Natural Disaster Risk Assessment and Area Business Continuity Plan Formulation for Industrial Agglomerated Areas in the ASEAN Region

Risk Profile Report
- Cavite, Laguna and Southern Part of Metropolitan Manila of the Philippines -

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AHA CENTRE

Japan International Cooperation Agency

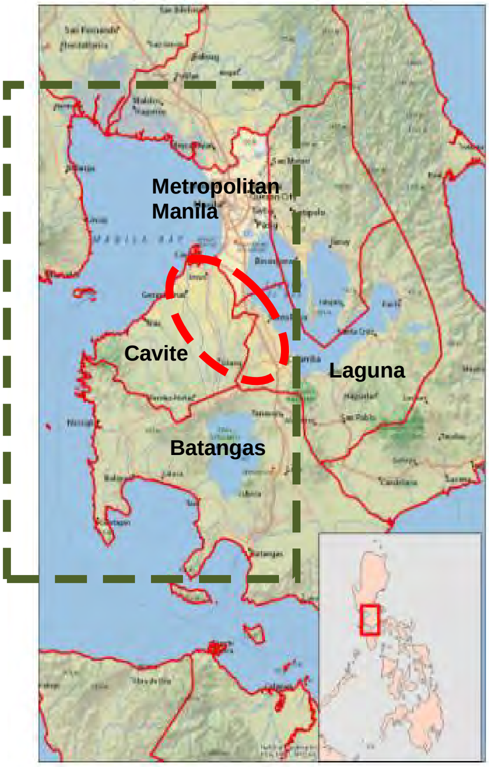
OYO International Corporation

Mitsubishi Research Institute, Inc.

CTI Engineering International Co., Ltd.

Outline of the Pilot Area

<table>
<tr><td>Country name</td><td>The Philippines</td></tr>
<tr><td>Pilot areas</td><td>Industrial clusters and surrounding areas in Cavite Province, Laguna Province and the southern part of Metropolitan Manila</td></tr>
<tr><td>Location of pilot areas</td><td>Pilot areas are located in the south of Metropolitan Manila. Industrial clusters are scattered across Cavite Province, Laguna Province and the southern part of Metropolitan Manila. (The approximate area where industrial parks are scattered is indicated by a red broken line.)



</td></tr>
<tr><td>Local administrative agencies in pilot areas</td><td>The land of the Philippines is largely divided into three blocks, which are subdivided into 17 Regions. Regions have 81 Provinces in total. Provinces consist of Cities and Municipalities. Metropolitan Manila (National Capital Region) is at the same level as Regions, consisting of 16 Cities and one Municipality with no Province.</td></tr>
<tr><td>Area and population of pilot areas</td><td>
<table>
<tr><th>Local administrative agencies</th><th>Area (km^2)</th><th>Population*</th></tr>
<tr><td>Metropolitan Manila</td><td>636</td><td>11,855,975</td></tr>
<tr><td>Cavite Province</td><td>1,427</td><td>3,090,691</td></tr>
<tr><td>Laguna Province</td><td>1,824</td><td>2,669,847</td></tr>
</table>
* May 2010, National Statistics Office, the Philippines</td></tr>
<tr><td>Natural conditions of pilot areas</td><td>The island of Luzon, where Metropolitan Manila, Cavite Province and Laguna Province are located, is a mountainous and volcanic region.
Laguna de Bay, the largest lake in the Philippines with the surface area of 949 km^2, is located at the southeast of Manila Bay. The Pasig River flows from Laguna de Bay into Manila Bay. The Pasig River is regarded as the most important river in the Philippines since it flows across the central area of Metropolitan Manila.
There are two lakes, named Caldera and Taal, in the south of Cavite Province. Mount</td></tr>
</table>

	Taal, the smallest volcano in the Philippines, rises in the center of Lake Taal. The climate is tropical monsoon. The annual mean temperature is 26°C-27° C. There are two seasons: the rainy season (June to November) and the dry season (December to May).
Hazards (disasters) in pilot areas: Flood	The types of floods striking the southern part of Manila and the Cavite and Laguna areas differ because they have different basins. The Cavite area is affected by flooding of the Imus, San Juan and Canas Rivers. The Laguna area is affected by the rise of the water level of the lake, while the southern part of Manila affected by the flow of drainage from the capital region. Although the towns in Cavite are at risk for flood damage, industrial parks have a lower risk of incurring direct damage. Major inundation damage is caused by floods due to tropical cyclones or typhoons, and flooding is caused by high waves.
Hazards (disasters) in pilot areas: Earthquake	There is no record in the disaster database of a seismic disaster with casualties occurring around the pilot areas since the 20th century. In the Philippines, PHIVOLCS catalogues historical earthquakes and has accumulated substantial data. According to this data, there is a record of an earthquake that killed more than 600 people in Manila in the 17th century. There was also an earthquake killing more than 400 in the 19th century. Moreover, the earthquake that occurred and killed a few people in the 18th century was caused by the activity of the Taal volcano located south of the pilot areas. PHIVOLCS found that an active fault extends in a north/south direction on the east side of Metropolitan Manila. If this fault moves, significant damage to Metropolitan Manila is projected.
Hazards (disasters) in pilot areas: Tsunami	According to the disaster database, there is one record of a tsunami (Mindro Island Tsunami) with casualties that occurred near the pilot areas in 1994. The tsunami rose to 8 m at Baco Island, killing 81 people. However, there is no record of a large tsunami directly hitting the pilot areas. Presumably, this is because the pilot areas are not likely to be affected by a tsunami generated in the open seas due to their location inside Manila Bay.
Hazards (disasters) in pilot areas: Volcanoes	Approximately 400 volcanoes are currently recognized in the Philippines, of which 23 are active while 26 are potentially active. Within 100 km of the pilot areas, there are three active volcanoes: Mount Pinatubo, Mount Taal and Mount Banahaw. According to the disaster database, the eruption of Mount Pinatubo in 1991 killed more than 600 and affected about one million people. Buildings and infrastructure around the volcano suffered damage. Ash fell and affected air routes significantly. The amount of loss exceeded USD 200 million, accounting for approx. 0.2 % of the GDP at that time. This eruption is the second largest of the 20th century. Mount Taal also erupted in 1965, killing 355, and erupted again in 1976. The last recorded eruption of Mount Banahaw was in 1843.
Industrial clusters in pilot areas	42 industrial parks are known to exist in Cavite Province, Laguna Province and Batangas Province. Among them, Japanese-affiliated companies are settled in 17 parks. There are 296 Japanese-affiliated companies in total. The Cavite Economic Zone has the largest number of Japanese companies (96). The Cavite Economic Zone has been selected as the representative industrial park in the pilot areas. Its outline is as follows. ✓ Developed by PEZA (Philippine Economic Zone Authority) ✓ 286 tenants (Japanese and Korean companies occupy approx. 40% each) ✓ Electric power supply IPP (Trans Asia Oil) generates power, NGCP transmits electricity, TRANSCO・MELARCO distributes electricity. ・Contract ① IPP-PEZA (five year contract from January 2013) ・Contract ② PEZA-Locator (PHP0.6/kWh: costs passed as distribution charge) ✓ Disaster damages ・10-day power outage in 2006 due to the flood caused by Milenyo (typhoon)
General economic	Among the pilot areas, investment has been promoted in the Calabarzon area

conditions of pilot areas	(including Cavite Province, Laguna Province, Batangas Province, Rizal Province and Quezon Province in the southern part of Manila) for the construction of industrial parks, etc. Japanese-affiliated companies have recently been moving to the industrial parks in Batangas Province, especially the First Philippines Industrial Park (FPIP) and the Lima Technology Center (LTC). Murata Manufacturing, Brother Industries, Canon, Shimano and others companies are settled in FPIP, while Bandai, Furukawa Electric, Epson and other companies are settled in LTC. On the other hand, since there very little space left in the industrial parks in Cavite and Laguna, further movement into these parks is not possible. Importing accounts for 70% and exporting accounts for 30% of the cargo movement at the Port of Manila, which is an important port infrastructure in the metropolitan area. Its handling capacity is always at the maximum limit. In Batangas Province, road infrastructure leading to the Port of Manila has been developed, and the Port of Batangas has also become usable. The Port of Subic has been developed on the north side of Manila. Promoting the use of these two ports may contribute to the improvement of distribution in Metropolitan Manila. Traffic congestion is severe, especially in the central area of Metropolitan Manila. It may take 6 to 7 hours from the industrial parks (Lima Technology Center, etc.) in Batangas Province. Conversely, the distance to the Port of Batangas is 35 km, and only slightly over one hour is required for shipment. Use of this port is clearly more economical. However, the amount of import cargo which can be handled by the Port of Batangas is still small, which may reduce the operational efficiency of distributors. Expanding the use of the Port of Subic and the Port of Batangas, in addition to the Port of Manila, would clearly ensure substitutability of distribution routes, and will bring advantages to the BCP. However, there are no economic merits since at present, the departure and arrival of liners is infrequent and the transaction volume is small.
BCP dissemination in the Philippines	The concept of the BCP is not well-known in the Philippines. Most companies probably have not considered development of the BCP. They are not aware of natural disaster prevention. Few companies have formed disaster prevention plans or emergency response plans, since disasters other than heavy rains and floods are not expected around Manila. However, some companies, including those involved in international transactions and major lifeline providers, have been actively promoting the development of an emergency response system and BCP, taking into consideration international requirements and the significant impact on society if business activities are suspended. Specifically, the local offices, customer centers, and data centers of major electric power providers have developed emergency response plans and BCP, and are also planning to establish comprehensive risk management plans.

Contents

Outline of the Pilot Area

Chapter 1 Disaster Risks of the Pilot Area

1.1 Overview

The disaster risks of the pilot area were assessed by the distribution of facilities that are mentioned in Chapter 4 overlaid on the hazard maps for seismic intensity or inundation depth, among others. (See Appendix) The main subjects of the assessment are traffic infrastructures and lifeline facilities, which are important for the continuation of businesses.

For tsunamis, floods and storm surges, the facilities in areas that will be inundated and/or are projected to be submerged are generally expected to receive damage. Past disaster records for the pilot area are the most valuable data for the assessment, because the extent of damage varies depending on the type and structure of the facilities, as well as their location. However, as past disaster records for the pilot area are not available for this study, disaster risk was assessed by referencing the disaster records in from other areas.

