, Dalague	Cebu	VII	9	46	42	123	27	0	OR	1956	Present
174	0724	Soil Conservation, Lal	Cebu	VII	10	19	0	123	55	0	OR	1956	1965
175	0718	Taytay, Badian	Cebu	VII	9	49	18	123	22	36	OR	1980	Present
176	0719	Guihulngan	Negros Ori.	VII	10	7	18	123	16	12	OR	1972	1987
177	0725	Mt. Bandila- An Siqui	Negros Ori.	VII	9	11	12	123	34	48	OR	1956	1965
178	0720	Nonas, Bayawan	Negros Ori.	VII	9	22	0	122	47	36	OR	1980	Present
179	0722	Pob. Bayawan	Negros Ori.	VII	-	-	-	-	-	-	OR	1967	1985
180	0721	Siaton	Negros Ori.	VII	9	3	48	123	2	0	OR	1971	Present
181	0818	Essc, Borongan	Eastern Samar	VIII	11	37	0	125	26	0	OR	1989	-
182	0801	Llorente	Eastern Samar	VIII	11	24	48	125	32	42	OR	1972	1994
183	0802	Barangay Olot, Tolosa	Leyte	VIII	11	3	54	125	2	12	VSS	1971	Present
184	0804	Baybay	Leyte	VIII	10	40	48	124	47	30	VSS	1971	1988
185	0803	Baybay	Leyte	VIII	10	42	0	124	48	0	OR	1970	1994
186	0805	Bnac, Biliran	Leyte	VIII	11	27	6	124	28	24	OR	1977	Present
187	0806	Casilda, Merida	Leyte	VIII	10	54	36	124	32	18	OR	1971	Present
188	0807	Inopacan	Leyte	VIII	10	30	0	124	44	18	OR	1966	Present
189	0808	Jaro	Leyte	VIII	11	11	24	124	46	48	OR	1973	Present
190	0809	Pob. Dagami	Leyte	VIII	11	3	48	124	54	0	OR	1977	Present
191	0810	Pob. Pastrana	Leyte	VIII	10	8	12	124	53	0	OR	1977	Present
192	0811	Pob. Sta. Fe	Leyte	VIII	11	10	30	124	54	42	OR	1977	1998
193	0812	Pob. Tolosa	Leyte	VIII	11	3	54	125	2	12	OR	1970	Present
194	0813	Allen	Northern Samar	VIII	12	30	12	124	17	0	OR	1971	1998
195	0814	Catubig	Northern Samar	VIII	12	24	0	125	2	36	OR	1972	Present
196	0815	Anahawan	Southern Leyte	VIII	10	16	30	125	15	30	OR	1972	1998
197	0816	Otikon, Libagon	Southern Leyte	VIII	10	19	36	125	2	12	OR	1969	Present
198	0817	Pob. Bontoc	Southern Leyte	VIII	10	21	18	124	58	12	OR	1981	1998
199	0905	Dapitan City	amboanga del Nor	IX	8	39	42	123	25	24	OR	1973	Present
200	0906	Sindangan	amboanga del Nor	IX	8	14	12	122	59	42	OR	1979	Present
201	0907	Malangas	Zamboanga del Su	IX	7	37	6	123	1	30	OR	1971	1988
202	1002	Baclayon Lantapan	Bukidnon	X	8	2	30	125	2	0	OR	1973	1981
203	1003	Dalwangan Malaybala	Bukidnon	X	8	13	48	125	2	30	OR	1961	1973
204	1004	Damilag Manolo Forti	Bukidnon	X	8	22	0	124	47	54	OR	1966	1984
205	1005	Impalutao Impasuging	Bukidnon	X	8	15	54	125	1	30	OR	1956	1978
206	1006	Impasugong	Bukidnon	X	8	19	30	124	59	30	OR	1974	1980
207	1007	Kalasungay Malaybala	Bukidnon	X	8	11	12	125	4	6	OR	1973	1980
208	1008	Kisolon, Sumilao	Bukidnon	X	8	17	54	124	56	18	OR	1980	Present
209	1009	Linabo Malaybalay	Bukidnon	X	8	5	30	125	6	0	VVS	1973	1981
210	1010	Mailag Valencia	Bukidnon	X	8	0	0	125	4	0	OR	1974	1982
211	1024	Malaybalay Ref. Proj	Bukidnon	X	8	9	12	125	4	54	OR	1975	1965
212	1011	Maluko Manolo Fortic	Bukidnon	X	8	25	0	124	57	48	OR	1974	1980

Appendix 3-3 List of Cooperative Stations (5/5)

No.	Stn.No.	Station Name	Province	Region	Latitude			Longitude			Type	Start	Last
213	1012	Maramag	Bukidnon	X	7	46	12	125	0	24	OR	1968	1977
214	1025	Menzi Plantation, Tala	Bukidnon	X	8	16	0	125	37	0	OR	1958	1965
215	1013	Miaray Dancagan	Bukidnon	X	7	38	24	125	2	0	OR	1973	1980
216	1014	Philips Manolo Forticl	Bukidnon	X	8	25	0	124	57	48	OR	1956	1981
217	1015	Quezon	Bukidnon	X	7	25	0	125	5	0	OR	1973	1980
218	1018	Alubijid	Misamis Ori.	X	8	35	0	124	29	0	OR	1980	Present
219	1016	Bonifacio Central Sch	Misamis Occ.	X	8	31	6	123	43	0	OR	1972	Present
220	1017	Clarin	Misamis Occ.	X	8	12	0	123	51	42	OR	1956	1976
221	1201	Baroy	Lanao del Norte	X	8	2	0	123	47	0	OR	1972	1996
222	1202	Kapatagan	Lanao del Norte	X	7	52	0	123	43	30	OR	1971	Present
223	1107	Bago Oshiro	Davao	XI	7	2	36	125	31	18	-	1956	1965
224	1108	Lawa Malita	Davao	XI	6	11	36	125	41	30	CC	1956	1965
225	1101	Mati Plantation, M.km	Davao	XI	6	57	0	126	13	0	CC	1956	1986
226	1102	Sta. Cruz	Davao	XI	6	50	6	125	24	48	CC	1956	1973
227	1103	Tagnanan	Davao	XI	7	15	30	125	50	18	CC	1956	1977
228	1104	Tagum	Davao	XI	7	20	48	125	43	30	CC	1956	1976
229	1205	Carmen, Tacurong	Sultan Kudarat	XII	6	47	0	124	37	0	OR	1970	1999
230	1001	Butan City	Agusan del Norte	XIII	8	56	48	125	32	36	OC	1966	1990
231	1019	Dapa	Surigao del Norte	XIII	9	45	30	126	3	6	VSS	1971	1984
232	1020	Sison	Surigao del Norte	XIII	9	40	0	125	31	0	OR	1981	Present
233	1021	Sncat, Magpayang, Ma	Surigao del Norte	XIII	9	31	42	125	31	30	OR	1981	Present
234	1022	Surigao City	Surigao del Norte	XIII	9	47	30	125	29	30	VSS	1979	1980
235	1105	Cagwait	Surigao del Sur	XIII	8	55	6	126	18	0	OR	1966	1973
236	1106	Cantillan	Surigao del Sur	XIII	9	20	30	125	59	0	OR	1971	1997
237	1203	Datu Piang	Maguindanao	ARMM	7	2	0	124	16	0	OR	1972	1998
238	1204	Parang	Maguindanao	ARMM	7	22	12	124	27	12	OR	1972	Present
239	0908	Basilan Plantation, Isa	Basilan	ARMM	6	42	18	121	58	12	OR	1956	1965
240	0901	Cdc, Lamitan	Basilan	ARMM	6	39	52	122	8	0	CC	1980	1991
241	0902	Eurasia M. Inc. Sumis	Basilan	ARMM	6	25	12	121	58	24	CC	1984	1992
242	0909	Maluso, Maluso Distri	Basilan	ARMM	6	33	0	121	53	0	OR	1956	1965
243	0903	Upland Grant, Sta. Cla	Basilan	ARMM	6	42	0	122	3	0	OR	1956	1977
245	0904	Lupa Pula, Cagayan de	Tawi-Tawi	ARMM	5	5	30	119	59	18	OR	1983	Present