For earthquakes, the extent of damage is determined by the intensity of seismic vibration at the point where the location of the facility and their seismic performance. Several relationships between seismic intensity and the extent of damage of typical facilities have been proposed based on past earthquake disasters as the damage functions. The notable examples of functions are ATC-13[1], ATC-25[2] and Hazus[3], which were based on damage that occurred in the U.S.A. For this study, the extent of damage and the time needed to recover are assessed based on these damage functions. Therefore, it should be noted that the assessed results in this study can be improved referring to the local situation of the facilities.

1.2 Identification of Predominant Hazards

Impacts to business continuity were assessed and shown in Figure 1.2.1. The hazard that will most likely interrupt the business in Cavite and Laguna is earthquake, followed by flooding. The assessment is based on the overlaid maps of hazards and important facilities shown in Figure 1.2.2 – Figure 1.2.6.

The hazards in the pilot area with a probability of occurring once in 200 years are as follows.

- Earthquake: seismic intensity of 8 to 9 on the MMI Scale (lower to upper 8 in PEIS); liquefaction probability is high along Manila Bay.
- Tsunami: Maximum wave height on the coast closest to the industrial park in Cavite is 1 m for the model with a return period of 100 to 600 years.
- Flood: Maximum inundation depth is 2 m along the Manila Bay coastal area and the duration is several days; the inundation area along Laguna Lake is limited.

1 ATC, 1985, ATC-13: Earthquake Damage Evaluation Data for California, Federal Emergency Management Agency, Applied Technology Council, California, U.S.A.

2 ATC, 1991, ATC-25: Seismic Vulnerability and Impact of Disruption on Lifelines in the Conterminous United States, Federal Emergency Management Agency, Applied Technology Council, California, U.S.A.

3 FEMA, 2011, Hazus -MH 2.1, Multi-hazard Loss Estimation Methodology, Earthquake Model.

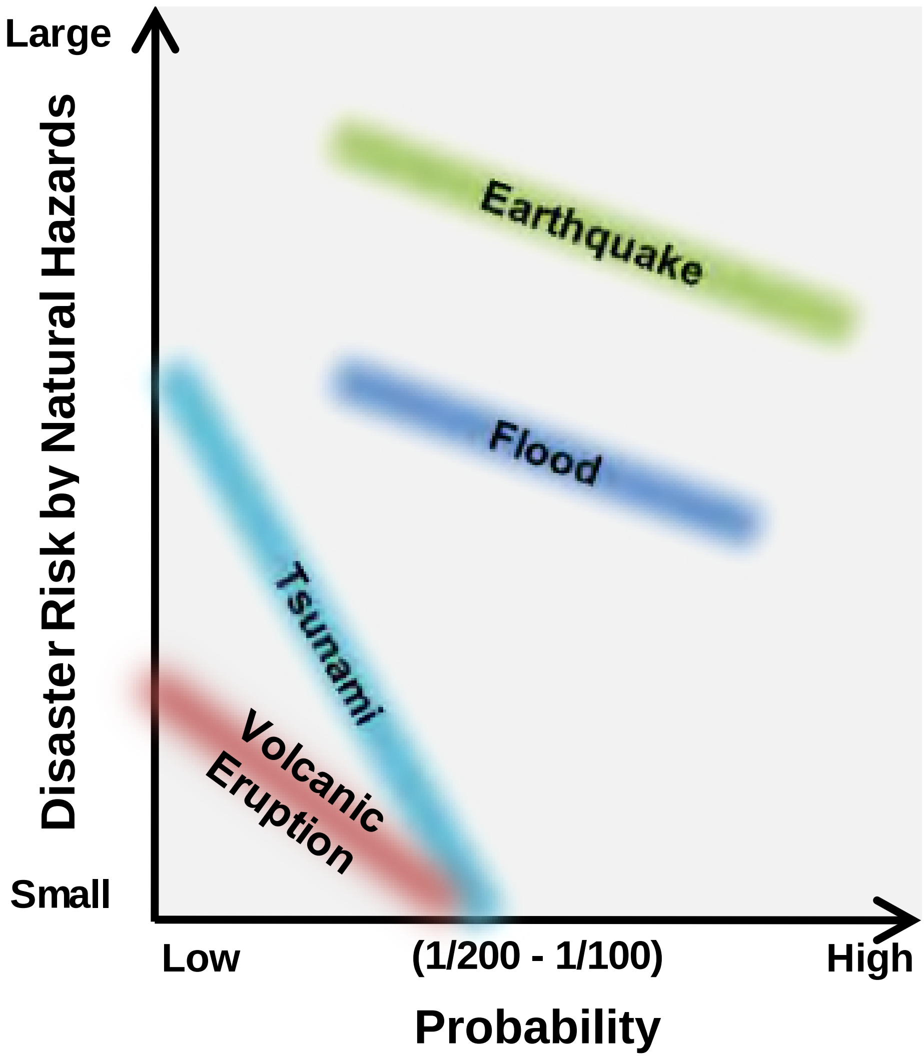


Figure 1.2.1 Identification of Predominant Hazards

Figure 1.2.2 Seismic intensity expected with a 200-year probability and the distribution of important facilities

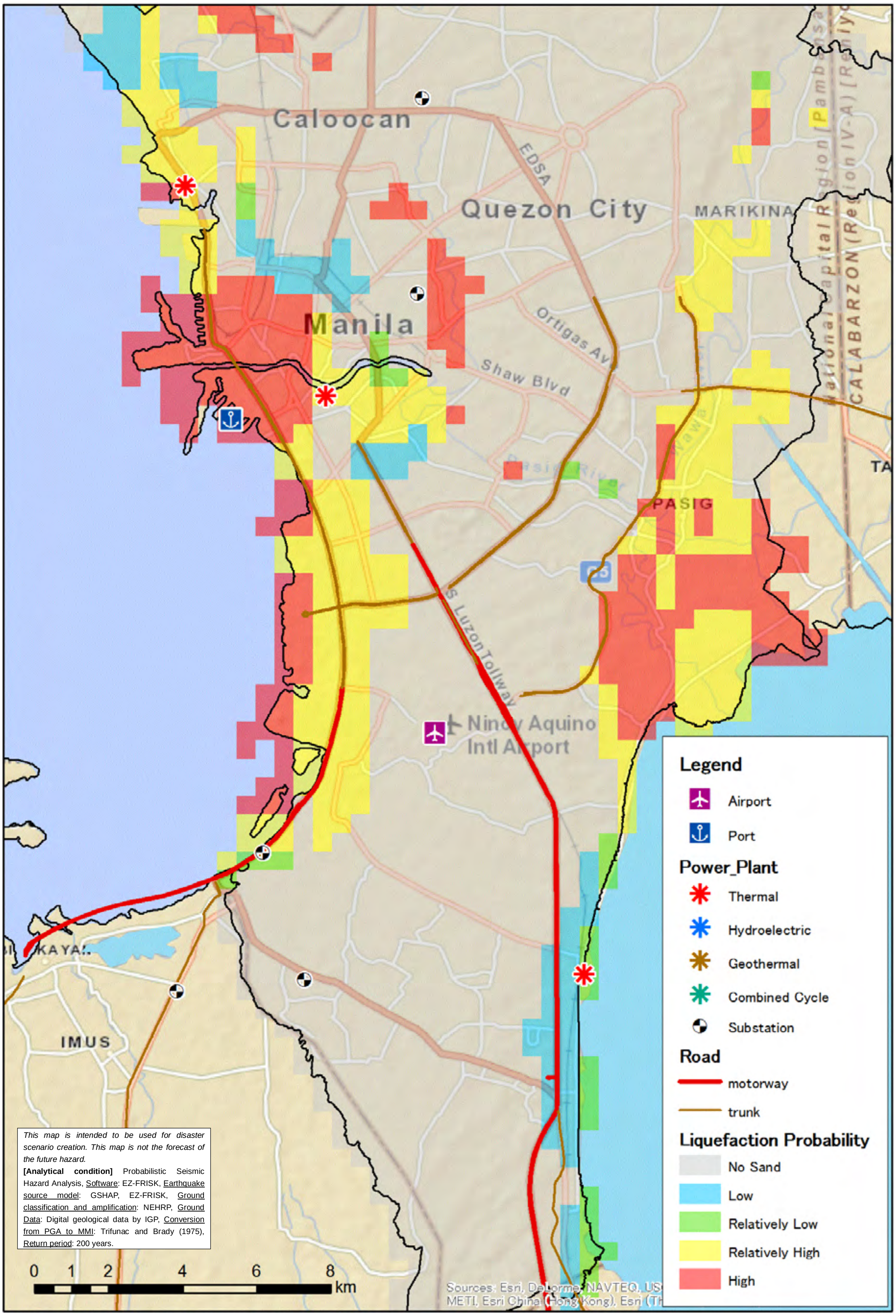


Figure 1.2.3 Liquefaction probability expected with a 200-year probability and the distribution of important facilities

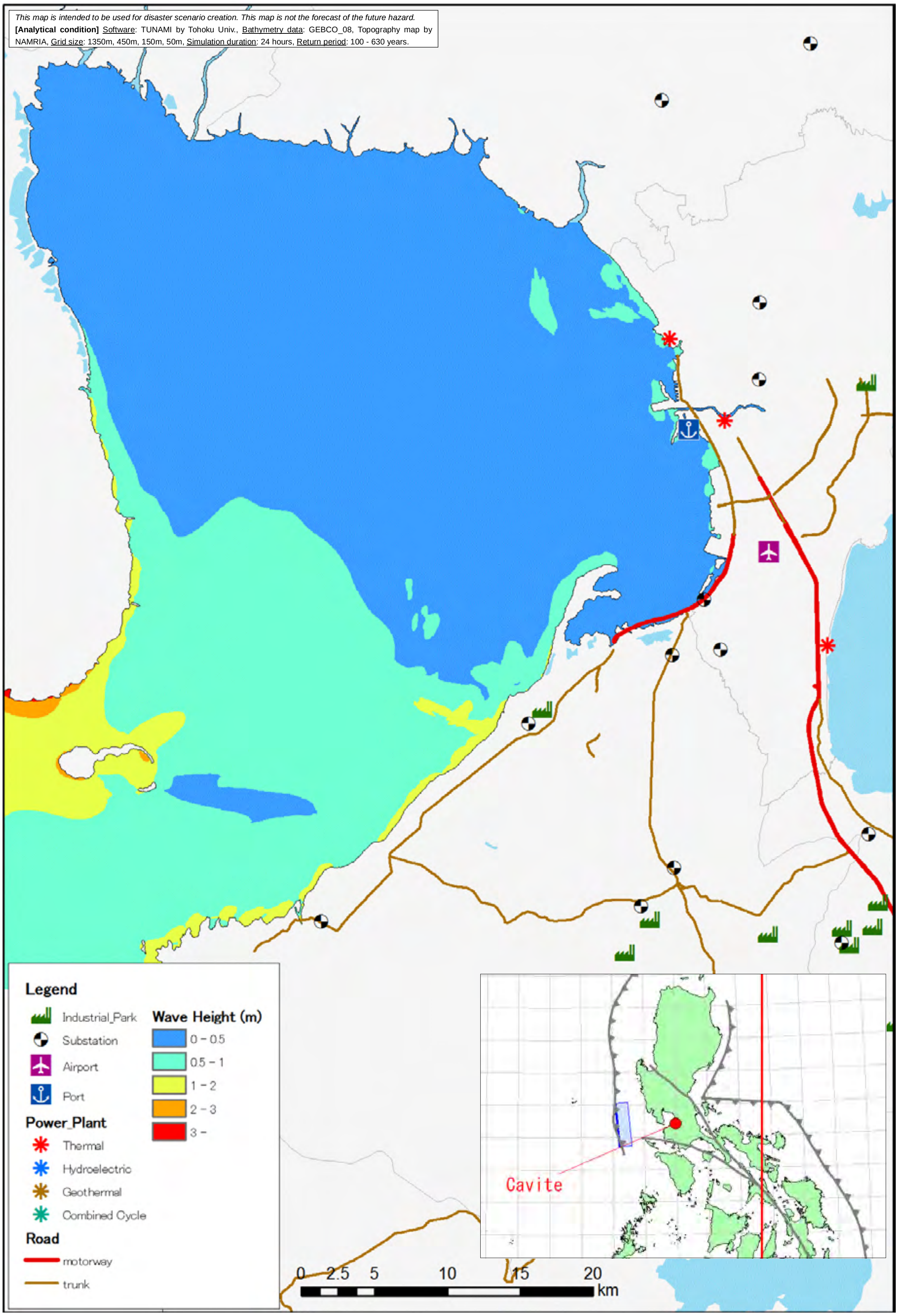


Figure 1.2.4 Maximum tsunami wave height for the Manila Bay offshore model (return period is 100 to 600 years)

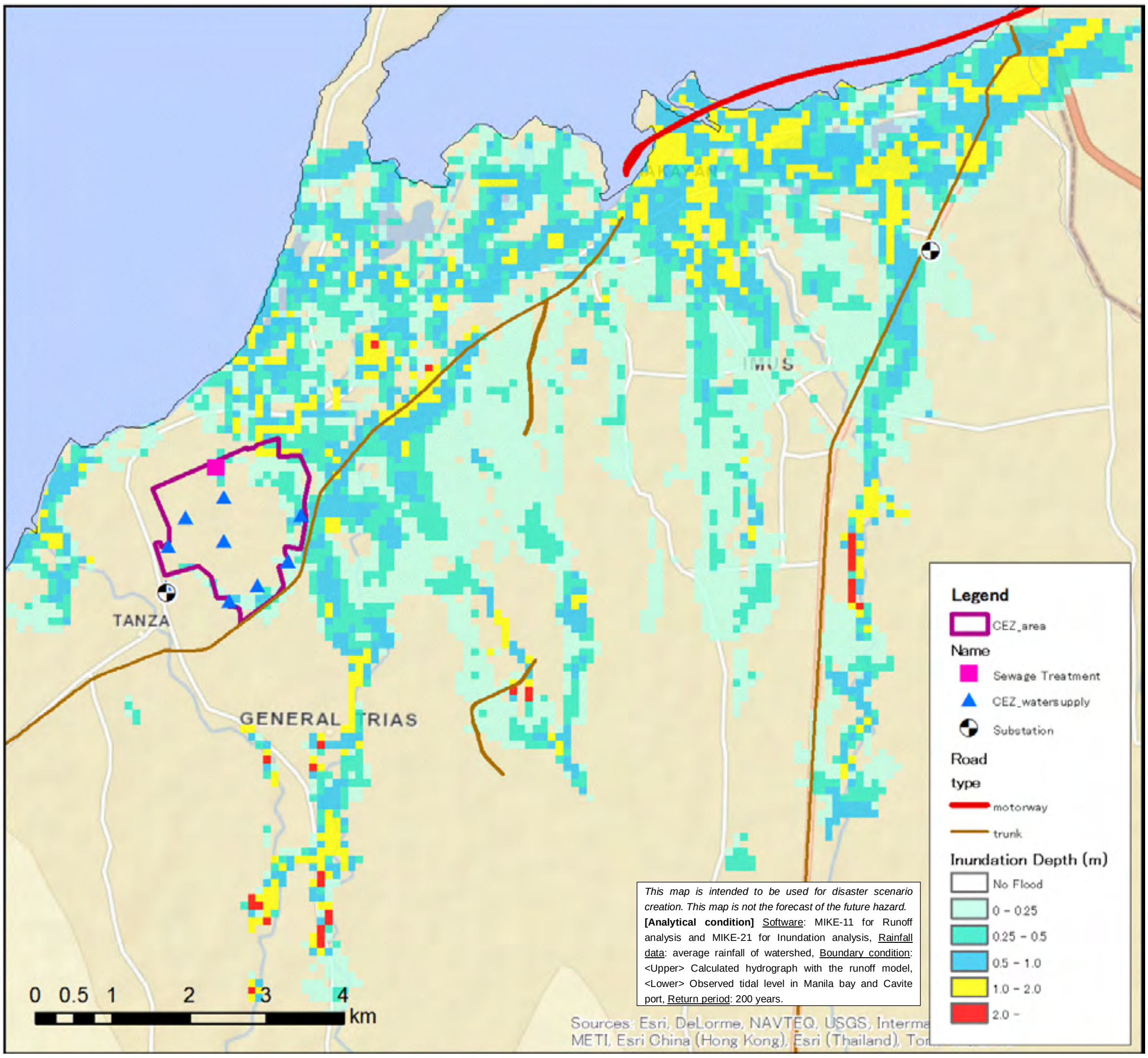


Figure 1.2.5 Maximum inundation depth expected with a 200-year probability in Cavite and the distribution of important facilities

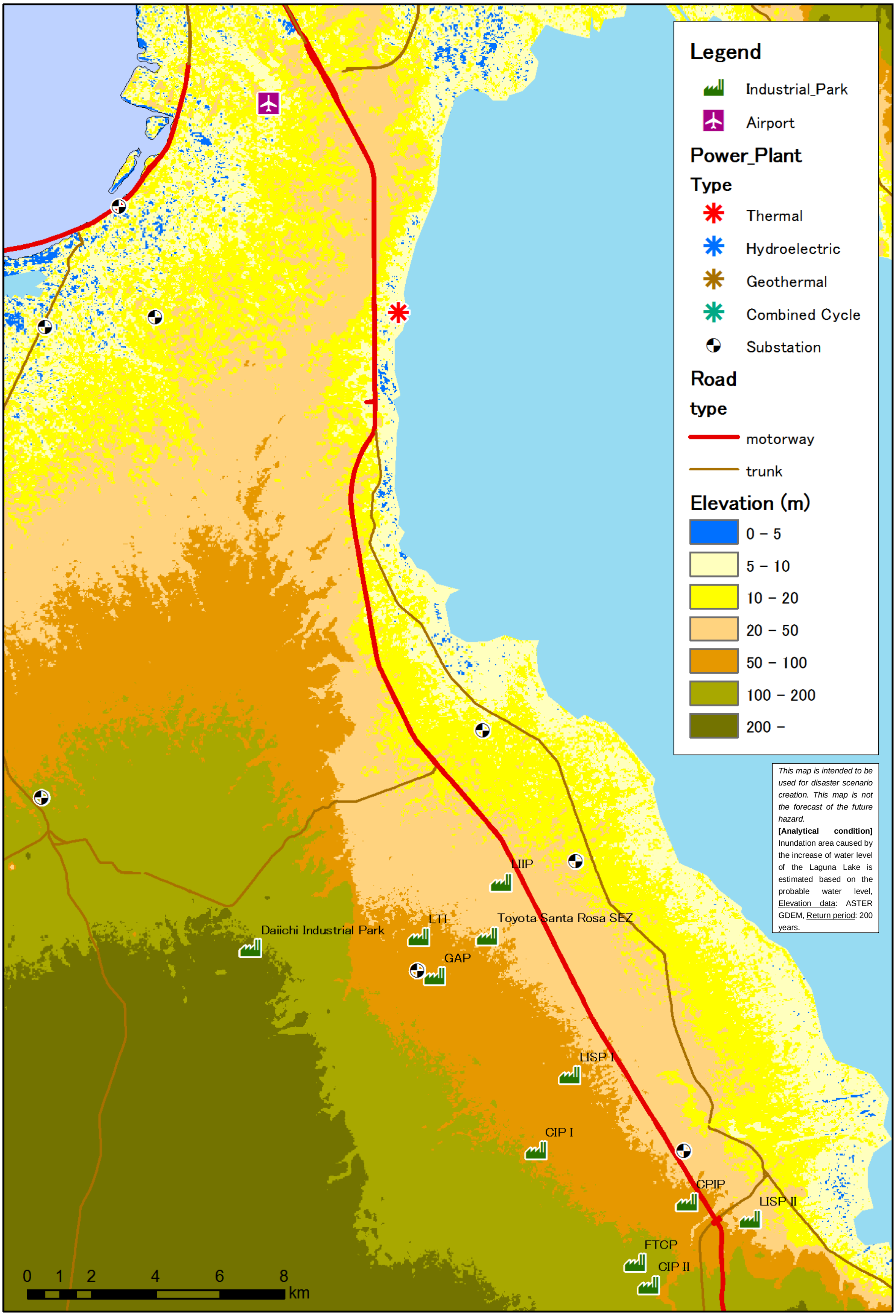


Figure 1.2.6 Inundation depth expected with a 200-year probability along Laguna Lake and the distribution of important facilities

1.3 Disaster Risk for Earthquakes

The disaster risk for earthquakes, which has been identified as the predominant hazard for business interruption with a 200-year probability was assessed and is shown in Table 1.3.1.