Appendix 3-2 List of Streamline Stations Operated by BRS (1/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
1	I	Abra	Ilocos Sur	I	17	33	20	120	28	30	1958	1977	Manual
2	I	Abra	Abra	CAR	17	37	0	120	43	28	1958	Present	Manual
3	I	Apangat	La Union	I	16	13	25	120	27	28	1986	Present	Manual
4	I	Aringay	La Union	I	16	23	30	120	22	6	1945	Present	Manual
5	I	Asin	La Union	I	-	-	-	-	-	-	2002	Present	Manual
6	I	Badoc	Ilocos Norte	I	17	55	42	120	29	18	1985	Present	Manual
7	I	Barobor	La Union	I	16	51	22	120	25	9	1985	Present	Manual
8	I	Baroro	La Union	I	16	40	10	120	23	26	1946	Present	Manual
9	I	Baruyen	Ilocos Norte	I	18	31	8	120	42	16	1985	Present	Manual
10	I	Bauang	La Union	I	16	31	26	120	20	48	1985	Present	Manual
11	I	Bonga	Ilocos Norte	I	18	5	0	120	42	0	1946	1994	Manual
12	I	Buaya	Ilocos Sur	I	17	6	42	120	30	18	1948	1989	Manual
13	I	Bucong	Ilocos Sur	I	17	13	50	120	28	50	1950	1977	Manual
14	I	Bued	Benguet	CAR	16	14	30	120	31	6	1946	Present	Manual
15	I	Bulu	Ilocos Norte	I	18	32	16	120	47	42	1986	Present	Manual
16	I	Cabacanan	Ilocos Norte	I	18	34	28	120	48	34	1986	Present	Manual
17	I	Cabugao	Ilocos Sur	I	17	48	6	120	27	10	1985	1995	Manual
18	I	Gasgas	Ilocos Norte	I	18	4	54	120	49	14	1946	Present	Manual
19	I	Laoag	Ilocos Norte	I	18	11	40	120	35	17	1958	Present	Manual
20	I	Maragayap	La Union	I	16	45	0	120	22	28	1946	Present	Manual
21	I	Naguilian	La Union	I	16	35	16	120	24	40	1946	1994	Manual
22	I	Narvacan	Ilocos Sur	I	17	27	0	120	31	6	1985	Present	Manual
23	I	Quiaoit	Ilocos Norte	I	18	3	26	120	33	42	1985	1999	Manual
24	I	Sinalang	Abra	CAR	17	33	30	120	38	24	1958	Present	Manual
25	I	Sta.Maria No.1	Ilocos Sur	I	17	18	45	120	32	22	1957	1975	Manual
26	I	Sta.Maria No.2	Ilocos Sur	I	17	16	27	120	31	14	1957	1994	Manual
27	I	Tineg	Abra	I	17	45	10	120	44	20	1959	1980	Manual
28	I	Tonoton	Ilocos Norte	I	18	9	15	120	42	9	1985	1994	Manual
29	II	Abulog	Kalinga-Apayao	CAR	18	21	15	121	49	30	1952	1970	Manual
30	II	Abulug	Cagayan	II	18	20	24	121	25	28	2002	Present	Manual
31	II	Addalam	Quirino	II	16	28	14	121	37	43	1964	Present	Manual
32	II	Addalam	Quirino	II	16	29	2	121	39	0	1964	1974	Manual
33	II	Alimit	Ifugao	CAR	16	44	28	121	19	33	1967	1973	Manual
34	II	Apian	Nueva Viscaya	II	16	20	18	121	6	28	1987	2001	Manual
35	II	Banaue	Ifugao	CAR	16	54	58	121	3	35	1987	Present	Manual
36	II	Banurbor	Cagayan	II	18	15	30	121	49	30	1952	1976	Manual
37	II	Baua	Cagayan	II	18	21	15	122	5	30	1956	1979	Manual
38	II	Binuan	Apayao	CAR	-	-	-	-	-	-	2002	Present	-
39	II	Burnay	Ifugao	CAR	-	-	-	-	-	-	1983	1988	Manual
40	II	Cadaclan	Ifugao	CAR	16	36	29	121	2	40	1967	1974	Manual
41	II	Cagayan	Cagayan	II	18	7	29	121	40	21	1983	Present	Manual
42	II	Cagayan	Isabela	II	17	4	20	121	50	26	1987	Present	Manual
43	II	Cagayan	Isabela	II	16	33	22	121	42	14	1985	Present	Manual
44	II	Cagayan	Quirino	II	16	15	43	121	38	58	1987	Present	Manual
45	II	Cagayan	Cagayan	II	17	57	53	121	37	9	2002	Present	Manual
46	II	Cagayan	Isabela	II	17	27	8	121	44	38	2002	Present	Manual
47	II	Cagayan	Isabela	II	17	0	45	121	49	0	1983	1990	Manual
48	II	Cagayan	Cagayan	II	18	22	0	121	37	4	1958	1979	Manual
49	II	Cagayan	Cagayan	II	18	16	54	121	40	32	1958	1980	Manual
50	II	Cagayan	Cagayan	II	18	18	1	121	39	8	1958	1975	Manual
51	II	Cagayan	Cagayan	II	18	3	30	121	38	15	1958	1976	Manual
52	II	Cagayan	Cagayan	II	17	57	16	121	38	0	1958	1979	Manual
53	II	Cagayan	Cagayan	II	17	49	14	121	23	15	1958	1976	Manual
54	II	Cagayan	Cagayan	II	17	45	20	121	44	26	1958	1979	Manual
55	II	Cagayan	Cagayan	II	17	42	4	121	44	0	1958	1980	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (2/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
56	II	Cagayan	Cagayan	II	17	35	27	121	40	25	1958	1976	Manual
57	II	Cagayan	Cagayan	II	17	32	28	121	47	7	1958	1974	Manual
58	II	Cagayan	Isabela	II	16	55	0	121	49	0	1961	1979	Manual
59	II	Cagayan	Isabela	II	16	36	12	121	41	0	1959	1974	Manual
60	II	Cagayan	Quirino	II	16	23	8	121	44	26	1965	1973	Manual
61	II	Casile	Isabela	II	17	12	45	121	35	42	1949	1991	Manual
62	II	Chico	Kalinga-Apayao	CAR	17	24	0	121	25	0	1963	1969	Recorder
63	II	Chico	Kalinga-Apayao	CAR	17	16	12	121	9	8	1967	1970	Recorder
64	II	Chico	Mt. Province	CAR	-	-	-	-	-	-	2002	Present	Manual
65	II	Dabubu	Isabela	II	16	26	40	121	46	31	1985	1998	Manual
66	II	Diadi	Isabela	II	16	41	48	121	33	18	1955	2001	Manual
67	II	Dibibi	Quirino	II	16	25	29	121	30	34	1987	Present	Manual
68	II	Dibuluan	Isabela	II	16	26	40	121	46	31	1964	1970	Recorder
69	II	Diduyon	Quirino	II	16	19	4	121	39	30	1987	2001	Manual
70	II	Disabungan	Isabela	II	16	56	46	122	3	35	1965	1969	Manual
71	II	Disulap	Isabela	II	16	57	56	122	4	44	1965	1970	Recorder
72	II	Dumanisi	Quirino	II	16	32	28	121	28	4	1990	2001	Manual
73	II	Dumatata	Quirino	II	16	31	22	121	33	44	1985	1995	Manual
74	II	Dummon	Cagayan	II	18	2	35	121	43	0	1964	1979	Manual
75	II	Ganano	Quirino	II	16	34	17	121	30	32	1983	Present	Manual
76	II	Ganano	Isabela	II	16	41	53	121	38	7	1986	Present	Manual
77	II	Ibulao	Ifugao	CAR	16	42	41	121	14	40	1964	Present	Manual
78	II	Ilut	Isabela	II	16	39	18	121	25	40	1985	2001	Manual
79	II	Lanog	Nueva Viscaya	II	16	33	30	121	11	16	1985	2001	Manual
80	II	Lukban	Quirino	II	16	36	30	121	29	20	1987	2001	Manual
81	II	Magat	Nueva Viscaya	II	16	35	6	121	16	7	1986	Present	Manual
82	II	Magat	Nueva Viscaya	II	16	25	57	121	6	51	1959	Present	Manual
83	II	Magat	Isabela	II	16	51	0	121	31	35	1941	1970	Manual
84	II	Magat	Nueva Viscaya	II	16	25	58	121	6	27	1987	1991	Manual
85	II	Mallig	Isabela	II	17	10	54	121	35	42	1948	1977	Manual
86	II	Marang	Nueva Viscaya	II	16	15	12	121	2	38	1985	2001	Manual
87	II	Matalag	Cagayan	II	17	49	40	121	25	28	1964	1980	Manual
88	II	Matuno	Nueva Viscaya	II	16	27	15	121	3	30	1956	1979	Manual
89	II	Nagan	Apayao	CAR	-	-	-	-	-	-	2002	Present	Manual
90	II	Pamplona	Cagayan	II	18	27	37	120	20	11	2002	Present	Manual
91	II	Pangul	Cagayan	II	17	39	45	121	37	30	1955	1976	Manual
92	II	Paret	Cagayan	II	17	54	46	121	41	6	1983	1996	Manual
93	II	Paret	Cagayan	II	17	54	46	121	41	6	1958	1969	Recorder
94	II	Paret	Cagayan	II	17	54	35	121	47	20	1968	1976	Manual
95	II	Pinacanauan	Isabela	II	17	7	27	121	54	22	1964	Present	Manual
96	II	Pinacanauan	Cagayan	II	17	37	46	121	46	19	1956	Present	Manual
97	II	Pinacanauan	Isabela	II	17	17	4	121	55	48	1964	1970	Manual
98	II	Rosario	Nueva Viscaya	II	16	39	15	121	18	8	1985	1998	Manual
99	II	Sabangan	Mt. Province	CAR	17	0	28	120	54	21	1965	1974	Manual
100	II	Saltan	Kalinga-Apayao	CAR	17	37	0	121	24	0	2002	Present	Manual
101	II	Saltan	Kalinga-Apayao	CAR	17	30	46	121	12	17	1965	1970	Manual
102	II	Siffu	Isabela	II	17	16	42	121	25	0	1948	1975	Manual
103	II	Sinundungan	Cagayan	II	18	3	31	121	35	7	1959	1976	Manual
104	II	Sta Cruz	Nueva Viscaya	II	16	25	0	120	56	58	1985	1992	Recorder
105	II	Sta. Fe	Nueva Viscaya	II	16	9	31	120	56	3	2002	Present	Manual
106	II	Sta. Fe	Nueva Viscaya	II	16	13	12	120	57	30	1983	1998	Manual
107	II	Tanudan	Kalinga-Apayao	CAR	17	23	10	121	15	42	1965	1970	Manual
108	II	Taotao	Isabela	II	16	57	0	121	32	56	1957	1972	Manual
109	II	Tungcab	Quirino	II	16	21	50	121	40	32	1987	2001	Manual
110	III	Abacan	Pampanga	III	15	7	6	120	42	11	1993	Present	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (3/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
111	III	Agno	Pangasinan	I	15	49	6	120	27	20	1908	Present	Manual
112	III	Agno	Benguet	CAR	16	35	0	120	49	0	1959	1973	Manual
113	III	Agno	Benguet	CAR	16	23	6	120	43	17	1965	1974	Manual
114	III	Agno	Pangasinan	I	16	8	7	120	41	45	1945	1980	Manual
115	III	Agno	Pangasinan	I	15	53	30	120	35	30	1946	1980	Manual
116	III	Agno	Pangasinan	I	15	49	7	120	27	22	1949	1976	Manual
117	III	Agno	Pangasinan	I	15	49	7	120	27	22	1949	1976	Manual
118	III	Agno	Pangasinan	I	16	0	39	120	12	30	1965	1977	Manual
119	III	Agno	Pangasinan	I	15	59	42	120	13	19	1965	1977	Manual
120	III	Agno	Pangasinan	I	15	52	0	120	19	32	1954	1970	Manual
121	III	Agno	Pangasinan	I	15	32	0	120	19	32	1954	1970	Manual
122	III	Agno	Pangasinan	I	15	45	50	120	26	28	1954	1970	Manual
123	III	Ambayoan	Pangasinan	I	16	7	10	120	46	45	1958	1977	Manual
124	III	Angat	Bulacan	III	14	56	23	121	1	20	1985	Present	Manual
125	III	Angat	Bulacan	III	14	53	30	120	51	50	1959	1989	Manual
126	III	Angat	Bulacan	III	14	54	7	120	47	0	1961	1980	Manual
127	III	Angat	Bulacan	III	14	53	55	120	50	36	1961	1970	Manual
128	III	Angat	Bulacan	III	14	52	36	121	8	30	1956	1970	Recorder
129	III	Bagsit	Zambales	III	15	25	52	120	1	0	1960	1972	Manual
130	III	Balincaguing	Pangasinan	I	16	4	10	119	56	20	1959	1973	Manual
131	III	Baliuag	Nueva Ecija	III	15	40	1	120	51	13	1957	Present	Manual
132	III	Bangot	Tarlac	III	15	22	5	120	29	19	1966	Present	Recorder
133	III	Bayabas	Bulacan	III	14	57	20	121	3	45	1964	1973	Manual
134	III	Bayaoas	Pangasinan	I	15	49	30	120	14	50	1958	Present	Manual
135	III	Bebe Coc1	Pampanga	III	14	52	40	120	42	18	1956	1972	Manual
136	III	Bebe Coc2	Pampanga	III	14	53	30	120	40	30	1956	1972	Manual
137	III	Benituan	Nueva Ecija	III	15	40	8	120	44	40	1957	1976	Manual
138	III	Bokod	Benguet	CAR	16	35	15	120	50	0	1949	1973	Manual
139	III	Bucao	Zambales	III	15	15	51	120	2	13	1955	Present	Manual
140	III	Bulate	Bataan	III	14	50	54	120	22	50	1946	1966	Manual
141	III	Bulo	Bulacan	III	15	13	45	121	4	12	1964	1976	Manual
142	III	Bulsa	Tarlac	III	15	28	6	120	26	56	1960	1973	Manual
143	III	Cabu	Nueva Ecija	III	15	31	45	121	3	30	1957	1999	Manual
144	III	Camiling	Tarlac	III	15	37	1	120	22	31	1964	Present	Manual
145	III	Candaba Swamps	Pampanga	III	15	6	37	120	51	0	1954	1970	Manual
146	III	Carranglan	Nueva Ecija	III	15	58	0	121	3	14	1958	1978	Manual
147	III	Caulaman	Pampanga	III	14	57	30	120	28	30	1954	1979	Manual
148	III	Chico	Nueva Ecija	III	15	21	48	121	4	7	1983	1994	Manual
149	III	Chico	Pampanga	III	15	13	11	120	46	54	1964	1970	Recorder
150	III	Chico	Tarlac	III	15	21	0	120	44	10	1961	1968	Manual
151	III	Colo	Bataan	III	14	50	50	120	24	48	1955	1979	Manual
152	III	Coronel	Nueva Ecija	III	15	35	19	121	7	48	1960	Present	Manual
153	III	Diaan	Bataan	III	14	28	26	120	27	20	-	-	Manual
154	III	Digmala	Nueva Ecija	III	15	38	52	121	15	50	1959	1972	Manual
155	III	Francis	Bulacan	III	14	56	22	120	45	6	1946	1974	Manual
156	III	Garlang	Bulacan	III	15	6	48	120	57	0	1955	1970	Manual
157	III	Garlang	Bulacan	III	15	7	18	120	57	8	1955	1972	Manual
158	III	Gumain	Pampanga	III	14	55	0	120	34	8	1958	2000	Manual
159	III	Gumain	Pampanga	III	14	56	45	120	30	42	1992	Present	Manual
160	III	Gumain	Pampanga	III	14	59	12	120	28	18	1944	1979	Manual
161	III	Labangan	Bulacan	III	14	50	28	120	44	55	1961	1979	Manual
162	III	Labangan	Bulacan	III	14	46	8	120	45	0	1961	1976	Manual
163	III	Labangan	Bulacan	III	14	52	45	120	45	38	1961	1992	Manual
164	III	Labangan	Bulacan	III	14	53	2	120	46	13	1946	1979	Manual
165	III	Maasim	Pampanga	III	15	1	58	120	53	0	1956	1992	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (4/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
166	III	Maasim	Bulacan	III	15	2	15	120	57	25	1946	1979	Manual
167	III	Madlum	Bulacan	III	15	10	10	120	3	9	1956	Present	Manual
168	III	Madlum	Bulacan	III	15	10	4	121	3	30	1955	1969	Manual
169	III	Maloma	Zambales	III	15	6	57	120	3	46	1984	Present	Manual
170	III	Miray	Bataan	III	14	38	0	120	31	25	1953	1979	Manual
171	III	Nayom	Zambales	III	15	48	31	119	58	48	1955	1979	Manual
172	III	O'donnel	Tarlac	III	15	23	47	120	30	5	1964	1985	Manual
173	III	Paitan	Pangasinan	I	16	5	8	120	1	30	1985	Present	Manual
174	III	Pampanga	Nueva Ecija	III	15	25	30	120	56	2	1985	Present	Manual
175	III	Pampanga	Nueva Ecija	III	15	18	44	120	54	13	1982	Present	Manual
176	III	Pampanga	Pampanga	III	15	9	59	120	47	0	1944	2002	Manual
177	III	Pampanga	Pampanga	III	14	56	4	120	45	33	1946	Present	Manual
178	III	Pampanga	Nueva Ecija	III	15	30	49	120	57	23	1964	Present	Manual
179	III	Pampanga	Nueva Ecija	III	15	35	54	121	6	36	-	-	Manual
180	III	Pampanga	Nueva Ecija	III	15	30	57	121	2	40	1957	1973	Manual
181	III	Pampanga	Nueva Ecija	III	15	20	45	120	54	30	1958	1979	Manual
182	III	Pampanga	Pampanga	III	15	10	6	120	46	48	1946	1979	Manual
183	III	Pampanga	Nueva Ecija	III	15	49	39	121	6	51	1959	1970	Recorder
184	III	Pampanga	Pampanga	III	15	5	48	120	49	18	1958	1980	Manual
185	III	Pampanga	Pampanga	III	15	0	26	120	46	35	1957	1979	Manual
186	III	Pampanga	Pampanga	III	15	0	51	120	46	37	1946	1979	Manual
187	III	Pampanga	Pampanga	III	14	56	24	120	45	43	1946	1977	Manual
188	III	Pampanga	Pampanga	III	14	46	16	120	39	11	1964	1970	Recorder
189	III	Pampanga	Bulacan	III	14	55	20	120	45	52	1946	1979	Manual
190	III	Pampanga	Bulacan	III	14	55	11	120	44	42	1946	1974	Manual
191	III	Pampanga	Nueva Ecija	III	15	13	18	120	48	31	1958	1968	Manual
192	III	Pantabangan	Nueva Ecija	III	15	51	31	121	8	4	1958	1972	Recorder
193	III	Parua	Tarlac	III	15	15	38	120	33	26	1958	1970	Manual
194	III	Pasig-Potrero	Pampanga	III	15	59	24	120	38	50	1965	1998	Manual
195	III	Pasig-Potrero	Pampanga	III	15	6	37	120	31	58	1966	1972	Manual
196	III	Penaranda	Nueva Ecija	III	15	20	30	120	56	30	1965	1973	Manual
197	III	Penaranda	Nueva Ecija	III	15	21	10	121	0	25	1945	1974	Manual
198	III	Penaranda	Nueva Ecija	III	15	19	10	120	56	52	1945	1973	Manual
199	III	Penaranda	Nueva Ecija	III	15	19	10	120	56	52	1945	1973	Manual
200	III	Pila	Pangasinan	I	15	45	52	120	16	53	1957	1965	Manual
201	III	Pilar	Bataan	III	14	37	53	120	31	53	1954	Present	Manual
202	III	Poponto Swamps	Pangasinan	I	15	44	52	120	27	50	1954	1977	Manual