Table 1.3.1 Disaster Risk for Earthquakes

Buildings in Industrial Parks	● 10% of the buildings suffer moderate damage. Repair is necessary for operations. ● Some ceiling panels and lights fall down and parts racks may topple. ● Non-anchored heavy machinery may move on the floor. ● Transformers may topple.
Lifeline Facilities	● Electric substations will cease operations for 1 week. Capacity recovers to 50% in 1 month after the earthquake, with 3 months needed for full recovery. ● Fixed-line phones and mobile phone lines become congested because of the limitation of channels due to the shortage of electric power. ● Wells and water tanks cease operations for several days. Capacity recovers to 50% in 1 week after the earthquake, with 1 month needed for full recovery.
Traffic Infrastructures	● The expressway between Manila and Cavite is closed for 2 weeks because of liquefaction. After temporary restoration work, limited traffic passage will become possible. ● Traffic capacity of the expressway between Manila and Laguna is limited in some sections. Capacity recovers to 50% in 1 week, with 2 weeks needed for ful recovery. ● Most piers at Manila Port cannot be used for several months due to the liquefaction. Several piers resume operation after temporary restoration work. ● Gantry cranes in container terminal are severely damaged. Cargo handling capacity will recover to 50% after 6 months.
Industrial Park Workers	● Some employees will be absent from work because 10% of their houses are heavily damaged and 20% suffer moderate structural damage. ● Traffic conditions will become worse and many workers will be late for their shifts.

1.4 Hazard and Risk Information Sources

■ Earthquakes, Tsunamis, Volcanoes

[PHIVOLCS] Philippine Institute of Volcanology and Seismology

http://www.phivolcs.dost.gov.ph/

Fault Zone Map

http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=379&Itemid=500023

Active Faults and Trenches, Active Faults and Liquefaction Susceptibility Map

http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=78&Itemid=500024_

Tsunami Prone Areas and Tsunami Hazard Map

http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=312&Itemid=500027

Volcano Hazard Map

http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=57:active-volcanoes&catid=55&Itemid=114

Ready Project Map

http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=465&Itemid=500028

Earthquake Monitoring

http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=38&Itemid=75

[MGB] Mines and Geosciences Bureau

http://www.mgb.gov.ph/

Geological Map

http://www.mgb.gov.ph/lgmp.aspx

Geological Database Information System

http://gdis.denr.gov.ph/mgbviewer/

[NAMRIA] National Mapping and Resource Information Authority

http://www.namria.gov.ph/

[PAGASA] Philippine Atmospheric, Geophysical and Astronomical Services Administration

http://www.pagasa.dost.gov.ph/

■ Meteorological Hazards, Floods

[NDRRMC] National Disaster Risk Reduction and Management Council

http://www.ndrrmc.gov.ph/

[OCD] Office of Civil Defense

http://ocd.gov.ph/

[PAGASA] Philippine Atmospheric, Geophysical & Astronomical Services Administration

http://www.pagasa.dost.gov.ph/index.shtml

[DOST-ICTO] The Department of Science and Technology-Information and Communications Technology Office

http://www.dost.gov.ph/

[NAMRIA] National Mapping and Resource Information Authority

http://www.namria.gov.ph/

[UP] University of the Philippines Diliman

http://www.upd.edu.ph/

Chapter 2 Natural Hazards in the Pilot Area

2.1 Floods

(1) The pilot area has suffered from floods and inundation caused by storm rainfalls due to tropical cyclones and typhoons.

The Pasig-Marikina River and Laguna Lake Basin in Metropolitan Manila suffered from severe flooding and inundation caused by storm rainfall during the tropical storm Ondoy, which was assessed as a flood with a probability of over 100 years. The southern part of Metropolitan Manila was affected by storm waters and inundated for one to three days. The area along Laguna Lake was submerged for a long time because the water level rose over the normal water level (11.50 m) to 13.90 m due to the storm rainfall.

The Cavite area has been frequently affected by floods, even by 2-year probable floods caused by the Imus River, San Juan River and Canas River, which flow through the urban area.

In this area, there are also floods caused by river overflow and inundation due to storm rainfalls from tropical cyclones and typhoons. There is a risk of storm surges in the low-lying coastal areas. The severest flood disasters were caused by Typhoon Milenyo (in 2006), which was evaluated as a flood with a probability of 100 years. However, the industrial estates are generally protected from the floods.

(2) The eastern part of Cavite province, in which industrial estates are located, lies close to Metropolitan Manila. The provincial government of Cavite conducts dredging of the major river channels as a flood control measure in order to maintain their discharge capacities. After Typhoon Milenyo, a development study was conducted by JICA on flood disaster prevention from 2007 to 2009, with a project scheduled to be implemented from 2014. The project includes the construction of three retarding basins (two at the Imus River and one at the San Juan River) and channel improvements for the Imus and San Juan Rivers.

(3) As for the formulation of national and regional disaster prevention plans, a new Republic Act (1012) entitled “An Act Strengthening the Philippine Disaster Risk Reduction and Management System” was issued in 2010. Based on the new act, national and local governments established Disaster Risk Reduction Management Offices and are preparing Disaster Risk Reduction Plans. The MMDA and the provincial governments of Laguna and Cavite have already prepared DRRMPs. However, the industrial estates in the area are not included as communities in the RDRRMP. The Area BCP must thus consider their participation in the RDRRMP.

(4) The flood warning system of the Cavite Provincial Government is completely dependent on information from PAGASA, as they do not have their own monitoring system like MMDA and the

Laguna Provincial Government. In Cavite, when considering the scale of rivers (catchment area: 110 km^2~150 km^2, river length: 42 km ~ 45 km, river slope: 1/66~1/80), it can be seen that they must develop their own monitoring system in order to improve the level of safety for its residents.

2.2 Typhoons/ Hydrometeorology

The Philippines is subject to various risks of natural disasters caused by typhoons and tropical cyclones, floods, flashfloods, mud flows and landslides, storm surges, volcanic eruptions and earthquakes. Typhoons are the most destructive in the country.

Typhoons generally originate in the region of the Mariana and Caroline Islands in the Pacific Ocean and move northwest. An average of 20 typhoons pass through the country annually, four (4) ~ five (5) of them cause major disasters by floods, storm surges and strong winds.

In recent years, flood and inundation disasters were caused by Typhoon Milenyo in 2006, Typhoon Frank in 2008, Tropical Storm Ondoy in 2009, Typhoon Basyang in 2010 and Typhoon Maring in 2013.

2.3 Storm Surges

The Ready Project has created hazard maps of natural disasters including a hazard map for storm surges. According to the hazard map, the storm surge disaster risk areas are identified as the coastal areas that are 2 m below MSL, which include 60 Barangays (including 15 Barangays in Cavite city) located along the coast.

2.4 Earthquakes

There is no record of an earthquake with casualties in or around the pilot area after the 20th century. However, tracing back history using the PHIVOLCS earthquake catalog, an earthquake with over 600 deaths was found in the 17th century. Additionally, an earthquake which was generated by the activity of the Taar volcano, which is located south of the pilot area, caused several deaths in the 18th century. According to PHIVOLCS research, an active fault is running in a north-south direction on the east side of Manila. Serious damage to Metro Manila is predicted if this fault slips. However, the level of fault activity is not clear. Conversely, there is no record of damage caused by earthquakes occurring along the Manila Trench.

The Global Seismic Hazard Assessment Program (GSHAP) modeled global seismic activity and conducted probabilistic seismic hazard analyses. The published peak ground acceleration (PGA) for the pilot area with a 10% probability of exceedance in 50 years (475-year return period) is about 400 gal above bedrock. However, according to a geological map published by NAMRIA, some of the pilot area is covered by soft sediment from the Quaternary period, which is expected to amplify seismic motion by 50% higher on the ground surface. Conversely, when a 100-year return period is adopted for BCP, a smaller PGA would be expected. Analysis by the Study Team predicts a PGA of 180-450 gal (MMI 8 - 9). This ground motion level is expected to impact the facilities.

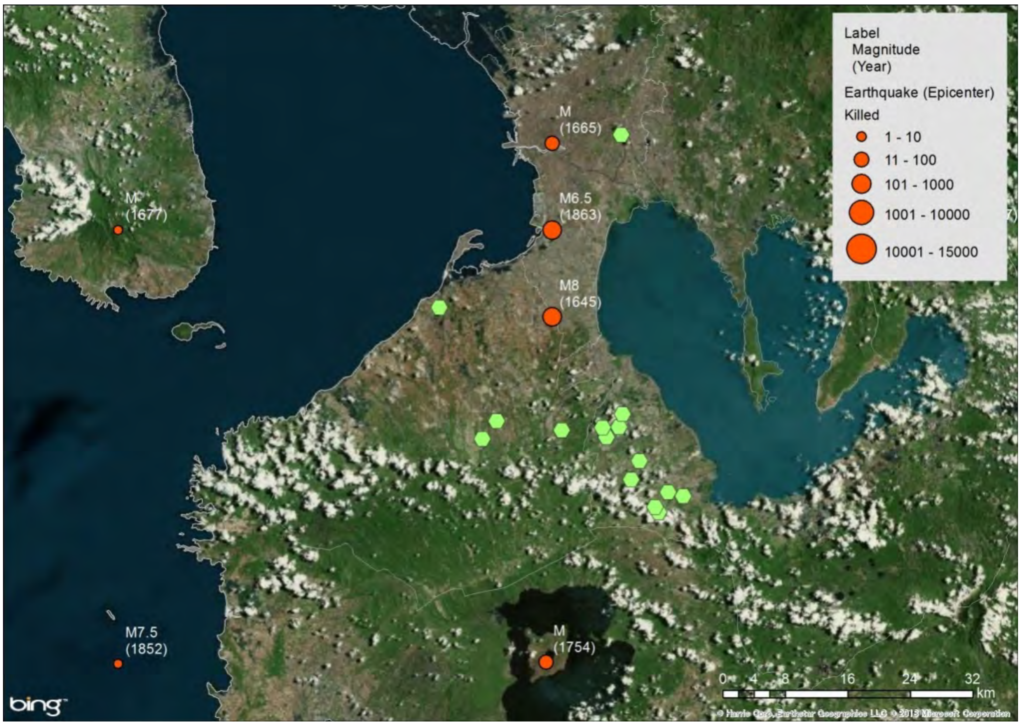


Figure 2.4.1 Earthquakes with Casualties in the Pilot Area

2.5 Tsunamis

The disaster database shows a record of the 1994 Mindoro tsunami, which caused casualties near the pilot area. At that time, the tsunami has a run-up height of 8 m on Baso island and caused 81 deaths. However, there is no record of tsunamis directly hitting the pilot area. One reason for this is that the pilot area is located behind Manila Bay, and is thus protected from tsunamis generated in the open ocean.

PHIVOLCS developed and published tsunami hazard maps for all areas of the Philippines. According to the tsunami hazard map for Cavite, it is predicted that with an 8.2M earthquake along the Manila Trench, the generated tsunami will inundate an area of 1-2 km from the coastline on the Pacific Ocean side and in the vicinity of the mouth of the Manila Bay. However, there is no record of a tsunami-generating earthquake along the Manila Trench and seismic activity appears low. According to the results of statistical analysis using the small and medium sized earthquake catalog, the occurrence probability of an 8M earthquake is low.