203	III	Porac	Pampanga	III	15	0	35	120	32	2	1958	Present	Manual
204	III	Porac	Pampanga	III	15	4	20	120	32	30	1985	Present	Manual
205	III	Porac	Pampanga	III	14	59	34	120	32	5	1945	Present	Manual
206	III	Porac	Pampanga	III	14	58	55	120	32	6	1958	1975	Manual
207	III	Rio Chico	Nueva Ecija	III	15	26	40	120	45	4	1960	Present	Manual
208	III	Sacobia	Tarlac	III	15	17	48	120	38	15	1992	1999	Manual
209	III	San Miguel	Bulacan	III	15	8	48	120	58	20	1955	1989	Manual
210	III	Santor	Nueva Ecija	III	15	36	8	121	9	57	1957	1976	Manual
211	III	Santor	Nueva Ecija	III	15	28	30	121	18	48	1957	1976	Manual
212	III	Sinocalan	Pangasinan	I	16	0	0	120	31	20	1958	1978	Manual
213	III	Sta. Maria	Bulacan	III	14	48	50	120	57	38	1966	1973	Manual
214	III	Sto. Tomas	Zambales	III	15	2	14	120	4	28	1993	1999	Manual
215	III	Sulipan Coc	Pampanga	III	14	56	13	120	45	26	1957	1979	Manual
216	III	Sumacbao	Nueva Ecija	III	15	20	28	121	6	25	1960	1975	Manual
217	III	Tabuating	Nueva Ecija	III	15	24	11	120	59	54	1960	Present	Manual
218	III	Tagamusing	Pangasinan	I	16	2	56	120	35	42	1958	Present	Manual
219	III	Talavera	Nueva Ecija	III	15	42	58	121	0	35	1956	Present	Manual
220	III	Talavera	Nueva Ecija	III	15	41	26	120	58	10	1959	1976	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (5/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
221	III	Tarlac	Tarlac	III	15	39	35	120	32	4	1945	1992	Manual
222	III	Toboy	Pangasinan	I	16	7	36	120	40	0	1964	1973	Manual
223	III	Twin	Benguet	CAR	16	23	8	120	43	22	1967	1975	Manual
224	III	Viray de Palo	Pangasinan	I	16	1	10	120	44	25	1987	Present	Manual
225	IV	Agus	Quezon	IV-A	14	45	15	121	36	45	1949	1985	Manual
226	IV	Alemang	Cavite	IV-A	14	19	6	120	46	28	1985	Present	Manual
227	IV	Arangilan	Laguna	IV-A	14	14	10	121	7	30	1956	1976	Manual
228	IV	Baco	Ori.Mindoro	IV-B	-	-	-	-	-	-	1990	1993	Manual
229	IV	Balanac	Laguna	IV-A	14	12	24	121	26	33	1958	1980	Manual
230	IV	Balanac	Laguna	IV-A	14	14	0	121	26	15	1956	1979	Manual
231	IV	BalayBalay	Quezon	IV-A	14	6	52	121	41	11	1985	Present	Manual
232	IV	Balite	Ori.Mindoro	IV-B	-	-	-	-	-	-	2001	2002	Manual
233	IV	Balogo	Romblon	IV-B	12	35	53	122	1	54	1958	1976	Manual
234	IV	Balsahan	Cavite	IV-A	14	16	59	120	48	30	1954	1985	Manual
235	IV	Banadero	Romblon	IV-B	12	36	0	122	4	30	1959	1979	Manual
236	IV	Baroc	Ori.Mindoro	IV-B	-	-	-	-	-	-	2001	2002	Manual
237	IV	Binonga-An	Romblon	IV-B	12	32	47	122	6	12	1960	1979	Manual
238	IV	Boac	Marinduque	IV-B	13	27	7	121	50	44	1991	Present	Manual
239	IV	Boac	Marinduque	IV-B	13	26	30	121	5	0	1959	1969	Manual
240	IV	Bucayao	Ori.Mindoro	IV-B	13	18	40	121	11	12	1951	Present	Manual
241	IV	Bugsuanga	Occ.Mindoro	IV-B	12	31	12	121	6	30	1956	1969	Manual
242	IV	Bulakin	Quezon	IV-A	14	2	30	121	21	15	1959	1974	Manual
243	IV	Cabatangan	Quezon	IV-A	15	44	9	121	24	28	1955	1972	Manual
244	IV	Caguray	Occ.Mindoro	IV-B	12	20	18	121	11	3	1956	1969	Manual
245	IV	Cantingas	Romblon	IV-B	12	19	45	122	34	47	1056	1970	Manual
246	IV	Dacanlao	Batangas	IV-A	13	56	20	120	46	36	1958	Present	Manual
247	IV	Disalit	Quezon	IV-A	15	43	30	121	31	40	1956	1976	Manual
248	IV	Dubduban	Romblon	IV-B	12	35	0	122	6	15	1957	1976	Manual
249	IV	Dumaca-A	Quezon	IV-A	14	2	20	121	37	30	1945	1985	Manual
250	IV	Dumaca-A	Quezon	IV-A	14	3	24	121	37	20	1945	1975	Manual
251	IV	Estero de Vitas	MM	NCR	-	-	-	-	-	-	1988	1999	Manual
252	IV	Hibanga	Quezon	IV-A	14	2	10	121	30	45	1956	1976	Manual
253	IV	Hinugusan	Romblon	IV-B	12	30	17	122	5	35	1058	1979	Manual
254	IV	Ibia	Quezon	IV-A	14	1	42	121	36	51	1950	1977	Manual
255	IV	Ilang-Ilang	Cavite	IV-A	14	24	30	120	54	20	1952	1985	Manual
256	IV	Iyam	Quezon	IV-A	13	57	43	121	36	14	1987	Present	Manual
257	IV	Lagnas	Quezon	IV-A	13	57	22	121	21	4	1952	2000	Manual
258	IV	Laguna Lake	Laguna	IV-A	14	10	59	121	13	15	1984	Present	Manual
259	IV	Laguna Lake	Rizal	IV-A	14	31	22	121	9	16	1988	Present	Manual
260	IV	Laguna Lake	MM	NCR	14	31	22	121	9	16	1959	1980	Manual
261	IV	Laguna Lake	MM	NCR	14	21	29	121	2	46	1959	1978	Manual
262	IV	Laguna Lake	Laguna	IV-A	14	11	6	121	13	10	1946	1970	Recorder
263	IV	Laguna Lake	Laguna	IV-A	14	18	58	121	27	50	1964	1970	Manual
264	IV	Libtangan	Marinduque	IV-B	13	21	3	121	49	48	1991	Present	Manual
265	IV	Luzong	Romblon	IV-B	12	31	2	122	5	16	1058	1979	Manual
266	IV	Maapon	Quezon	IV-A	14	10	0	121	38	20	1958	1989	Manual
267	IV	Mabacan	Laguna	IV-A	14	9	52	121	17	29	1955	1980	Manual
268	IV	Mag-Asawang Tubig	Ori.Mindoro	IV-B	13	16	47	121	15	30	1989	Present	Manual
269	IV	Mag-Asawang Tubig	Ori.Mindoro	IV-B	13	14	15	121	14	15	1951	1969	Manual
270	IV	Malabon	Marinduque	IV-B	13	25	45	122	3	50	1959	1969	Manual
271	IV	Mamburao	Occ.Mindoro	IV-B	13	19	35	120	39	30	1958	1969	Manual
272	IV	Mangamnan	Marinduque	IV-B	13	28	0	121	55	0	1959	1969	Manual
273	IV	Maragondon	Cavite	IV-A	14	16	26	120	45	32	1945	Present	Manual
274	IV	Marikina	Rizal	IV-A	14	44	8	121	7	45	1988	Present	Manual
275	IV	Marikina	MM	NCR	14	38	15	121	5	30	1958	Present	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (6/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
276	IV	Marikina	Rizal	IV-A	14	44	0	121	10	20	1956	Present	Manual
277	IV	Marikina	MM	NCR	14	36	12	121	5	11	1959	1959	Manual
278	IV	Marikina	MM	NCR	14	36	12	121	5	22	1959	1959	Recorder
279	IV	Mayor	Laguna	IV-A	14	26	44	121	27	12	1949	Present	Manual
280	IV	Mingping	Occ.Mindoro	IV-B	13	12	45	120	38	50	1990	Present	Manual
281	IV	Mogpog	Marinduque	IV-B	13	28	48	121	51	22	1991	Present	Manual
282	IV	Molino	Batangas	IV-A	14	1	14	120	43	16	1956	1985	Manual
283	IV	Morong	Quezon	IV-A	13	55	58	121	33	18	1956	1977	Manual
284	IV	Nangka	MM	NCR	14	41	53	121	6	30	1959	2002	Manual
285	IV	Napindan	MM	NCR	-	-	-	-	-	-	1984	1986	Manual
286	IV	Pagbahan	Occ.Mindoro	IV-B	13	8	16	120	41	40	1960	Present	Manual
287	IV	Pagsanjan	Laguna	IV-A	14	16	41	121	27	25	1984	Present	Manual
288	IV	Palico	Batangas	IV-A	14	2	53	120	41	30	1956	Present	Manual
289	IV	Panaysayan	Cavite	IV-A	14	20	15	120	52	45	1957	Present	Manual
290	IV	Pandacan	MM	NCR	-	-	-	-	-	-	2002	2002	Manual
291	IV	Pangalaan	Ori.Mindoro	IV-B	13	18	10	121	11	46	1989	Present	Manual
292	IV	Pangalaan	Ori.Mindoro	IV-B	13	15	33	121	11	24	1951	1969	Manual
293	IV	Pansiipit	Batangas	IV-A	13	55	42	120	56	43	1958	Present	Manual
294	IV	Paputok	Laguna	IV-A	14	8	12	121	21	3	1955	1980	Manual
295	IV	Pasig	MM	NCR	14	34	12	121	2	40	1988	Present	Manual
296	IV	Pasig	MM	NCR	14	35	47	121	0	37	1945	1980	Manual
297	IV	Pasig	MM	NCR	14	34	12	121	2	40	1946	1946	Manual
298	IV	Pasig	MM	NCR	14	33	50	121	3	39	1946	1946	Manual
299	IV	Pasig	MM	NCR	14	33	51	121	3	42	1959	1959	Manual
300	IV	Pasig	MM	NCR	14	32	28	121	5	44	1946	1978	Manual
301	IV	Pasig	MM	NCR	14	35	48	100	58	2	1961	1970	Recorder
302	IV	Pasig	MM	NCR	-	-	-	-	-	-	1988	1989	Manual
303	IV	Pilila	Rizal	IV-A	14	29	25	121	18	19	1984	Present	Manual
304	IV	Pola	Ori.Mindoro	IV-B	13	3	2	121	25	24	1989	Present	Manual
305	IV	Pola	Ori.Mindoro	IV-B	13	0	30	121	23	38	1952	1969	Manual
306	IV	San Cristobal	Laguna	IV-A	14	13	18	121	8	16	1984	Present	Manual
307	IV	San Juan	Laguna	IV-A	14	12	35	121	9	10	1984	Present	Manual
308	IV	San Juan	MM	NCR	-	-	-	-	-	-	1988	1989	Manual
309	IV	San Roque	Batangas	IV-A	13	47	33	120	59	19	1987	Present	Manual
310	IV	Sariaya	Quezon	IV-A	13	57	3	121	31	26	1956	Present	Manual
311	IV	Sta. Cruz	Laguna	IV-A	14	16	6	121	25	19	1984	Present	Manual
312	IV	Sta. Cruz	Laguna	IV-A	14	11	55	121	24	30	1944	1974	Manual
313	IV	Sumagui	Ori.Mindoro	IV-B	-	-	-	-	-	-	2001	2002	Manual
314	IV	Tignoan	Quezon	IV-A	14	34	0	121	36	54	1985	Present	Manual
315	IV	Tuay	Occ.Mindoro	IV-B	13	24	27	122	42	9	1958	1969	Manual
316	IV	Tullahan	MM	NCR	-	-	-	-	-	-	2002	2002	Manual
317	V	Agus	Albay	V	13	20	25	123	24	1	1954	Present	Manual
318	V	Alibuag	Catanduanes	V	13	37	55	124	4	51	1954	Present	Manual
319	V	Anayan	Cam.Sur	V	13	34	19	123	17	23	1954	Present	Manual
320	V	Asiong	Cam.Sur	V	13	40	25	122	59	48	1954	Present	Manual
321	V	Barit	Cam.Sur	V	13	24	9	123	24	42	1951	1978	Manual
322	V	Batongan	Masbate	V	12	19	16	123	20	0	1945	1988	Manual
323	V	Bicol	Cam.Sur	V	13	24	18	123	19	28	1910	Present	Manual
324	V	Bicol	Cam.Sur	V	13	31	15	123	12	0	1959	1986	Manual
325	V	Bicol	Cam.Sur	V	13	37	0	123	1	50	1959	1988	Manual
326	V	Bicol	Cam.Sur	V	13	40	54	123	5	20	1960	1973	Manual
327	V	Bicol	Cam.Sur	V	13	28	25	123	14	30	1959	1978	Manual
328	V	Cabilogan	Albay	V	13	14	30	123	31	1	1956	Present	Manual
329	V	Cadacan	Sorsogon	V	12	46	8	123	58	56	1981	1994	Manual
330	V	Cagaycay	Cam.Sur	V	13	43	46	123	27	32	1982	Present	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (7/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
331	V	Cawayan	Catanduanes	V	13	36	50	124	11	43	1954	Present	Manual
332	V	Cawayan	Sorsogon	V	12	59	20	123	57	0	1954	1982	Manual
333	V	Culacling	Cam.Sur	V	13	46	52	122	52	50	1947	Present	Manual
334	V	Cumadcad	Sorsogon	V	12	58	43	123	46	59	1957	Present	Manual
335	V	Daet	Cam.Sur	V	14	5	43	122	54	18	1954	1986	Manual
336	V	Donsol	Albay	V	13	4	32	123	36	2	1981	Present	Manual
337	V	Hinaguianan	Cam.Sur	V	13	43	43	123	16	22	1945	Present	Manual
338	V	Irraya	Albay	V	13	15	26	123	29	58	1959	1978	Manual
339	V	Lagonoy	Cam.Sur	V	13	44	38	123	31	52	1951	1978	Manual
340	V	Lake Bato	Cam.Sur	V	13	21	8	123	22	0	1959	1978	Manual
341	V	Lalo	Cam.Sur	V	13	22	48	123	32	16	1964	Present	Manual
342	V	Libjo	Catanduanes	V	13	37	24	124	18	54	1954	Present	Manual
343	V	Libmanan	Cam.Sur	V	13	41	34	123	3	29	1945	Present	Manual
344	V	Malbog	Sorsogon	V	12	58	25	123	47	40	1955	1970	Manual
345	V	Mambang	Catanduanes	V	14	3	30	124	9	30	1954	1985	Manual
346	V	Matogdon	Cam.Norte	V	14	8	53	122	50	18	1950	1987	Manual
347	V	Namuat	Sorsogon	V	12	49	44	124	3	12	1954	Present	Manual
348	V	Nasisi	Albay	V	13	15	30	123	35	30	1945	1985	Manual
349	V	Oco	Catanduanes	V	13	51	0	124	16	30	1954	1978	Manual
350	V	Ogsong	Albay	V	13	14	29	123	35	8	1954	Present	Manual
351	V	Patorok	Catanduanes	V	13	36	20	124	6	25	1954	1975	Manual
352	V	Pawic	Sorsogon	V	12	39	37	123	57	21	1981	Present	Manual
353	V	Pawili	Cam.Sur	V	13	32	36	123	22	40	1952	Present	Manual
354	V	Pawili	Cam.Sur	V	13	28	15	123	16	40	1958	1985	Manual
355	V	Payo	Catanduanes	V	13	53	27	124	16	14	1954	Present	Manual
356	V	Pili	Sorsogon	V	12	58	50	123	51	0	1955	1970	Manual
357	V	Pinangapungan	Masbate	V	12	11	10	123	47	47	1951	1987	Manual
358	V	Pulantuna	Cam.Sur	V	13	53	46	122	55	17	1956	Present	Manual
359	V	Quinali	Albay	V	13	24	18	123	42	4	1981	Present	Manual
360	V	Quinali	Albay	V	13	15	28	123	28	46	1954	Present	Manual
361	V	Sagawsawan	Masbate	V	12	21	22	123	37	48	1959	1974	Manual
362	V	San Agustin	Albay	V	13	19	34	123	25	56	1959	Present	Manual
363	V	San Francisco	Sorsogon	V	12	44	9	123	55	16	1959	Present	Manual
364	V	San Francisco	Albay	V	13	14	0	123	31	34	1956	1978	Manual
365	V	San Ramon	Sorsogon	V	12	40	0	123	55	45	1952	1970	Manual
366	V	Sebanjan	Catanduanes	V	13	35	50	124	14	20	1954	1978	Manual
367	V	Sipocot	Cam.Sur	V	13	48	44	122	59	40	1946	1983	Manual
368	V	Talisay	Albay	V	13	11	34	123	27	21	1964	Present	Manual
369	V	Talisay	Cam.Norte	V	14	8	25	122	55	42	1956	1986	Manual
370	V	Tambang	Cam.Sur	V	-	-	-	-	-	-	1981	1985	Manual
371	V	Tigman	Cam.Sur	V	13	40	53	123	11	7	1956	1986	Manual
372	V	Togas	Sorsogon	V	-	-	-	-	-	-	1981	1985	Manual
373	V	Ugsong	Albay	V	13	14	5	123	35	40	1955	1977	Manual
374	V	Yabo	Cam.Sur	V	13	37	25	123	14	45	1954	1984	Manual
375	V	Yabo	Cam.Sur	V	13	48	13	122	56	0	1955	1990	Manual
376	V	Yawa	Albay	V	13	9	54	123	44	15	1981	1992	Manual
377	VI	Aklan	Aklan	VI	11	42	54	122	21	44	1986	Present	Manual
378	VI	Aklan	Aklan	VI	-	-	-	-	-	-	1984	1986	Manual
379	VI	Aklan	Aklan	VI	11	35	23	122	18	14	1950	1979	Manual
380	VI	Bacong	Antique	VI	11	24	45	122	5	30	1958	1980	Manual
381	VI	Badbaran	Capiz	VI	11	18	28	122	40	6	1985	1990	Manual
382	VI	Badbaran	Capiz	VI	-	-	-	-	-	-	1984	1985	Manual
383	VI	Bago	Negros Occ.	VI	10	44	30	123	2	0	1949	1979	Manual
384	VI	Bago	Negros Occ.	VI	10	33	22	123	4	40	1967	Present	Manual
385	VI	Barotac	Iloilo	VI	10	56	0	122	9	39	1956	1977	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (8/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
386	VI	Binalbagan	Negros Occ.	VI	10	12	36	122	52	0	1987	1990	Manual
387	VI	Binalbagan	Negros Occ.	VI	10	15	36	123	5	5	1959	1980	Manual
388	VI	Cairawan	Antique	VI	11	7	8	122	2	20	1986	Present	Manual
389	VI	Cangaranan	Antique	VI	11	0	46	122	2	56	1986	1989	Manual
390	VI	Dalanas	Antique	VI	11	14	56	122	3	23	1986	1989	Manual
391	VI	Hilabangan	Negros Occ.	VI	9	58	8	122	50	8	1954	Present	Manual
392	VI	Hilabangan	Negros Occ.	VI	9	56	58	122	56	12	1955	1998	Manual
393	VI	Himogaan	Negros Occ.	VI	10	53	30	123	21	18	1987	1990	Manual
394	VI	Ilog	Negros Occ.	VI	10	1	20	122	44	0	1957	1980	Manual
395	VI	Ilog	Negros Occ.	VI	10	1	30	122	45	14	1954	1976	Manual
396	VI	Ilog	Negros Occ.	VI	10	0	37	122	48	0	1954	Present	Manual
397	VI	Ilog	Negros Occ.	VI	9	59	40	122	47	40	1964	1974	Manual
398	VI	Ilog	Negros Occ.	VI	9	59	15	122	48	30	1954	1979	Manual
399	VI	Ilog	Negros Occ.	VI	9	58	0	122	48	15	1954	1979	Manual
400	VI	Ilog	Negros Occ.	VI	9	57	15	122	48	50	1955	1979	Manual
401	VI	Ilog	Negros Occ.	VI	9	55	30	122	50	20	1956	1979	Manual
402	VI	Ilog	Negros Occ.	VI	9	53	20	122	50	40	1955	1978	Manual
403	VI	Ilog	Negros Occ.	VI	9	49	42	122	52	20	1965	1980	Manual
404	VI	Imbang	Negros Occ.	VI	10	44	32	123	2	48	1950	Present	Manual
405	VI	Inabasan	Iloilo	VI	10	50	23	122	26	55	1950	1980	Manual
406	VI	Ipayo	Antique	VI	10	55	5	121	59	46	1986	Present	Manual