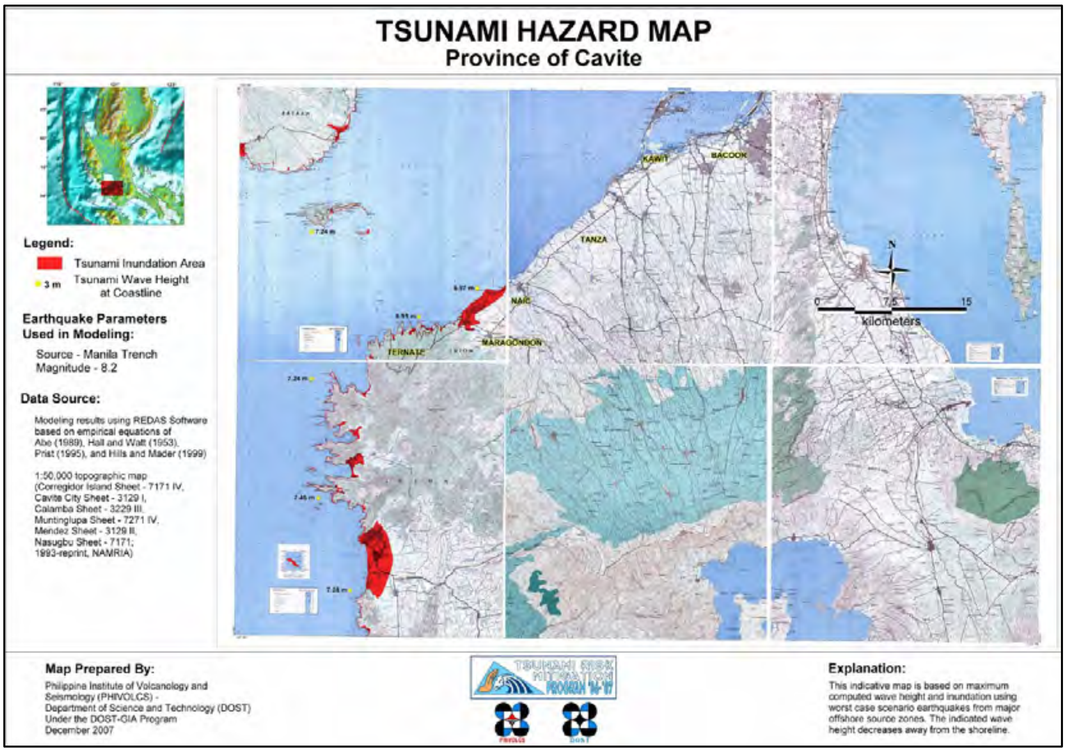


Figure 2.5.1 Example of Tsunami Hazard Map by PHIVOLCS

2.6 Volcanoes

There are about 400 volcanoes in the Philippines, of which 23 are active volcanoes and 26 are potentially active volcanoes. There are three active volcanoes within 100 km of the pilot area. They are Mt. Pinatubo, Mt. Taal and Mt. Banahaw.

According to the disaster database, the eruption of Mt. Pinatubo in 1991 was the most devastating eruption in the Philippines in recent years and it was the second largest eruption of the 20th century in the world. More than 600 people were killed and about one million people were affected by the eruption. Many buildings and infrastructures around Mt. Pinatubo were damaged, and ash fall affected air transportation. The loss amount exceeded USD 200 million, which was equivalent to 0.2% of Philippines' GDP at that time. Mt. Taal erupted in 1965 and caused 355 deaths. This volcano also erupted in 1976. The last eruption of Mt. Banahaw was recorded in 1843.

PHIVOLCS developed volcano hazard maps for 14 active volcanoes including Mt. Pinatubo and Mt. Taal. The maps identify hazardous items such as volcanic ash, lava flow, pyroclastic flow, lahar, and volcanic mud flow and they are used for evacuation plans, quick response and land use.

A real time observation system has been installed for Mr. Pinatubo and Mt. Taal, and PHIVOLCS issues of volcanic eruption warning with five alarm levels. Seismic activity monitoring is conducted for Mt. Banahaw.

Chapter 3 Outline of Natural Hazard Assessments

3.1 Seismic Hazard Assessment

The basic procedure of earthquake hazard assessment is shown in Figure 3.1.1. The details of each item are stated below.

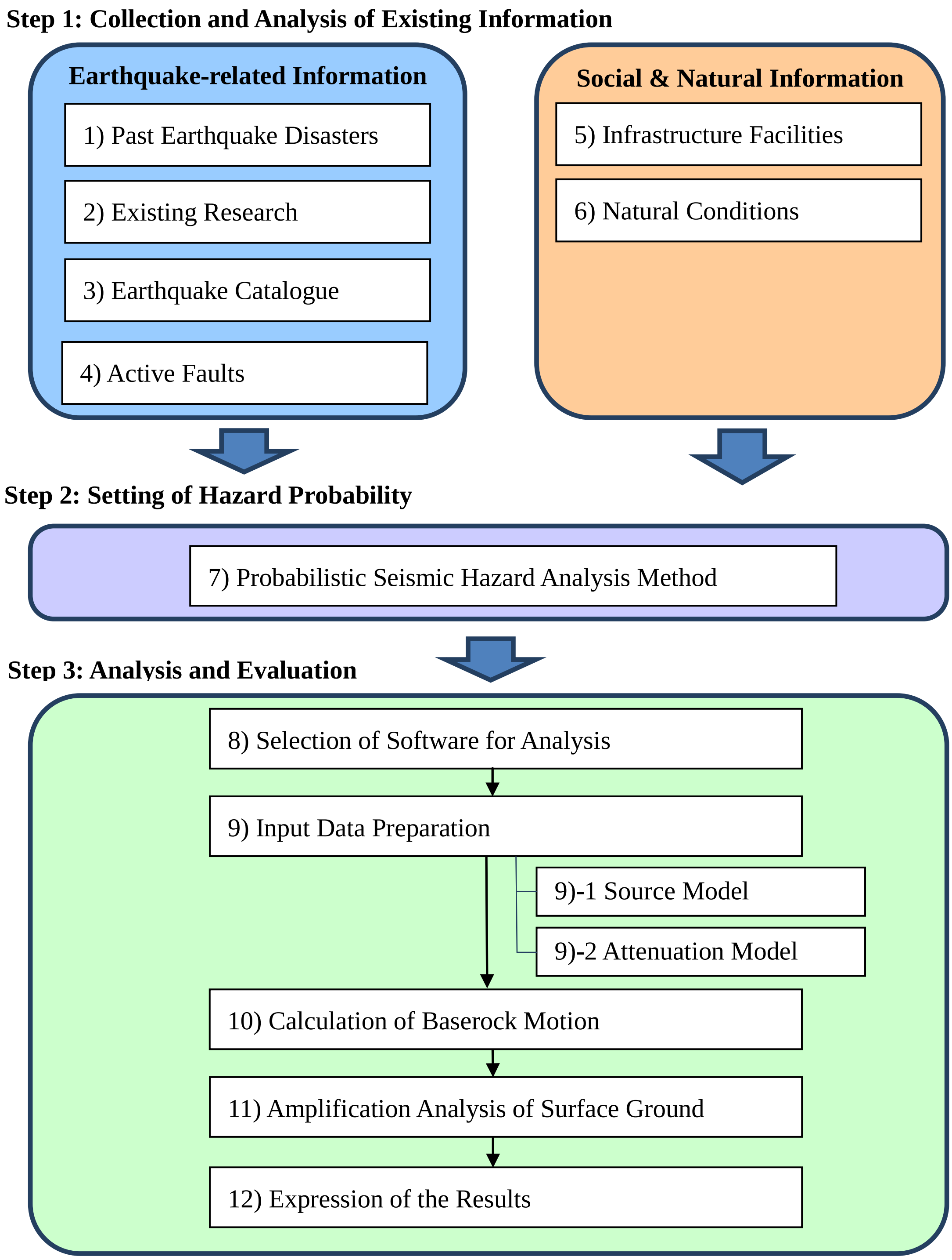


Figure 3.1.1 Basic Procedure of Earthquake Hazard Assessment

Step 1: Collection and Analysis of Existing Information

Earthquake-related Information

1) Past earthquake disaster records

Seismic intensity distribution data and disaster records of past earthquakes in the study area are collected. The frequency and the extent of earthquake disasters can be understood by analyzing the year of occurrence, earthquake magnitude, seismic intensity distribution and damage distribution.

2) Existing research and study

Existing research and study results of earthquake hazards in the area are collected. The information collected focuses on historical earthquake research, seismic hazard maps and studies on ground amplification of earthquake motion.

3) Earthquake catalogue

The earthquake catalogue is a list of past earthquakes including origin, depth, year/month/day/time of occurrence, seismic magnitude and so on. As the earthquake catalogue is a base for earthquake hazard analysis, a catalogue that covers a longer period is preferable. The catalogue should include the earthquakes that occurred within a 100 km range of the study area.

4) Active faults

An active fault is a fault which may generate earthquakes in the future. Data on active faults such as location, length and activity are necessary for earthquake hazard assessment.

Social and Natural Information

5) Infrastructure facilities

The distribution of infrastructure facilities on which industrial agglomerated areas are dependent is studied. Transportation facilities and lifeline facilities are the main target for study. The actual region where earthquake hazard is to be assessed is decided based on the distribution of infrastructure facilities. As infrastructure facilities are widely spread outside of industrial agglomerated areas, the region of hazard analysis is not limited to industrial agglomerated areas.

6) Natural conditions

Topography maps or DEM are collected as the basic information of the study area. Geological, geomorphological and land use maps are also collected to assess the amplification of earthquake motion caused by subsurface ground.

Step 2: Setting of Hazard Probability

7) Methodology of probabilistic seismic hazard analysis

Probabilistic methodology is used in the seismic hazard assessment because the probability of hazards is important for the Area BCP. Using the probabilistic method, the expected earthquake ground motion within a certain period at the study point is calculated, considering all the earthquake sources around the study point to reflect the possibilities of each source. Any hazard that has a high possibility of occurring during the lifetime of the industrial facilities is taken into account for the Area BCP. Therefore, estimating the probability of hazards is an essential component of the analysis.