407	VI	Jalaur	Iloilo	VI	11	6	8	122	38	27	1985	Present	Manual
408	VI	Jalaur	Iloilo	VI	10	47	33	122	33	45	1956	1980	Manual
409	VI	Jalaur	Iloilo	VI	10	49	30	122	39	30	1956	1980	Manual
410	VI	Jalaur	Iloilo	VI	10	55	36	120	40	7	1956	Present	Manual
411	VI	Jalaur	Iloilo	VI	11	6	15	122	37	40	1956	1970	Recorder
412	VI	Jalaur	Iloilo	VI	11	7	18	122	32	14	1956	Present	Manual
413	VI	Jalaur	Iloilo	VI	11	9	43	122	27	24	1956	1970	Manual
414	VI	Maayon	Capiz	VI	11	23	24	122	46	39	1956	Present	Manual
415	VI	Malisbog	Negros Occ.	VI	10	49	50	123	0	19	1986	Present	Manual
416	VI	Malogo	Negros Occ.	VI	10	53	44	123	2	14	1986	Present	Manual
417	VI	Malogo	Negros Occ.	VI	10	49	3	123	4	52	1960	1988	Manual
418	VI	Mambusao	Capiz	VI	11	25	18	122	39	54	1950	Present	Manual
419	VI	Paliuan	Antique	VI	11	4	44	122	3	14	1985	Present	Manual
420	VI	Paliuan	Antique	VI	11	4	42	122	2	21	1956	1980	Manual
421	VI	Panay	Capiz	VI	11	20	52	122	39	56	1984	Present	Manual
422	VI	Panay	Capiz	VI	11	27	54	122	46	6	1984	1989	Manual
423	VI	Panay	Capiz	VI	11	18	45	122	37	7	1956	Present	Manual
424	VI	Piguian	Negros Occ.	VI	10	21	15	123	8	15	1965	1979	Manual
425	VI	Sibajao	Iloilo	VI	11	25	46	123	5	45	1958	1979	Manual
426	VI	Sibalom	Iloilo	VI	10	46	28	122	23	39	1950	Present	Manual
427	VI	Sibalom	Antique	VI	10	48	30	121	59	15	1958	Present	Manual
428	VI	Sicaba	Negros Occ.	VI	10	55	50	123	10	6	1987	1989	Manual
429	VI	Suage	Iloilo	VI	10	56	8	122	34	42	1949	Present	Manual
430	VI	Tangalan	Aklan	VI	11	45	35	122	13	30	1958	1980	Manual
431	VI	Tigum	Iloilo	VI	10	53	9	122	28	7	1985	1989	Manual
432	VI	Tiolas	Iloilo	VI	10	34	26	122	4	7	1985	1989	Manual
433	VI	Troso	Cadiz City	VI	10	56	40	123	16	15	1987	1989	Manual
434	VI	Ulian	Iloilo	VI	11	3	58	122	35	12	1985	1989	Manual
435	VI	Ulian	Iloilo	VI	11	4	38	122	28	6	1957	Present	Manual
436	VII	Abatan	Bohol	VII	9	47	22	123	57	25	1984	Present	Manual
437	VII	Alum	Negros Ori.	VII	10	8	17	123	15	17	1985	Present	Manual
438	VII	Antequera	Bohol	VII	9	45	35	123	54	0	1984	Present	Manual
439	VII	Anulod	Negros Ori.	VII	9	45	4	123	8	31	1985	Present	Manual
440	VII	Argao	Cebu	VII	9	53	16	123	36	15	1985	Present	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (9/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
441	VII	Bais	Negros Ori.	VII	9	34	15	123	5	30	1962	1999	Manual
442	VII	Bais	Negros Ori.	VII	9	35	0	123	4	40	1984	Present	Manual
443	VII	Balamban	Cebu	VII	10	29	7	123	52	57	1957	1970	Recorder
444	VII	Bilar	Bohol	VII	9	41	30	124	6	42	1959	1977	Manual
445	VII	Cantimoc	Bohol	VII	9	50	12	124	10	45	1985	Present	Manual
446	VII	Carcar	Cebu	VII	10	7	52	123	36	5	1955	Present	Manual
447	VII	Gabayan	Bohol	VII	9	50	34	124	26	30	1985	Present	Manual
448	VII	Guinabasan	Cebu	VII	10	37	28	123	45	47	1984	Present	Manual
449	VII	Hibayog	Bohol	VII	9	52	25	124	7	47	1986	Present	Manual
450	VII	Hinlayagan	Bohol	VII	10	1	56	124	20	46	1984	Present	Manual
451	VII	La Libertad	Negros Ori.	VII	10	3	2	123	12	41	1986	Present	Manual
452	VII	Loboc	Bohol	VII	9	39	57	124	2	4	1922	1977	Manual
453	VII	Maite	Negros Ori.	VII	9	16	3	123	12	5	1959	1980	Manual
454	VII	Mambool	Bohol	VII	9	42	5	124	22	31	1986	Present	Manual
455	VII	Manaba	Bohol	VII	9	37	56	124	18	14	1984	Present	Manual
456	VII	Naga	Cebu	VII	-	-	-	-	-	-	1985	1986	Manual
457	VII	Nagsala	Negros Ori.	VII	9	30	15	123	6	15	1962	1977	Manual
458	VII	Nahawan	Bohol	VII	9	58	30	124	3	10	1985	Present	Manual
459	VII	Okoy	Negros Ori.	VII	9	18	58	123	13	52	1959	Present	Manual
460	VII	Pamacsalan	Bohol	VII	9	50	58	124	21	9	1956	1977	Manual
461	VII	Pitogo	Cebu	VII	10	22	42	123	57	38	1955	1977	Manual
462	VII	Siaton	Negros Ori.	VII	9	3	38	123	1	34	1984	Present	Manual
463	VII	Sta. Ana	Cebu	VII	10	6	40	123	30	58	1984	Present	Manual
464	VII	Tanguhay	Bohol	VII	9	46	4	124	28	25	1985	Present	Manual
465	VII	Tanjay	Negros Ori.	VII	9	27	48	123	6	20	1959	Present	Manual
466	VII	Wahig	Bohol	VII	9	47	0	124	15	25	1955	1977	Manual
467	VII	Zamora	Bohol	VII	10	5	56	124	17	49	1985	1998	Manual
468	VIII	Amparo	Southern Leyte	VIII	10	6	7	124	54	54	1985	Present	Manual
469	VIII	Baleon	Leyte	VIII	11	6	41	124	34	20	1956	1980	Manual
470	VIII	Bangkerohan	Leyte	VIII	10	23	37	124	49	58	1984	Present	Manual
471	VIII	Bao	Leyte	VIII	11	8	12	124	35	52	1951	1980	Manual
472	VIII	Bito	Leyte	VIII	10	46	10	124	57	22	1957	1970	Recorder
473	VIII	Bobon	Samar	VIII	12	29	25	124	32	37	1958	1978	Manual
474	VIII	Borongan	Eastern Samar	VIII	11	37	47	125	24	7	1986	Present	Manual
475	VIII	Calingcaguin	Leyte	VIII	11	14	45	124	31	30	1948	1978	Manual
476	VIII	Catarman	Northern Samar	VIII	12	21	30	124	39	22	1959	1988	Manual
477	VIII	Catmon	Samar	VIII	11	31	41	124	25	33	1986	1988	Manual
478	VIII	Catubig	Samar	VIII	12	17	19	125	2	22	1955	1978	Manual
479	VIII	Daguitan	Leyte	VIII	10	58	21	124	53	44	1957	Present	Manual
480	VIII	Dapdap	Leyte	VIII	11	13	0	124	51	0	1952	1980	Manual
481	VIII	Das-Ay	Southern Leyte	VIII	10	22	14	125	9	51	1958	Present	Manual
482	VIII	Hiraan	Leyte	VIII	11	16	53	124	40	15	1986	Present	Manual
483	VIII	Hirawahan	Samar	VIII	12	25	12	125	1	54	1957	1979	Manual
484	VIII	Jicontrol	Samar	VIII	12	1	35	125	19	22	1959	1975	Manual
485	VIII	Lawigan	Southern Leyte	VIII	10	17	23	125	7	22	1958	Present	Manual
486	VIII	Layug	Leyte	VIII	10	41	34	124	57	35	1984	Present	Manual
487	VIII	Leyte	Leyte	VIII	11	16	59	124	33	43	1985	Present	Manual
488	VIII	Lingayon	Leyte	VIII	11	11	36	124	53	31	1948	Present	Manual
489	VIII	Loom	Eastern Samar	VIII	11	35	44	125	24	9	1986	Present	Manual
490	VIII	Mainit	Leyte	VIII	11	13	21	124	49	30	1949	1980	Manual
491	VIII	Mas-In	Leyte	VIII	11	3	52	124	30	48	1956	1980	Manual
492	VIII	Mawo	Samar	VIII	12	26	30	124	20	20	1968	1976	Manual
493	VIII	Pagbanganan	Leyte	VIII	10	38	18	124	51	51	1984	Present	Manual
494	VIII	Pagsanga-an	Leyte	VIII	11	2	35	124	32	44	1985	Present	Manual
495	VIII	Rizal	Leyte	VIII	11	23	25	124	53	22	1987	Present	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (10/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
496	VIII	Sapiniton	Leyte	VIII	11	18	15	124	49	42	1984	Present	Manual
497	VIII	Tenani	Samar	VIII	11	48	26	125	7	32	1959	Present	Manual
498	VIII	Tubig	Samar	VIII	11	45	41	125	13	53	1984	2002	Manual
499	VIII	Tunga	North Leyte	VIII	11	14	46	124	45	15	1985	1991	Manual
500	IX	Aloran	Misamis Occ.	X	8	25	9	123	48	51	1959	Present	Manual
501	IX	Clarin	Misamis Occ.	X	8	12	52	123	50	3	1984	2000	Manual
502	IX	Dapitan	Zam.Norte	IX	8	32	21	123	28	19	1985	Present	Manual
503	IX	Dinas	Zam.Sur	IX	7	38	52	123	21	24	1985	Present	Manual
504	IX	Dipolo	Zam.Norte	IX	8	6	52	123	23	53	1951	1970	Manual
505	IX	Disacan	Zam.Norte	IX	8	28	50	123	2	49	1959	Present	Manual
506	IX	Ingin	Zam.Norte	IX	8	11	23	122	58	49	1985	Present	Manual
507	IX	Jimenez	Misamis Occ.	X	8	19	59	123	49	33	1956	Present	Manual
508	IX	Kabasalan	Zam.Sur	IX	7	49	57	122	46	37	1986	Present	Manual
509	IX	Kumalarang	Zam.Sur	IX	7	47	4	123	10	39	1984	Present	Manual
510	IX	Labangan	Zam.Sur	IX	7	54	45	123	21	39	1950	Present	Manual
511	IX	Labo	Misamis Occ.	X	8	9	57	123	48	9	1959	2000	Manual
512	IX	Langaran	Misamis Occ.	X	8	36	6	123	40	58	1959	Present	Manual
513	IX	Layawan	Zam.Norte	IX	8	30	4	123	21	15	1959	Present	Manual
514	IX	Layawan	Misamis Occ.	X	8	28	0	123	47	0	1949	1978	Manual
518	IX	Mercedes	Zam.Sur	IX	6	58	50	122	7	50	1961	Present	Manual
519	IX	Paca	Misamis Occ.	X	8	13	14	123	50	0	1959	1977	Manual
520	IX	Pines	Misamis Occ.	X	8	26	52	123	47	59	1959	Present	Manual
521	IX	Salug-Daku	Zam.Sur	IX	8	9	19	123	26	11	1950	Present	Manual
522	IX	Sibuguey	Zam.Sur	IX	7	38	53	122	55	42	1984	Present	Manual
523	IX	Sindangan	Zam.Norte	IX	8	13	13	123	3	13	1984	Present	Manual
524	IX	Tukuran	Zam.Sur	IX	7	52	41	123	35	57	1985	Present	Manual
525	X	Adgaoan	Agusan del Sur	XIII	8	14	55	125	45	8	1967	1970	Manual
526	X	Agusan	Davao	XI	7	49	58	126	3	0	1958	Present	Manual
527	X	Agusan	Bukidnon	X	8	21	35	124	48	23	1986	Present	Manual
528	X	Agusan	Agusan del Nort	XIII	8	56	56	125	32	40	1957	Present	Manual
529	X	Agusan	Agusan del Sur	XIII	7	59	20	126	1	59	1955	Present	Manual
530	X	Agusan	Davao	XI	7	30	33	126	6	18	1967	1985	Manual
531	X	Agusan	Davao	XI	7	50	0	126	3	0	1981	1986	Manual
532	X	Agusan	Agusan del Sur	XIII	8	32	4	125	46	31	1955	1980	Manual
533	X	Agusan	Agusan del Sur	XIII	8	0	38	125	58	10	1955	1970	Manual
534	X	Alubijid	Misamis Ori.	X	8	34	13	124	28	36	1950	Present	Manual
535	X	Andanan	Agusan del Sur	XIII	8	44	0	123	43	0	1967	1987	Manual
536	X	Asiga	Agusan del Nort	XIII	9	14	45	125	33	39	1986	Present	Manual
537	X	Balatukan	Misamis Ori.	X	8	47	10	124	48	53	1968	1970	Manual
538	X	Bunawan	Agusan del Sur	XIII	-	-	-	-	-	-	1982	1986	Manual
539	X	Busilao	Agusan del Sur	XIII	8	38	48	125	34	15	1967	1970	Manual
540	X	Cabadbaran	Agusan del Nort	XIII	9	7	38	125	32	18	1986	Present	Manual
541	X	Cabulig	Misamis Ori.	X	8	39	21	124	44	51	1986	Present	Manual
542	X	Cagayan	Misamis Ori.	X	8	23	19	124	36	46	1954	Present	Manual
543	X	Gibong	Agusan del Sur	XIII	8	36	40	125	54	46	1965	1975	Manual
544	X	Guihao-An	Agusan del Nort	XIII	8	58	15	125	23	56	1986	Present	Manual
545	X	Hinatuan	Surigao del Sur	XIII	8	25	18	126	11	58	2002	Present	Manual
546	X	Ihaoan	Agusan del Sur	XIII	8	6	15	125	52	15	1967	1968	Manual
547	X	Iponan	Misamis Ori.	X	8	26	26	124	34	8	2001	Present	Manual
548	X	Iponan	Misamis Ori.	X	8	28	42	124	20	0	1957	1978	Manual
549	X	Kalinawan	Agusan del Nort	XIII	9	21	4	125	32	0	1968	1979	Manual
550	X	Kasilayan	Agusan del Sur	XIII	8	27	12	125	42	58	1968	1969	Manual
551	X	Kayawan	Agusan del Sur	XIII	8	14	56	125	42	59	1967	1980	Manual
552	X	Maasam	Agusan del Sur	XIII	8	30	54	125	42	30	-	-	Manual
553	X	Maigo	Lanao Norte	X	8	8	38	123	57	14	1986	Present	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (11/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
554	X	Mandulog	Lanao Norte	X	8	15	27	124	15	57	1986	Present	Manual
555	X	Maranding	Lanao Norte	X	7	55	14	123	46	15	1986	Present	Manual
556	X	Mayag	Surigao	XIII	9	32	45	125	29	35	1952	1980	Manual
557	X	Ojot	Agusan del Sur	XIII	8	41	0	125	31	30	-	-	-
558	X	Panusugan	Agusan del Sur	XIII	8	9	47	126	0	30	1967	1968	Manual
559	X	Sanghan	Agusan del Nort	XIII	9	5	27	125	34	30	1950	1970	Manual
560	X	Simulao	Agusan del Sur	XIII	8	10	33	125	59	32	1981	Present	Manual
561	X	Simulao	Agusan del Sur	XIII	8	1	13	126	9	18	1983	Present	Manual
562	X	Sonkoy	Surigao del Nort	XIII	9	32	25	125	34	18	1955	1980	Manual
563	X	Surigao	Surigao del Nort	XIII	9	43	50	125	29	45	1957	Present	Manual
564	X	Tagoloan	Misamis Ori.	X	8	32	2	124	47	45	1960	1980	Manual
565	X	Tagpaco	Misamis Ori.	X	8	49	45	125	10	42	1991	Present	Manual
566	X	Taguibo	Agusan del Nort	XIII	8	59	1	125	36	43	1991	1998	Manual
567	X	Wawa	Agusan del Sur	XIII	8	47	50	125	42	0	1957	2000	Manual
568	X	Wawa	Agusan del Sur	XIII	8	40	4	125	43	0	1981	1987	Manual
569	XI	Bacuag	Surigao del Nort	XIII	9	37	0	125	37	0	1952	1979	Manual
570	XI	Balatukan	Davao del Sur	XI	6	41	56	125	11	7	1984	Present	Manual
571	XI	Bitanagan	Davao Oriental	XI	7	57	48	126	17	38	1985	Present	Manual
572	XI	Boya-An	Surigao del Nort	XIII	9	14	12	126	0	0	1956	1976	Manual
573	XI	Buayan	South Cot.	XII	6	18	50	125	15	55	1957	Present	Manual
574	XI	Carac-An	Surigao del Nort	XIII	9	14	25	125	56	10	1950	1970	Manual
575	XI	Caraga	Davao Oriental	XI	7	20	50	126	30	23	1964	1969	Manual
576	XI	Casauman	Davao Oriental	XI	7	10	32	126	30	15	1985	2001	Manual
577	XI	Cateel	Davao	XI	7	45	22	126	22	18	1958	1970	Manual
578	XI	Cebulan	Davao del Sur	XI	6	55	45	125	28	0	1986	Present	Manual
579	XI	Clinan	South Cot.	XII	6	8	15	125	11	19	1950	1975	Manual
580	XI	Culaman	Davao del Sur	XI	6	24	40	125	36	55	1986	1989	Manual
581	XI	Davao	Davao del Sur	XI	7	5	38	125	35	55	1984	Present	Manual
582	XI	Digos	Davao del Sur	XI	6	45	46	125	21	18	1985	Present	Manual
583	XI	Glan	South Cot.	XI	5	49	28	125	12	42	1984	Present	Manual
584	XI	Hijo	Davao	XI	7	23	55	125	50	6	1951	Present	Manual
585	XI	Kipalico	Davao	XI	7	36	9	125	40	51	1986	Present	Manual
586	XI	Lais	Davao del Sur	XI	6	18	36	125	37	36	1986	1989	Manual
587	XI	Lasang	Davao	XI	7	19	28	125	32	2	1985	1989	Manual
588	XI	Lipadas	Davao del Sur	XI	7	0	18	125	29	4	1986	Present	Manual
589	XI	Lun Masla	South Cot.	XII	6	1	34	125	17	30	1986	1988	Manual
590	XI	Lun Padidu	South Cot.	XII	6	2	33	125	17	12	1984	Present	Manual
591	XI	Mal	Davao	XI	6	41	30	125	14	42	1956	1978	Manual
592	XI	Maribulan	South Cot.	XII	6	7	0	125	14	34	1985	Present	Manual
593	XI	Matiao	Davao	XI	7	6	24	125	54	41	1985	Present	Manual
594	XI	Matina	Davao	XI	7	7	16	125	32	21	1959	1978	Manual
595	XI	Padada	Davao	XI	6	40	0	125	17	0	1949	1978	Manual
596	XI	Quinonoan	Davao Oriental	XI	7	5	40	126	27	54	1986	Present	Manual
597	XI	Seguil	South Cot.	XII	5	57	38	125	5	42	1988	Present	Manual
598	XI	Sibulan	Davao del Sur	XI	6	58	5	125	22	40	1955	1978	Manual
599	XI	Silway	South Cot.	XII	6	11	47	125	5	18	1956	Present	Manual
600	XI	Tago	Surigao del Sur	XIII	9	0	50	126	4	0	1959	1972	Manual
601	XI	Tagum	Davao	XI	7	28	0	125	45	0	1949	1969	Recorder
602	XI	Talomo	Davao del Sur	XI	7	8	2	125	28	50	1985	Present	Manual
603	XI	Tuganay	Davao	XI	7	22	10	125	43	10	1985	Present	Manual
604	XII	Agus	Lanao del Norte	X	8	7	3	124	13	8	1981	1985	Manual
605	XII	Alip	Maguindanao	ARMM	6	45	2	124	50	11	1955	Present	Manual
606	XII	Allah	Sultan Kudarat	XII	6	31	30	124	36	5	1951	1994	Manual
607	XII	Allah	Maguindanao	ARMM	6	40	45	124	32	50	1959	1976	Manual
608	XII	Banga	Cotabato	XII	6	26	45	124	45	43	1959	1995	Manual

Appendix 3-2 List of Streamline Stations Operated by BRS (12/12)

ID	WRR	River	Province	Region	Latitude			Longitude			Start	Last	Type
609	XII	Binay	Cotabato	XII	7	9	4	125	3	16	1988	1992	Manual
610	XII	Buluan	Maguindanao	ARMM	6	43	14	124	47	45	1970	Present	Manual
611	XII	Dansalan	Maguindanao	ARMM	6	54	53	124	32	27	1955	1994	Manual
612	XII	Kabacan	Cotabato	XII	7	7	30	125	3	20	1993	Present	Manual
613	XII	Kabakan	Cotabato	XII	7	6	32	124	52	39	1955	1970	Manual
614	XII	Kalaong	South Cot.	XII	6	4	3	124	27	46	1986	Present	Manual
615	XII	Kapingkong	Sultan Kudarat	XII	6	40	11	124	37	38	1989	Present	Manual
616	XII	Kapingkong	Cotabato	XII	6	40	42	124	37	20	1968	1976	Manual
617	XII	Kraan	Sultan Kudarat	XII	6	7	32	124	19	30	1986	1988	Manual
618	XII	Kulaman	Bukidnon	X	7	49	0	125	1	0	1968	1973	Manual
619	XII	Lake Sebu	South Cot.	XII	6	13	5	124	42	20	1980	1984	Manual
620	XII	Libungan	Cotabato	XII	7	14	38	124	32	45	1950	Present	Manual
621	XII	Loel	South Cot.	XII	6	12	38	124	42	3	1980	Present	Manual
622	XII	Lonon	South Cot.	XII	6	14	31	124	43	52	1966	Present	Manual
623	XII	Maganoy	Maguindanao	ARMM	-	-	-	-	-	-	1981	1985	Manual
624	XII	Maganoy	Maguindanao	ARMM	-	-	-	-	-	-	1981	1984	Manual
625	XII	Maigo	Lanao del Norte	X	8	9	7	123	57	0	1951	1970	Recorder
626	XII	Maitum	South Cot.	XII	6	2	52	124	29	23	1987	Present	Manual
627	XII	Makabasa	Cotabato	XII	7	26	16	124	30	54	1986	Present	Manual
628	XII	Malasila	Cotabato	XII	6	50	45	124	54	10	1952	1973	Manual
629	XII	Malitubog	South Cot.	XII	-	-	-	-	-	-	1983	1985	Manual
630	XII	Mandulog	Lanao del Norte	X	8	15	32	124	16	16	1959	1978	Manual
631	XII	Manupali	Bukidnon	X	7	58	15	125	8	10	1968	1978	Manual
632	XII	Maranding	Lanao del Norte	X	7	54	10	123	47	53	1951	1970	Manual
633	XII	Marbel	Cotabato	XII	6	24	26	124	54	28	1950	1977	Manual
634	XII	Maridagao	Cotabato	XII	7	9	0	124	42	0	1959	1973	Manual
635	XII	Mindanao	Maguindanao	ARMM	7	13	45	124	15	13	1965	Present	Manual
636	XII	Mindanao	Maguindanao	ARMM	7	1	59	124	29	57	1959	1973	Manual
637	XII	M'Lang	Cotabato	XII	6	56	18	124	55	31	1952	1975	Manual
638	XII	Muleta	Bukidnon	X	7	26	12	124	52	36	1967	Present	Manual
639	XII	Nica-an	Cotabato	XII	7	19	44	124	34	0	1988	Present	Manual
640	XII	Nituan	Maguindanao	ARMM	7	22	2	124	16	15	1986	Present	Manual
641	XII	Pulangui	Cotabato	XII	7	8	43	124	48	7	1959	Present	Manual
642	XII	Pulangui	Bukidnon	X	7	54	20	125	5	35	1964	1985	Manual
643	XII	Pulangui	Cotabato	XII	7	3	9	124	42	27	1955	1990	Manual
644	XII	Rio Grande de Mindanao	Maguindanao	ARMM	7	1	0	124	29	0	1981	1985	Manual
645	XII	Sagomata (s-3)	Bukidnon	X	7	55	28	124	56	50	1967	1973	Manual
646	XII	Saguing	Cotabato	XII	6	59	38	125	4	47	1955	Present	Manual
647	XII	Sawaga	Bukidnon	X	8	2	16	125	9	15	1956	Present	Manual
648	XII	Simuay	Cotabato	XII	7	17	18	124	17	55	1969	Present	Manual
649	XII	Taganibong (s-1)	Bukidnon	X	7	52	33	125	2	7	1967	1969	Manual
650	XII	Taganibong (s-2)	Bukidnon	X	7	54	32	124	58	32	-	-	-
651	XII	Tamontaka	Maguindanao	ARMM	7	10	58	124	13	16	1969	Present	Manual
652	XII	Tamontaka	Maguindanao	ARMM	7	11	45	124	13	40	1969	1972	Manual