Step 3: Analysis and Evaluation

8) Selection of software for analysis

As the probabilistic seismic hazard analysis involves complicated numerical calculations, many computing programs have been developed for this purpose and some of them are freely available. However, they are intended to be used by researchers or engineers with expert knowledge. EZ-FRISK is commercial software offered by Risk Engineering Inc. Analysis using EZ-FRISK is comparatively easy because the earthquake source model and attenuation formula are provided with the program.

9) Input data preparation

9)-1 Source model

The earthquake source model should include all the active faults within several 100 km of the study point. The earthquakes for which sources are unknown and for which it is difficult to make a definite estimation of the magnitude/location of future events are modeled as background seismic activities.

9)-2 Attenuation formula

The empirical attenuation formula is used to calculate earthquake ground motion based on the magnitude of the earthquake and the distance between epicenter and the study point. It is desirable to use an attenuation formula that was created for use on the study site. It is generally more desirable to use a new proposed attenuation formula because this newer formula is derived from precise, recent earthquake observation records.

10) Calculation of baserock motion

The earthquake ground motion calculated with a probabilistic method is expressed as follows.

a) The probability that the study site experiences a certain earthquake ground motion.

e.g. The probability of experiencing 100 gal or more is 10% in 50 years.

b) The earthquake ground motion value for a certain probability.

e.g. 100 gal or more will be experienced with a probability of 10% in 50 years.

11) Amplification analysis of surface ground

Seismic waves are amplified by the surface ground. There are several methodologies to evaluate the amplification characteristics of surface ground; for example, evaluation can be based on the surface soil, the average S wave velocity of surface soil layers, and numerical response analysis using the ground structure model. The most suitable method is selected by considering the available data, necessary work and budget.

12) Expression of the results

Calculated values for ground movement are physical quantities, such as peak ground acceleration or velocity. Seismic intensity is another way to express the strength of the ground vibration caused by earthquakes and is a more popularly understandable way of expressing values. Seismic intensity is also used to estimate damage based on past earthquake disasters. Though the relationship between PGA or PGV and seismic intensity is not a one-to-one ratio, empirical formulas are used to convert the former to the latter.

3.2 Tsunami Hazard Assessment

The basic procedure of hazard assessment for tsunamis generated by earthquakes is shown in Figure 3.2.1. The details of each item are stated below.

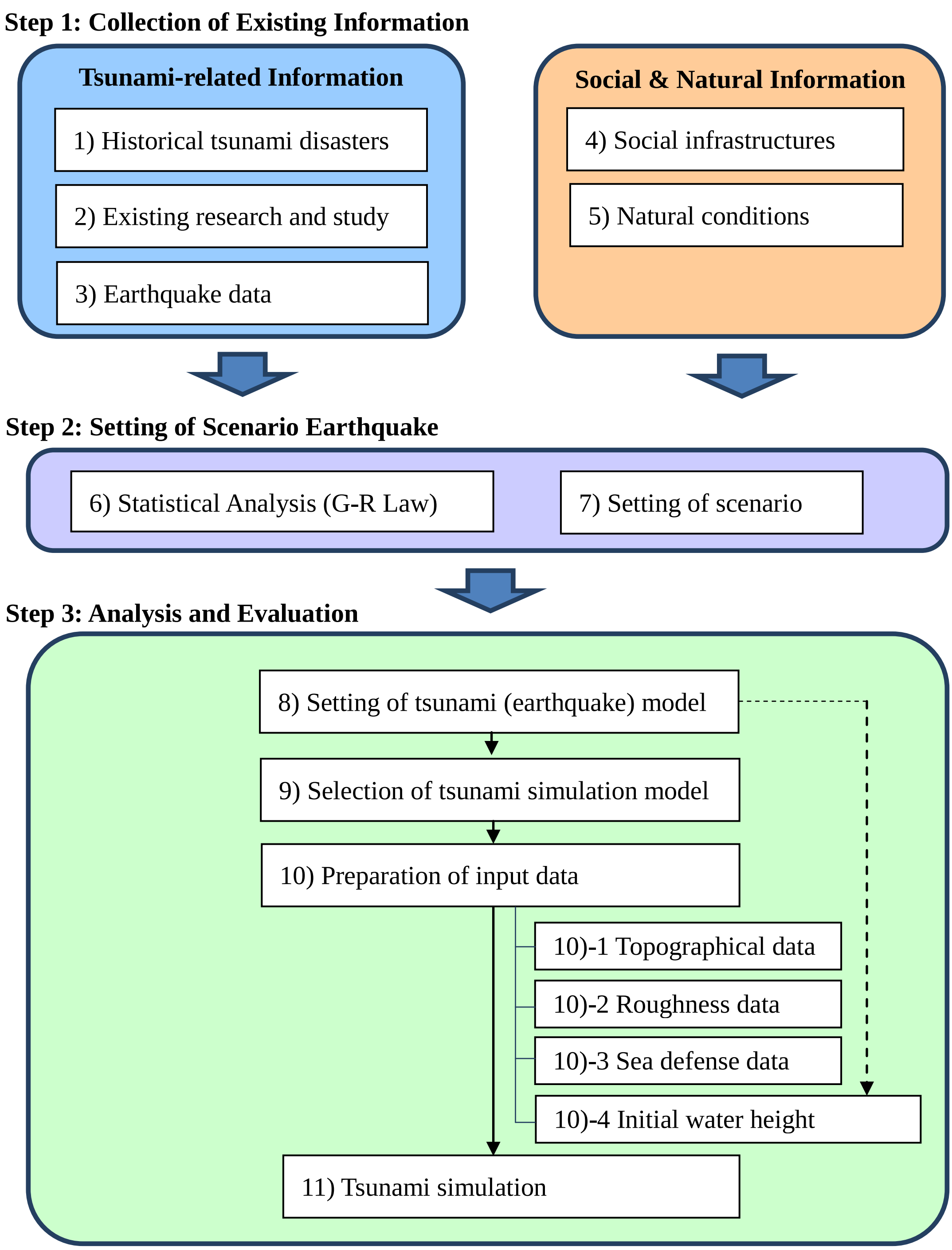


Figure 3.2.1 Basic Procedure of Tsunami Hazard Assessment

Step 1: Collection of Existing Information

Tsunami-related Information

1) Records of historical tsunami disasters

Inundation data and disaster records of past tsunamis in the study area are collected. The frequency and the extent of tsunami disaster can be understood by analyzing the year of occurrence, tsunami wave height, inundation and damage distribution.

2) Existing research and study

Existing research and study results of tsunami hazards in the area are collected. The information collected focuses on historical tsunami research and tsunami hazard maps.

3) Earthquake data (earthquake catalogue)

Data on earthquakes that have caused tsunamis is collected. The earthquake catalogue is the list of past earthquakes including the origin, depth, year/month/day/time of occurrence, seismic magnitude and so on. Earthquakes which generated tsunami are selected.

Social and Natural Information

4) Social infrastructures

Information on industrial agglomerated areas and social infrastructure that would be potentially affected by tsunami will be collected. Social infrastructures are categorized into transportation infrastructures and lifelines. The actual region where tsunami hazard is to be assessed is decided based on the distribution of infrastructure facilities. As infrastructure facilities are widely spread outside of industrial agglomerated areas, the region of hazard analysis is not limited to industrial agglomerated areas.

5) Natural conditions

Topography maps, bathymetry maps or DEM are collected as the basic information of the study area. Land use maps and geological maps are also useful for more precise analysis.

Step 2: Setting of Scenario Earthquake

A scale of tsunami disaster for risk assessment is decided based on the collected data. The scale of tsunamis is defined as the scale of the earthquake which generates the tsunami.

6) Statistical analysis of earthquake (Gutenberg-Richter Law)

The recurrence interval of scenario earthquakes that generate tsunami is decided based on the earthquake catalogue around the source area of scenario earthquakes. The relationship of earthquake magnitude and the frequency of earthquake occurrence, which is known as the Gutenberg-Richter Law is used. The annual probability or recurrence interval of the scenario earthquake of arbitrary magnitude can be estimated.

7) Setting of scenario earthquake

A scenario earthquake and its magnitude should be set for the Area BCP. If a larger magnitude is assumed, the components of the Area BCP increase and the process to formulate it becomes more complicated. However, business continuity after a disaster will be more stable. Conversely, if a smaller magnitude is assumed, the Area BCP can be more easily formulated. However if the disaster is larger than the estimated scenario, business continuity may become difficult. Therefore, it is desirable to decide the magnitude of the scenario earthquake by holding discussions with stakeholders, including citizens, on local disaster management planning, governmental policy and feasibility of the plan.

Step 3: Analysis and Evaluation

8) Setting of tsunami (earthquake) model

The fault parameters of the scenario earthquake such as location, size, slip, etc. are decided for numerical simulation.

9) Selection of tsunami simulation model

Tsunami propagation simulations require complicated numerical calculations. There are several theories to describe tsunami propagation, depending on the relationship between wavelength and depth of water or distance to the tsunami source area. Several computing programs have been developed in for these theories; however, most of them are intended to be used by researchers or engineers with expert knowledge.

10) Preparation of input data

The general input data for tsunami simulation is as follows. This data is given to each grid, which is explained below.

10)-1 Topographical data

For the simulation, it is necessary to create a topographical model for the area that includes the source area of the scenario earthquake, the objective area, and the route of tsunami propagation. The topographical model includes the topography of the sea floor, the topography of the land surface where tsunami might run up, and the sea defense structures.

The simulation area is divided and covered by a square grid, and altitude and roughness data are allotted to each grid. The size of grid is appropriate defined, taking into account the complexity of the topography and the wave length of the tsunami. The grid size is usually defined from larger to smaller according to the distance from coast, considering that the topography becomes more complex and shorter wave components become dominant near the coast. This methodology is called "nesting." The grid size is defined as, for instance, 1350 m → 450 m → 150 m → 50 m from the tsunami source region to the coast.

10)-2 Roughness data

The effect of friction for tsunami wave propagation is expressed by Manning's roughness coefficient (n). The roughness coefficient usually adopted for marine areas is n=0.025.

10)-3 Sea defense data

Embankments and other sea defense structures are modeled as height data in the grid.

10)-4 Initial water height data (= deformation of sea floor)

Changes of water heights caused by fault movement are given as initial conditions for tsunami simulations. Changes of water height are assumed to be same as the vertical components of sea floor deformation.

11) Tsunami simulation

The general output of the tsunami simulation is as follows. Output items are obtained for each grid.

1. Maximum water height or maximum inundation height
2. Maximum velocity
3. Elapsed time of maximum water height
4. Elapsed time of given water height (x cm, for instance)

3.3 Flood Hazard Assessment

The basic procedure of Flood Hazard Assessment is shown in Figure 3.3.1. The detailed procedure is described below.