Appendix 3-3 List of Tide Stations

No.	Station Name	Province	Region	Type	Latitude			Longitude			Start	Last
1	Manira South Harbor	Metro Manila	NCR	Primary	14	35	0	120	58	0	1947	2002
2	Cebu Port	Cebu	VII	Primary	10	18	0	123	55	0	1947	2003
3	Davao Gulf, Davao	Davao del Sur	XI	Primary	7	5	0	125	38	0	1948	1997
4	Legaspi Port	Albay	V	Primary	13	9	0	123	45	0	1947	2003
5	San Fernando Harbor	La Union	I	Primary	16	37	0	120	18	0	1988	2003
6	Srigao Port, Surigao	Surigao del Norte	XIII	Primary	9	47	0	125	30	0	1987	2003
7	San Jose	Occ. Mindoro	IV-A	Primary	12	20	0	121	5	0	1987	2003
8	Port Irene	Cagayan	II	Primary	18	23	0	122	6	0	1987	2003
9	Puerto Princesa	Palawan	IV-B	Primary	9	45	0	118	44	0	1990	2003
10	Real Port	Quezon	IV-A	Primary	14	40	0	121	37	0	1995	2003
11	Jolo Port, Sulu	Sulu	ARMM	Secondary	6	4	0	121	0	0	1947	1996
12	Tacloban Port	Leyte	VIII	Secondary	11	15	0	125	0	0	-	-
13	San Vicente	Cagayan	II	Secondary	18	31	0	122	8	0	-	-
14	Batangas Bay	Batangas	IV-A	Secondary	13	46	0	120	58	0	-	-
15	Dumaguete Port	Negros Ori.	VII	Secondary	9	18	0	123	18	0	-	-
16	Macabalan Port	Misamis Ori.	X	Secondary	8	30	0	124	40	0	-	-
17	Iligan Bay	Misamis Ori.	X	Secondary	8	13	0	124	13	0	-	-
18	Banago	Negros Occ.	IV-A	Secondary	10	42	0	122	56	0	-	-
19	Port Batan	Aklan	VI	Secondary	11	35	0	122	30	0	-	-
20	Bislig Bay	Surigao del Sur	XIII	Secondary	8	12	0	126	22	0	-	-
21	Virac	Catanduanes	V	Secondary	13	35	0	124	14	0	-	-
22	Currimao	Ilocos Norte	I	Secondary	17	59	0	120	29	0	-	-
23	Penascosa	Palawan	IV-B	Secondary	9	46	0	118	31	0	-	-
24	Laoang	Samar	VIII	Secondary	12	35	0	125	0	0	-	-
25	Iloilo Port	Iloilo	VI	Secondary	10	42	0	122	35	0	-	-
26	Ormoc	Leyte	VIII	Secondary	11	0	0	124	36	0	-	-
27	Balabac	Palawan	IV-B	Secondary	8	0	0	117	4	0	-	-
28	Ozamiz Port	Misamis Occ.	X	Secondary	8	8	0	123	51	0	-	-
29	Tagbilaran City	Bohol	VII	Secondary	9	39	0	123	51	0	-	-
30	Solvec	Ilocos Sur	I	Secondary	17	27	0	120	27	0	-	-
31	Manira North Harbor	Metro Manila	NCR	Secondary	14	36	0	120	57	0	-	-
32	San Narciso	Quezon	IV-A	Secondary	13	35	0	122	34	0	-	-
33	Catanauan	Quezon	IV-A	Secondary	13	34	0	122	19	0	-	-
34	Navotas Port	Metro Manila	NCR	Secondary	14	41	0	120	56	0	-	-
35	Baler	Aurora	IV-A	Secondary	15	45	0	121	35	0	-	-
36	Basco	Batanes	II	Secondary	20	27	0	121	58	0	-	-
37	Claveria	Cagayan	II	Secondary	18	36	0	121	4	0	-	-
38	Palanan	Isabela	II	Secondary	17	7	0	122	28	0	-	-
39	Pagasa Island	Palawan	IV-B	Secondary	11	2	0	114	17	0	-	-
40	Subic Bay	Zambales	III	Secondary	14	49	0	120	17	0	-	-
41	Limay	Bataan	III	Secondary	14	30	0	120	36	0	-	-
42	Matnog	Sorsogon	V	Secondary	12	35	0	124	5	0	-	-
43	Zamboanga City	Zamboanga del sur	IX	Secondary	6	55	0	122	4	0	-	-
44	Maker, General Santos	South Cotabato	XII	Secondary	6	10	0	125	0	0	-	-

Assessment of Data Availability of Maps, Digital and Hardcopy and other Databases

Physical Conditions Data

		Coverage	*Source*	*Scale*	*Year*	*Format*	*Coordinate System*	*Note*
Base Map								
	Topographic Map 1:1,500,000 Series	Philippines	NAMRIA	1:1,500,000	1954	Hardcopy/Digital	GCS	The 1:1,500,000 map covering the Philippines was originally compiled by the Philippine Coast & Geodetic Survey in 1954 with some locations updated from 1987 to 1997. The map is published by NAMRIA in paper form and covers the entire country in one sheet.
	Topographic Map 1:1,250,000 Series	Philippines	NAMRIA	1:250,000	1954	Hardcopy/Digital	GCS	The 1:250,000 map covering the Philippines was produced in 1954 with information from the Philippine Coast & Geodetic Survey, Army Map Service Corps of Engineers and the US Coast & Geodetic Survey. The 1:250,000 series of maps are published by NAMRIA and consists of 55 sheets. Contours are at 100 m intervals. These maps have already been digitized and is being used by Phivolcs for disaster related activities.
	Topographic Map - 711 Series	Philippines	NAMRIA	1:50,000	1947 to 1953	Hardcopy	GCS	The 711 series of maps were originally published by the US Army Service and compiled from aerial photographs taken in 1947 to 1953. Contours are at 20 m intervals. The total number of sheets for the 711 series is 842.
	Topographic Map - 701 Series	Luzon	NAMRIA	1:50,000	1976 to 1979	Hardcopy	GCS	The 701 series maps published by NAMRIA covers most of Luzon and replaces the 711 series of maps covering the area.The maps were produced using aerial photography taken fom 1976 to 1979. The total number of sheets for the 701 series is 151.
	Topographic Map - NTMS Series	Selected Areas	NAMRIA	1:50,000	1988	Hardcopy	GCS	The National Topographic Mapping Series (NTMS) series of maps will eventually replace the S701 and S711 maps. The Philippines will be eventually covered in 672 sheets.The series is currently being updated and presently, about 79 sheets are available. Production of the NTMS started in 1988.
	SEDIP-SME Topographic Maps	Selected Provinces (Reref to SEDIP-SME list for information on covered provinces)	DepEd	1:50,000	2003	Shapefile	PTM	The SEDIP-SME topographic maps were produced in 2003 for the Secondary Education Development and Improvement Project - School Mapping Exercise (SEDIP-SME) to support the GIS analysis requirements of the project. The maps were initially digitized from the NAMRIA 1:50,000 maps and updated with data gathered from DPWH, SPOT 20m multispectral Imagery and GPS survey
	Topographic Map - 1:10,000 Series	Metro Manila	NAMRIA	1:10,000	1982	Hardcopy/Digital	GCS	The 1:10,000 scale maps were produced as a joint project between NAMRIA and the Japan International Cooperation Agency (JICA) based on aerial photography taken in 1982. Digital version of this data are also available.
	Digital Elevation Model	Philippines	USGS	1 Km Resolution		Digital		This Digital Elevation model is free downloadable from USGS.
	Maps at National Irrigation Authority	Selected Areas	NIA	Detailed Topo 1:1000 to 1:4000 with 0.25 to 1.0 m contours		Mostly Analogue		NIA is tasked with the development, construction, monitoring and maintenance of all irrigation systems throughout the country. The total land area now under irrigation is 1,338,800 ha of which 678,500 ha falls under the National Irrigation System (NIS), while 486,100 ha under the Communal Irrigation System (CIS) and the remaining 174,200 ha is under Private Pump Irrigation System. The potential irrigable area of the country is estimated at 3,128,000 ha hence there is still about 1,789,200 ha or 57.2% of the country's total irrigable area to be developed. The topographic maps at NIA were compiled at a large scale and can be a significant source of topographic information for disaster management. Most of the data are still in analogue format, converting these data to digital format can make the data useful in GIS analyses.
				Dam Site Topo 1:400 to 1:500 with 0.1 to 1.0 m contours		Mostly Analogue		
				Reservoir Topo maps 1:4000 to 1:10000 with 2.0 to 10.0 m contours		Mostly Analogue		
	MMEIRS Topographic Map	Metro Manila	MMEIRS	1:5,000	2003	Hardcopy/Digital	PTM III	The MMEIRS topographic map was produced to support the GIS analyses requirements of the Earthquake Impact Reduction Study for Metro Manila (MMIERS). The maps were based on aerial photography taken in 2003.

Land Cover Map / Land Use								
	SEDIP-SME Land Cover Maps	Selected Provinces (Reref to SEDIP-SME list for information on covered provinces)	DepEd	1:50,000	1998-2000	Shapefile	PTM	Land cover was interpreted from SPOT 20m multispectral imagery. The land cover maps were produced as part of the Secondary Education Development and Improvement Project - School Mapping Exercise (SEDIP-SME)
	Mapping of the Natural Conditions of the Philippines	Phillippines	NAMRIA	1:250,000	1987-1988	Hardcopy	GCS	The Land Cover Maps were produced using SPOT satellite images taken in 1987-1988. Thes maps were outputs of the project, "Mapping the Natural Conditions of the Philippines" which was funded by the World Bank and the Swedish Space Corporation. Given emphasis on these maps are forests, extensive and intensive land use, coastal areas covering approximately 300,000 sq km of land area. Supporting statistics are also available. Topographic maps at 1:250,000 scale were used as base maps

Assessment of Data Availability of Maps, Digital and Hardcopy and other Databases

		Coverage	Source	Scale	Year	Format	Coordinate System	Note
	Land Use and Forest Type Maps	Luzon & Visayas	NAMRIA	1:100,000	1994	Hardcopy	GCS	Land Use and Forest Type maps give emphasis on the type of forest such as old-growth,mossy, residual, sub-marginal, pine and mangrove, usage of land such as brush reproduction, coconut, plantation, grass lands, agriculture, bare/rocky and built up area. Statistics supporting classification in contained in a book called Forest Register.These maps were the results of "Wide Area Tropical Resource Survey (FY1994) which was carried out by the Japan Forest Technical Association). These were based on Landsat TM data of 1993 selected from image scenes with least cloud cover. Topographic scale 1:100,000 were used as base maps.
	MMEIRS Land Use Map	NCR	MMEIRS	1:5,000	2003	Shapefile	PTM III	Based on 2003 aerial photo and field verification, these were produced under the MMEIRS project in cooperation with NAMRIA. It contains detailed classification of residential areas considering density and number of storeys of house and building structures.
Geology								
	Geology	Philippines	Mines & Geosciences Bureau	1:50,000				
	Geological Formations	NCR	Phivolcs/MMEIRS		2000	Shapefile	PTM III	

Socio-economic Data

		Coverage	Source	Scale	Year	Format	Coordinate System	Note
Population and Housing								
	Population Data	Philippines	NSO	n.a.	1980, 1990, 1995 and 2000	Shapefile	GCS	Population data for the whole country is available from the National Statistics Office (NSO). These data can be exgtracted from the Data Kit of Official Philippine Statistics (DATOS), which is being distributed by NSO for a fee. DATOS is a collection of statistics for each region, province, city municipality, and barangay in the country. The data on total population presented in DATOS are the official census figures for the 1980, 1990, and the 2000 Census of Population and Housing as well as the 1995 Population Census.
	Building Inventory	Philippines	NSO	n.a.	2000	Public Use File (Text)	n.a.	Data on individual building counts per barangay can be obtained from NSO in the form of Public Use File (PUF). The PUF is a text file containing raw data such as outer wall and roof material, construction year, state of repair and approximate roof area for each building included in the 2000 Census on Population and Housing. The census on housing is complete enumeration of all housing units wether occupied or vacant at the time of the census.
Administrative Boundaries								
	National, Regional and Provincial	Philippines	NSO		2000	Shapefile	GCS	Boundary data for the whole country is available from the National Statistics Office (NSO). These data can be found in the Data Kit of Official Philippine Statistics (DATOS), which is being distributed by NSO for a fee. DATOS is a collection of statistics for each region, province, city/municipality, and barangay in the country. The boundary data were digitized based on sketches,prepared by survey enumerators in the field thereby making it difficult to judge the accuracy and scale at which the maps were prepared. The data was digitized by NSO with technical assistance provided by NAMRIA.
		Philippines	DPWH	1:250,000	2003	Shapefile	GCS	DPWH believes that all Administrative data were digitized from NAMRIA base mapping in the early 1990's from 1:250,000 series maps. DPWH has made minor modifications to municipalities and cities boundaries. DPWH has also generated Congressional District, Provincial and Regional Boundaries based on the constituent municipalities and cities. It is believed that the Congressional District, Provincial and Regional Boundaries are correct as of January 2003 (assuming the accuracy of the municipalities and cities). There are 1606 municipalities/cities in the DPWH layers, although National Census data year 2000 indicates there may be 1609, however the remaining 3 cannot be identified from known sources. It is also believed that the Municipal/City boundaries in the vicinity of Lake Lanao in Mindanao are highly inaccurate, maybe as much as 4 km out from the National Road Network.
	Regional	NCR	MMEIRS	1:5,000	2000	Shapefile	PTM III	Boundaries originally provided by MMDA and editted to match NSO 2000 boundaries
		NCR	MMEIRS	1:5,000	2003	AutoCAD 2000 / Shapefile	PTM III	Boundaries were digitized based on data gathered from individual LGU's
	City/Municipal	Philippines	NSO		2000	Shapefile	GCS	Same note as National, Regional and Provincial Boundaries from NSO.
		NCR	MMEIRS	1:5,000	2000	Shapefile	PTM III	Boundaries originally provided by MMDA and edditted to matched NSO 2000 boundaries
		NCR	MMEIRS	1:5,000	2003	AutoCAD 2000 / Shapefile	PTM III	Boundaries were digitized based on data gathered from individual LGU's
		Cabanatuan City	Certeza/SRDP Consulting Inc.	1:2,000	2002	AutoCAD 2000 / Autodesk World	PTM III	Boundaries were provided by the City Planning & Development Office of the LGU.
		Balanga City	Certeza/SRDP Consulting Inc.	1:2,000	2002	AutoCAD 2000 / Shapefile	PTM III	Boundaries were digitized based on Tax Maps provided by the City Assessor's Office.
		Angono Municipality	Certeza/SRDP Consulting Inc.	1:2,000	2003	AutoCAD 2000 / Shapefile	PTM III	Boundaries were digitized based on Tax Maps provided by the Municipality of Angono.
	Barangay	Philippines	NSO		2000	Shapefile	GCS	Same note as National, Regional and Provincial Boundaries from NSO.
		Cabanatuan City	Certeza/SRDP Consulting Inc.	1:2,000	2002	AutoCAD 2000 / Autodesk World	PTM III	Boundaries were provided by the City Planning & Development Office of the LGU.
		Balanga City	Certeza/SRDP Consulting Inc.	1:2,000	2002	AutoCAD 2000 / Shapefile	PTM III	Boundaries were digitized based on Tax Maps provided by the City Assessor's Office.
		Angono Municipality	Certeza/SRDP Consulting Inc.	1:2,000	2003	AutoCAD 2000 / Shapefile	PTM III	Boundaries were digitized based on Tax Maps provided by the Municipality of Angono.

Assessment of Data Availability of Maps, Digital and Hardcopy and other Databases

			Coverage	Source	Scale	Year	Format	Coordinate System	Note
Public Facilities									
		Hospitals	Philippines	DOH,NAMRIA	+/- 5m accuracy	2003	GIS	GCS	The DOH with the assistance of NAMRIA, mapped all the Regional Health Units (RHU), hospitals and municipal health centers throughout the Philippines as part of the Women's Health & Safe Motherhood Project. Attributes such as facilities available and personnel were also captured for each RHU, hospital, and municipal health center.
		Basic Education Information System (BEIS)	Philippines	DepEd	n.a.	2003	Excel File	n.a.	The BEIS contains a listing of all public elementary and high schools in the Philippines. The list is compiled and maintained by the Research and Statistics Office of the Department of Education Central Office. Attribute information about each school such as number of students, teachers and other school related data are included. It is updated yearly from information gathered from each school by DepEd Regional Offices.
		Public Elementary & High Schools	NCR	MMEIRS	1:5,000	2003	Shapefile	PTM	Locations of Public Elementary and high schools were plotted as part of the MMEIRS project. Schools were assigned codes compatible with the codes used by DepED's BEIS database. This would facilitate linking of school locations with BEIS.
		Public Elementary & High Schools	Selected Provinces	DepEd	1:50,000	2003	Shapefile	GCS	Locations of Public Elementary and high schools were plotted as part of the DepEd's SEDIP-SME project. Schools were assigned codes compatible with the codes used by DepED's BEIS database. This would facilitate linking of school locations with BEIS. In addition, pictures, school site development plans and other schools documents are also available. These data are summarized in an application called "Geographic Database of Secondary Schools" which was developed as part of the project.
Infrastructure									
		National Road Network	Philippines	DPWH	+/-10m accuracy	2000 to 2002	Shapefile	GCS	National Road Data was collected using vehicle-mounted GPS with differential post-processing. It is believed that this data is accurate to +/-10 meters. The vast majority of this data was collected in year 2000, but the network in Regions IX and XII were collected in late 2002. Some "gap" sections remain (due to impassable roads, failed bridges at the time of survey). DPWH has processes and procedures in place to maintain this data, therefore updates will be available in future, probably on an annual basis.
		Provincial Road Network	Phillippines	DPWH	1:250,00	1954	Shapefile	GCS	Provincial Roads were digitized from NAMRIA base mapping in the early 1990's from the DPWH believe, 1:250,000 series maps. DPWH has made no attempt to reconcile this data with the (National Road Network). It is known that some roads in this provincial layer have now been converted to National jurisdiction, therefore they should be deleted from this layer. DPWH may clean this layer in future, however it is not a high priority at present.
		Bridges	Philippines	DPWH	n.a.	1995	Database	n.a.	The DPWH conducted an inventory of all Bridges throughout the Philippines under the "Nationwide Bridge Inspection Project". This is a part of an umbrella project called "Rehabilitation and Maintenance of Bridges along Arterial Roads". Attributes of bridges such as type and dimensions of bridges are included in the database.
General Hazard Data									
	Maps at the Bureau of Soils and Water Management (BSWM) of the Department of Agrarian Reform	Soil Map		BSWM	Scale is usually 1:50,000 or 1:250,000				Bureau of Soils and Water Management (BSWM) of the Department of Agriculture is the main producer of agricultural related thematic maps in the country and the range of BWSM's map products are generated based on NAMRIA's topographic base maps of 1:50,000 and 1:250,000. They are mainly in analogue format and some in digital format
		Land Factor Maps							
		Hydro-Ecological Zone							
		Pedo-Ecological Zone							
		Land Management Unit							
		Elevation							
		Slope							
		Flooding							
		Geomorphological							
		Land Use and Vegetation Maps							
		Decision Maps							
		SAFDZ maps							
		Networks of Protected Areas for Agriculture							
		Key Production Areas							
		Crop Based Cropping System							
		Crop Development Zone							
		Prime Land							
		Land Use Opportunity							
		Land Degradation							
		Land Limitation							
		Land Limitation & Use Efficiency							
		Agro-Socio-Economic Map							
		Geographic Flow Map							
		Socio-Institutional & Support Services							
		Geology	Philippines	Mines & Geosciences Bureau	1:50,000				
		Geological Formations	NCR	Phivolcs/MMEIRS		2000	Shapefile	PTM III	
		SEDIP-SME Soil Erosion Classification	Selected Provinces	BSWM/DepEd		1950's	Shapefile	PTM	Digitized from BSWM Erosion Maps
	Earthquake								
		Trench Map	Phivolcs	Philippines	1:250,000	2000	Shapefile	GCS	