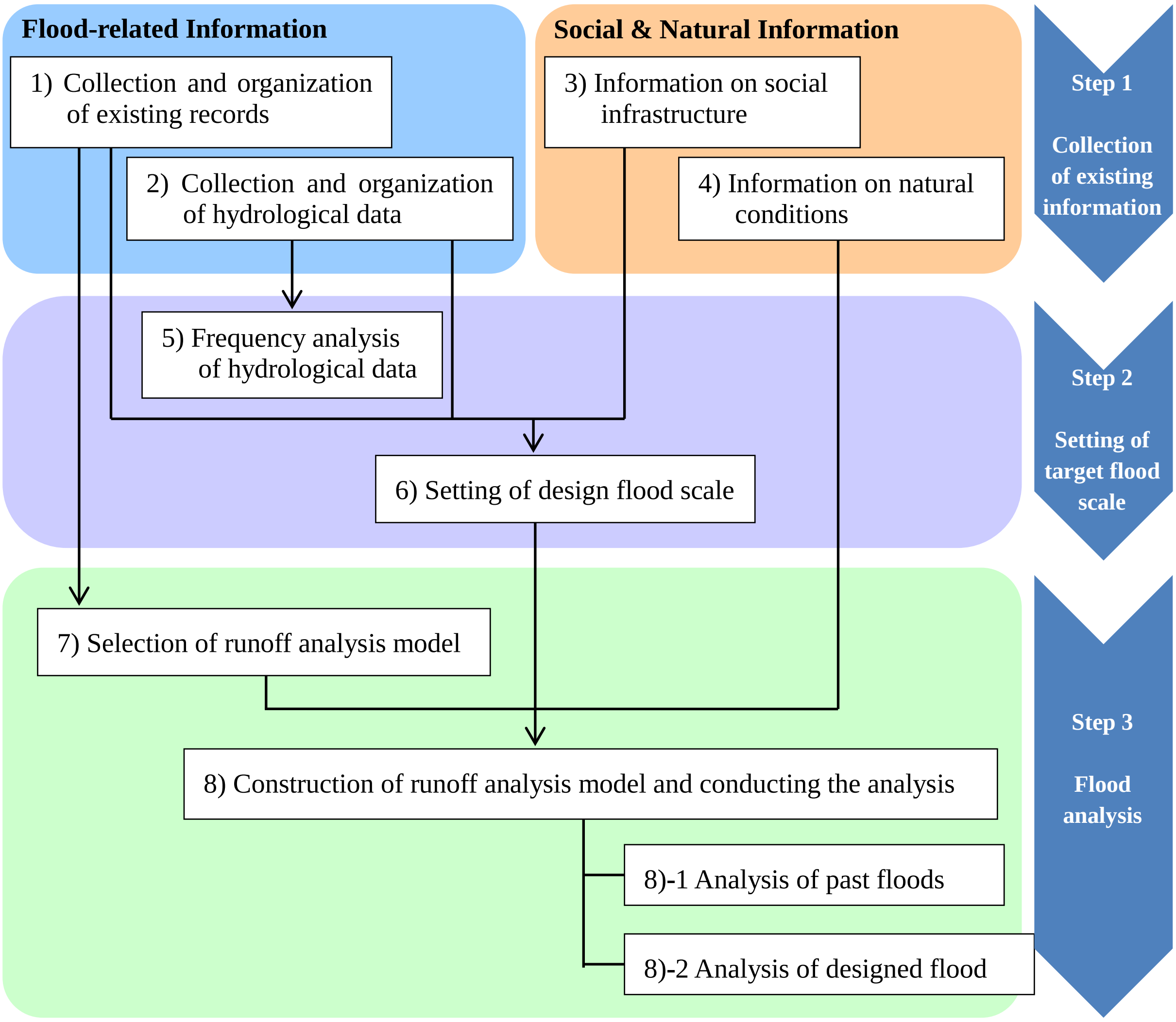


Figure 3.3.1 Basic Procedure of Flood Hazard Assessment

Step 1: Collection of existing information

Flood-related Information

1) Collection and organization of existing flood record

Flood-related information in the target area for flood risk evaluation is collected. Collecting data such as rainfall during floods, water level, and river discharge makes it possible to grasp the characteristics of floods. Inundation areas, duration time, water depth, and the cause of the flood as indicated in damage reports or photographs are also helpful in understanding the phenomena of inundation. If a flood hazard map is available in the target area, the information (inundation area, duration time and depth) shown in the map will be utilized.

2) Collection and organization of hydrological data

Existing hydrological data in target area is collected. Data on rainfall (hourly data or daily data), river water level, river discharge and tidal level should be collected. If there are river facilities such as dams or gates, it is advisable to collect the operational reports of these facilities during floods. Before organizing this data, confirm if there is incorrect or missing data.

Based on the collected hydrological data, flood duration, probability of flood occurrence, and situation when the largest recorded flood occurred will be analyzed. Cross-cutting profile data is also helpful in this step of model construction.

Information on Social Infrastructure and Natural Conditions

3) Collection and organization of information on social infrastructure

Information on industrial estates and social infrastructure that would be affected by flooding is collected. Social infrastructure can be divided into two categories: the transportation infrastructure related to transport to and from industrial estates and the lifeline infrastructures necessary to maintain business operations.

The actual region where flood hazard is to be assessed is decided based on the distribution of infrastructure facilities. As infrastructure facilities are widely spread outside of industrial agglomerated areas, the region of hazard analysis is not limited to industrial agglomerated areas.

4) Collection and organization of information on natural conditions

Topographic maps are collected, and data relating to natural conditions such as altitude, land use pattern and geology is organized. From the aspect of data accuracy, it is advisable to use a detailed map with a scale of 1/5,000 or more.

Step 2: Setting of target flood scale

Based on the data collected in Step 1, the target flood scale for formulating the Area BCP is set. The basic flood scale set as the largest recorded flood, 50-year return period, 100-year return period and 200-year return period.

5) Frequency analysis on hydrological data

Probable hydrological value is calculated using collected hydrological data. The procedure for processing statistics will involve applying probability density functions such as exponential distribution, evaluating the probability density function, and then determining the appropriate probability density function. For reliable probability density function results, samples for at least 50 years are needed.

6) Setting of design flood scale

The design flood scale for formulating the Area BCP is set. If the designed flood is large in scale, there are more components for formulating the Area BCP. In this case, a considerable amount of work is necessary to formulate the Area BCP, but level of safety in the plan is high. Conversely, if the designed flood scale is small, the target scope of the Area BCP becomes limited, which makes it easier to formulate the Area BCP. In this case, there is a possibility the Area BCP will not be effective. Hence, design flood scale should be set in accordance with regional city plans, administrative strategy, and feasibility of plan, and upon discussions with stakeholders, including local residents.

Step 3: Runoff analysis/evaluation

7) Selection of runoff analysis model

The appropriate model for analyzing the characteristics of floods in target area is selected. The appropriate analysis model should be selected from the viewpoint of runoff characteristics, required resolution, and financial capacity for purchasing software. At first, it is preferable to use free software like IFAS for formulating the Area BCP.

8) Construction of flood analysis model and conducting the analysis

8)-1 Analysis of past floods

Flood analysis with the selected model and past rainfall data is conducted. After that, simulation accuracy is confirmed by comparing the results of the simulation with actual discharge records. If the precision of the simulation is not satisfactory, attempts to improve the accuracy will be made by modifying parameters.

8)-2 Analysis of designed scale flood

Runoff analysis on the designed flood is conducted.

Chapter 4 Profile of the Pilot Area

4.1 Outline of the Pilot Area

The pilot areas in the Philippines are industrial agglomerated areas and the areas surrounding them. They are located in Cavite Province, Laguna Province and southern part of Metropolitan Manila. Pilot areas are encircled by the red dashed line as shown in Figure 4.1.1. Basic information on the pilot areas is shown in

Figure 4.1.1 Location of Pilot Areas

Table 4.1.1 Basic Information on the Pilot Areas

Pilot area	Industrial agglomerated areas and the areas surrounding them. They are located in Cavite Province, Laguna Province and Southern part of Metro Manila.
Area and population (As of 2010 May)	(see table below)
Natural conditions	The island of Luzon, where Metropolitan Manila, Cavite Province and Laguna Province are located, is a mountainous and volcanic region. Laguna de Bay, the largest lake in the Philippines with the surface area of 949 km2, is located at the southeast of Manila Bay. The Pasig River flows from Laguna de Bay into Manila Bay. The Pasig River is regarded as the most important river in the Philippines since it flows across the central area of Metropolitan Manila. There are two lakes, named Caldera and Taal, in the south of Cavite Province. Mount Taal, the smallest volcano in the Philippines, rises in the center of Lake Taal. The climate is tropical monsoon. The annual mean temperature is 26°C-27°C. There are two seasons: the rainy season (June to November) and the dry season (December to May).

Local Government	Area (km^2)	Population
Metropolitan Manila	636	11,855,975
Cavite Province	1,427	3,090,691
Laguna Province	1,824	2,669,847

* As of May 2010, National Statistics Office, the Philippines

4.2 Outline of the Local Authorities

4.2.1 Local Administrative System of the Philippines

The Philippines is divided into three main classes and sub-divided into 17 administrative regions. There are 81 provinces in the Philippines. The local administrative system in the Philippines consists of provinces, cities, municipalities and barangays.

There are three types of cities under the jurisdiction of province: (1) Highly Urbanized Cities, (2) Independent Component Cities, and (3) Component Cities. Highly Urbanized Cities and Independent Component Cities are on an equal footing with provinces. All cities are under the jurisdiction of the province. All of municipalities and cities are composed of barangays. Each local government has a chief executive, vice-chief executive and councilors, who are elected. Barangays composed of 50-100 households are the smallest administrative divisions in the Philippines. Barangays have a captain, councilor’s secretary and financial officer but there is no central government staff.

The National Capital Region (NCR) is composed of one city and 16 municipalities. The NCR is positioned at the local government level.