Assessment of Data Availability of Maps, Digital and Hardcopy and other Databases

		Coverage	Source	Scale	Year	Format	Coordinate System	Note
	Fault Map	Phivolcs	Philippines	1:250,000	2000	Shapefile	GCS	
	Liquefaction Potential	NCR	MMEIRS	1:5,000	2003	Shapefile	PTM III	These hazard maps were prepared as part of the Eathquake Impact Reduction study for
	Slope Stability	NCR	MMEIRS	1:5,000	2003	Shapefile	PTM III	Metropolitan Manila conducted by JICA in cooperation with MMDA and PHIVOLCS
	Peak Ground Acceleration	NCR	MMEIRS	1:5,000	2003	Shapefile	PTM III	
Volcano								
	Volcano Locations/Classifications	Phivolcs	Philippines	1:50,000	2000	Shapefile	GCS	
	Volcano Hazard Maps	Phivolcs	Most Active Volcanoes	Varies	Varies	Digital	GCS	

Note 1. Provinces covered in SEDIP-SME Maps

Ifugao,CAR
Benguet,CAR
Antique, R6
Guimaras, R6
Agusan del Sur, CARAGA
Surigao del Sur, CARAGA
Romblon, R4
Masbate, R5
Negros Oriental, R7
Biliran, R8
Leyte, R8
Southern Leyte, R8
Zamboanga del Sur, R9
North Cotabato, R12

2. Many LGU's in the Philippines other that those mentioned in the list have, on their own, initiated the preparation of base maps of their respective areas. This is based usually on aerial photography or satelite imagery. Scale used ranges from 1:2000 to 1:25,000. The LGU's in the list were mentioned to illustrate the typical amount of detail that can be found in this maps.

3. Specific areas of the Philippines have also been covered by large scale mapping on a per project basis.

Abreviations

Government Agencies

DepEd	Department of Education
DPWH	Department of Public Works and Highways
MMDA	Metropolitan Manila Development Authority
NAMRIA	National Mapping Resources Information Agency
NSO	National Statistics Office
PHIVOLCS	Philippine Institute of Volcanology and Seismology

Project Names

BEIS	Basic Education and Information System
MMEIRS	Earthquake Impact Reduction Study for Metropolitan Manila
SEDIP-SME	Secondary Education Development and Improvement Project - School Mapping Exercise

Coordinate Systems

GCS	Geographic Coordinate System
PTM	Philippine Transverse Mercator

Appendix 8

The World Bank
National Disaster Coordination Council (NDCC)

Natural Disaster Risk Management in the Philippines
Reducing Vulnerability
Follow-on Study

Questionnaire on Disaster Risk Management

Province: ______________________________

Name of Respondent: ____________________ Sex: ___________________

Agency/Office: ____________________________________

Position: _________________________________

Tel No.: ____________________ Fax No.: ____________________ E-mail: ________________

1. Most Severely Damaging Disasters in Recent Years

1-1 Water Related Disasters

Please fill up the table below with information concerning the most severely damaging water-related disaster that occurred in the province during the period 1990-2004. Please attach detailed damage descriptions and maps of affected area (if any) at the end of this questionnaire.

a) Date		b) River Basin Name	
c) Affected areas		d) Availability of map of affected area ☐Yes ☐No	
e) Type of disaster		☐Flood ☐Flash flood ☐Debris / Mud flow (Sediment) ☐Storm surge ☐Landslide ☐Others (Pls. Specify): ______________________________	
f) Cause of disaster		☐ Extreme typhoon ☐ Tropical depression ☐ Local heavy rains ☐ Insufficient discharge capacity of river channel ☐ Insufficient structural measures	

	☐ Siltation ☐ Deforestation ☐ Improper land use ☐ Illegal structure along the river channel ☐ Delay of evacuation ☐ Others (Pls. specify): ______________________
g) Major damage	☐ People ☐ Houses and buildings ☐ Road ☐ Water supply ☐ Electricity ☐ Agriculture ☐ Fishery including fishpond ☐ Others (Pls. specify): ______________________

1-2 Earthquake Disaster

a) Has the province ever experienced any disastrous damage caused by earthquake since 1970?

☐ Yes ☐ No

If yes, when did the last disastrous earthquake occur? ______________________

b) If yes, what were the secondary causes of damage induced by the last earthquake that occurred?

☐ Building Collapse ☐ Fire ☐ Liquefaction
☐ Crack of ground ☐ Landslide ☐ Tsunami
☐ Others (Pls. specify): ____________________

c) What were the major damages caused by the last earthquake that occurred?

☐ Damage to people ☐ Building ☐ Land subsidence
☐ Crack of ground ☐ Landslide ☐ Road
☐ Water supply ☐ Electricity
☐ Others (Pls. specify): ____________________

1-3 Volcanic Disaster

a) Has the province ever experienced any severe volcanic disaster?

☐ Yes ☐ No

If yes, when did the last disastrous volcanic eruption occur? ____________________

b) If yes, what were the major cause(s) of volcanic disaster in the province?

☐ Pyroclastic flow ☐ Lava flow ☐ Volcanic gas
☐ Volcanic Ash ☐ Lahar
☐ Others (Pls. specify): ____________________

c) What were the major damage(s) caused by the volcanic eruption?

☐ Damage to people ☐ Building ☐ Agriculture
☐ Fisheries ☐ Road ☐ Water supply
☐ Electricity ☐ Others (Pls. specify): ____________________

2. Problems and Directions for Disaster Risk Management

Looking back to the time when the last severely damaging disaster occurred, please answer the following questions about your experiences regarding preparedness and the response measures that you adopted.

2-1 Preparedness

1) Awareness

a) For those who experienced a severely damaging flooding, sedimentation or typhoon:
Are you aware of the fact that the province is flood-prone or sediment-prone or typhoon-prone area? ☐ Yes ☐ No

Do you think that people in the province are aware of the fact that the province is flood-prone or sediment-prone or typhoon-prone area? ☐ Yes ☐ No

b) For those who experienced a severely damaging earthquake:
Are you aware of the fact that the province is one of the most earthquake prone areas of the country? ☐ Yes ☐ No

Do you think that people in the province are aware of the fact that the province is one of the most earthquake prone areas of the country? ☐ Yes ☐ No

c) For those who have experienced a severely damaging volcanic eruption:
Are you aware of the fact that the province is one of the areas of the country, which are most prone to volcanic disaster? ☐ Yes ☐ No

Do you think that people in the province are aware of the fact that the province is one of the areas of the country, which are most prone to volcanic disaster? ☐ Yes ☐ No

2) Preparedness (related to questions 2-1 1):

a) Are there any preparatory measures you have been taking? ☐ Yes ☐ No

b) If Yes, what are these? Please mention 5 major preparatory measures you have been adopting in the province. Please explain briefly each of the measures.

1. ____________________
2. ____________________

3. ____________________
4. ____________________
5. ____________________

c) Do you think that there are constraints to the successful adoption of the <u>existing</u> preparatory measures you mentioned above (item b)? ☐ Yes ☐ No

If Yes, what are these?

____
____
____
____

d) What other preparatory measures do you think are necessary in addition to the ones you mentioned in item b)? Please mention the first five most important ones.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

e) Do you think that there will be constraints to the successful adoption of the <u>additional</u> preparatory measures that you have mentioned in item d)? ☐ Yes ☐ No

If Yes, what are these?

____
____
____
____

2-2 Mitigation Measures (Structural and Non-structural Measures)

a) Are there any existing mitigation measures in the province in times of disaster?

☐ Yes ☐ No

b) If Yes, what are these existing disaster mitigation measures?

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

Example of mitigation measures:

Structural:	*Flood control facilities*
	Sediment and landslide control facilities.
	Strengthening of infrastructure facilities against earthquake
Non-structural:	*Real-time observation stations for rainfall and water level*
	Real-time observation stations for earthquake
	Forecasting and warning system
	Re-forestation
	Land use management for the hazard prone areas

c) Do you think that there are any constraints in the successful adoption of the mitigation measures you mentioned above (item a)? ☐ Yes ☐ No

If Yes, what are these?

____

____

____

____

d) In your idea, what are the necessary actions to improve the existing mitigation measures in the province? Please mention the first five major ones.

1. ____________________________________
2. ____________________________________
3. ____________________________________
4. ____________________________________
5. ____________________________________

2-3 Evacuation

1) When do you usually evacuate people from disaster areas?

☐ Early evacuation (before disaster) ☐ Just before the disaster occurs

☐ During the occurrence of disaster ☐ No evacuation

2) Who determines the evacuation timing? ________________________________

<u>Early Evacuation Before Disaster Happens</u>

a) Is the early evacuation being conducted effectively? ☐ Yes ☐ No

b) If No, what are the reasons why early evacuation could not be conducted effectively? Please mention the 5 most major ones.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

c) What are the measures necessary in order to improve the conduct of early evacuation? Please mention the 5 most major ones.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

d) Generally, are there good communication lines between and among the PDCC, MDCC and BDCC during early evacuation? ☐ Yes ☐ No

e) If No, what are the main reasons for the poor communication lines between and among PDCC, MDCC and BDCC during early evacuation? Please mention the 5 most major reasons.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

2-4 Responses During Disaster Stage (i.e., rescuing victims etc.)

a) Are there constraints to the immediate response during the occurrence of the disaster?

☐ Yes ☐ No

If Yes, what are these constraints? Please mention the 5 most major ones.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

b) What are the actions necessary to improve the immediate response measures during disasters? Please mention the 5 most major ones.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

c) Generally, are there good communication lines between and among the PDCC, MDCC and BDCC during the response stage? ☐ Yes ☐ No

e) If No, what are the main reasons for the poor communication lines between and among PDCC, MDCC and BDCC during the response stage? Please mention the 5 most major reasons.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

2-5 Post-Disaster Stage (Rehabilitation measures such as reconstruction of houses etc.)

a) Are there constraints to the effective implementation of rehabilitation measures during the post-disaster stage? ☐ Yes ☐ No

If Yes, what are these constraints? Please mention the 5 most major ones.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

b) What are the measures necessary in order to improve the implementation of rehabilitation measures? Please mention the 5 most major ones.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

3. Data and Hazard Map Requirement for Disaster Risk Management

In order to facilitate the improvement of disaster risk management, data requirement and hazard map requirement are likewise given focus in this study. Please answer the following questions based on your knowledge about the present status of disaster risk management in the province.

3-1 Data Requirements

1) Availability of Baseline Information

- ☐ Topographic maps: Scale:__________ , Year __________
  Scale:__________ , Year __________
  Scale:__________ , Year __________
- ☐ Aerial photographs: Scale:__________ , Year __________
- ☐ Geological maps: Scale:__________ , Year __________
- ☐ Land Use Map: Scale:__________ , Year __________
- ☐ Meteorological data: Number of existing stations under operation __________
- ☐ Hydrological data: Number of existing stations under operation __________
- ☐ Socio-Economic Data/Profile: Year __________ (most recent)
- ☐ Other data (Please specify): ____________________ Year: ________

2) Which types of data do you think need to be strengthened/enhanced in order to improve disaster risk management in the province?

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

3) Do you see any problems or constraints to such data strengthening/enhancement?

☐ Yes ☐ No

If Yes, what are these problems or constraints. Please describe.

3-2 Hazard Map Requirement

1) Have any hazard maps been created before? ☐ Yes ☐ No

   If Yes, please attach the hazard maps at the end of this questionnaire.

   If No, what are the reasons why the hazard maps have not been created?

2) Is there any evacuation place identified in the province? ☐Yes ☐No

3) Is there any evacuation route identified in the province? ☐Yes ☐No

4) Are there any maps indicating the evacuation places and routes? ☐Yes ☐No

   If Yes, please attach the maps at the end of this questionnaire.

5a) Have the evacuation places functioned effectively during the last occurrence of the most severely damaging disaster? ☐Yes ☐No

   If No, what do you think are the reasons why they have not functioned effectively?

5b) Have the evacuation routes functioned effectively during the last occurrence of the most severely damaging disaster? ☐Yes ☐No

   If No, what do you think are the reasons why they have not functioned effectively?

6a) Do people know the location of evacuation places? ☐Yes ☐No

6b) Do people know the location of evacuation routes? ☐Yes ☐No

7) In what ways can people be informed about the location of evacuation places and routes?

____

____

____

____

4. Burden of Disaster Rehabilitation

We would like to know the burden of disaster rehabilitation on the provincial budget and expenditure during the last 5 years since the start of disaster risk management in the province.

Item	Year				
1) Total Provincial Budget (In Million Pesos)					
a) Budget for construction and investment					
b) Budget for operation and maintenance					
c) Budget for rehabilitation of the damage					
d) Budget for others					
2) Total Provincial Expenditure (In Million Pesos)					
a) Expenditure for construction and investment					
b) Expenditure for operations and maintenance					
c) Expenditure for rehabilitation of the damage					
d) Expenditure for others					

5. Opinions and Suggestions for Disaster Risk Management

Please describe the problems of the province regarding Disaster Risk Management, if you know of any. Also, give your suggestions on how it can be improved, if you have any.

____

____

____

____

Thank you for your cooperation!