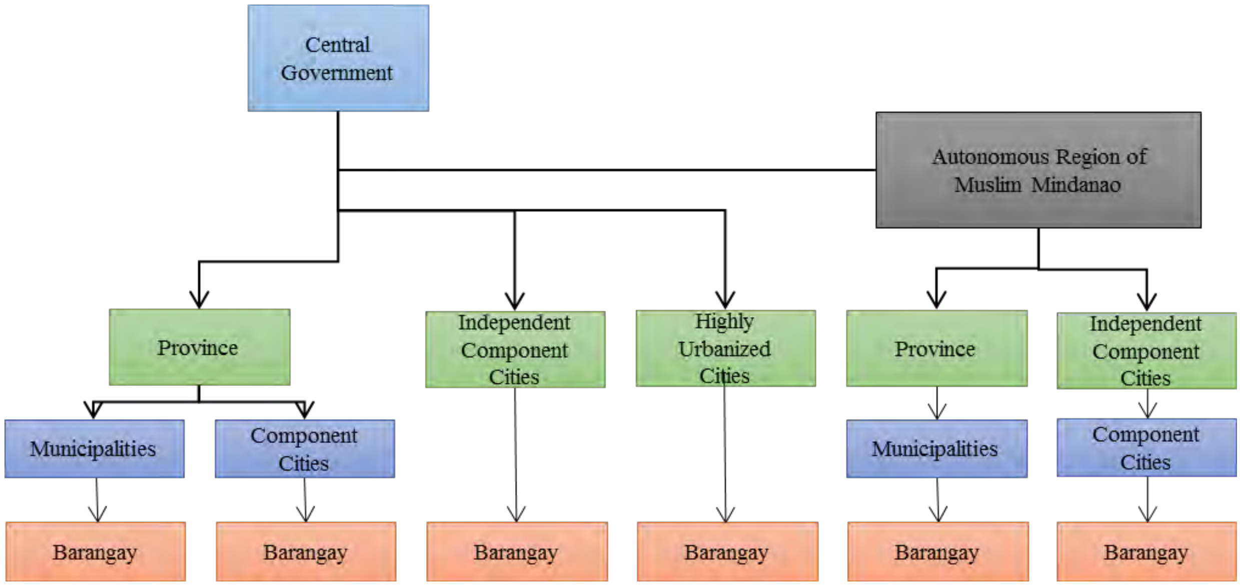
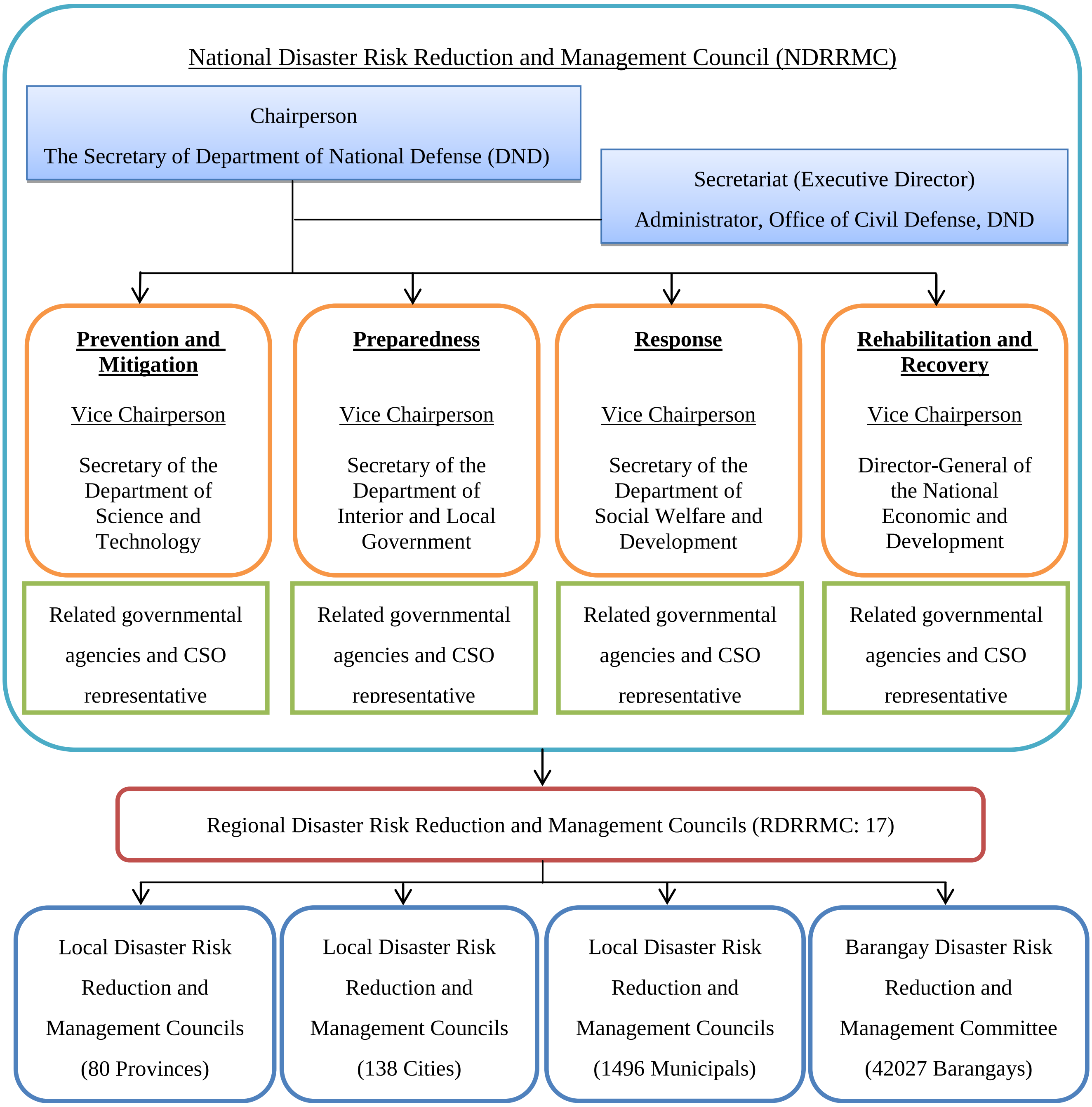


Figure 4.2.1 Local Administrative System in the Philippines

4.2.2 Disaster Management Organizations

(1) Country Level

The National Disaster Coordination Council was renamed as the National Disaster Risk Reduction Management Council (NDRRMC) by Republic Act 101211. More authority was granted to NDRRMC followed by the increase of its membership from 23 to 43 (including participants from civil society and private sector). The chairperson of NDRRMC is the Secretary of the Department of National Defense (DND) and four Vice-chairpersons are also appointed in charge of four thematic areas. The Administrator of the Office of Civil Defense (OCD), DND is appointed as the Executive Director for NDRRMC. Figure 4.2.2 below shows a detail organizational structure.



Source: Data collection survey on ASEAN regional collaboration in disaster management final report.

Note: Local level disaster risk reduction and management councils are established as follows: (1) 17 RDRRMCs (region) (2) LDRRMCs (80 provinces, 138 cities, 1496 municipalities), (3) BDRRMCs (42,027 Barangays. RDRRMCs are chaired by OCD Regional Directors, while other levels are chaired by the Local Chief Executives.)

Figure 4.2.2 Philippines' Disaster Management Structure

(2) Metropolitan Manila

The disaster management organization of Metropolitan Manila is shown in Figure 4.2.3. The Chairperson of the Metropolitan Manila Development Authority (MMDA) posts as Chairman of the organization, and the Office Civil Defense (OCD) NCR Regional Director posts as Senior

Vice-Chair. The Senior Vice-Chair supervises Vice-Chairs in four fields: (1) preparation and mitigation, (2) preparedness, (3) response, and (4) rehabilitation.

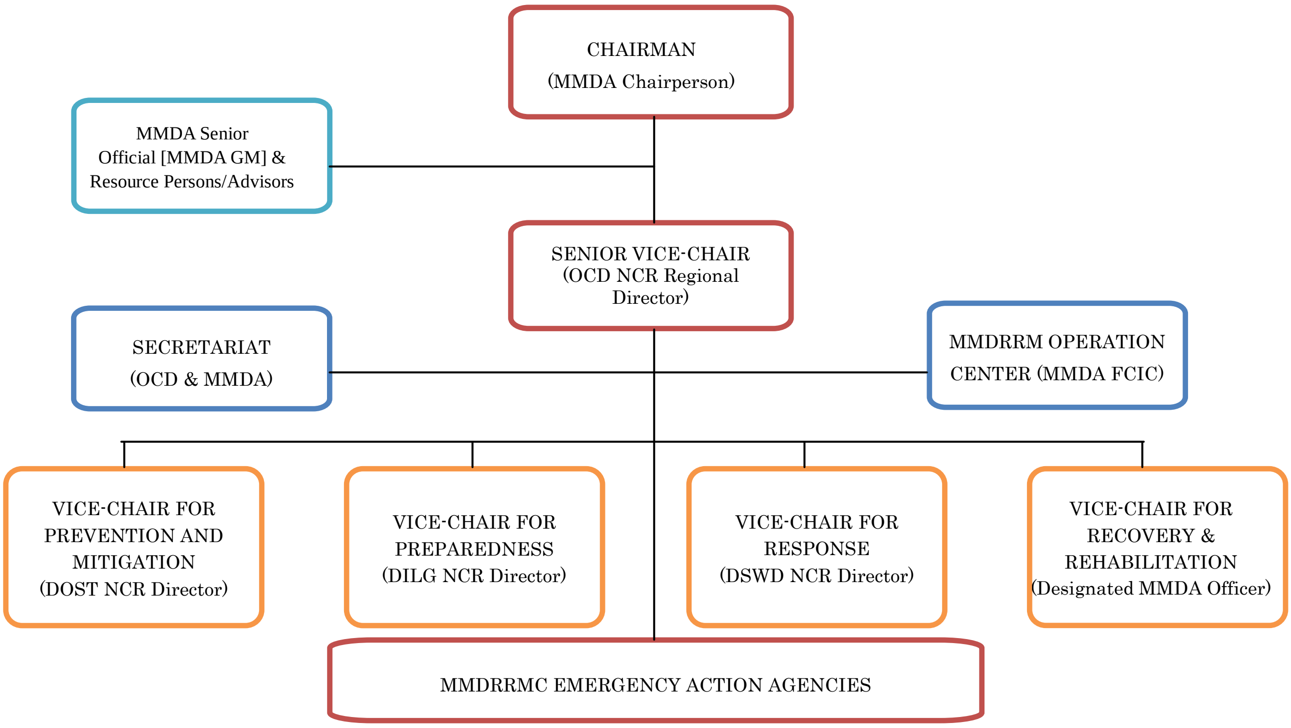


Figure 4.2.3 Disaster Management Organization of Metropolitan Manila

(3) Cavite Province

The disaster management organization of Cavite Province is shown in Figure 4.2.4. The Committee on Peace, Public Safety and Order is in charge of disaster management in Cavite Province.

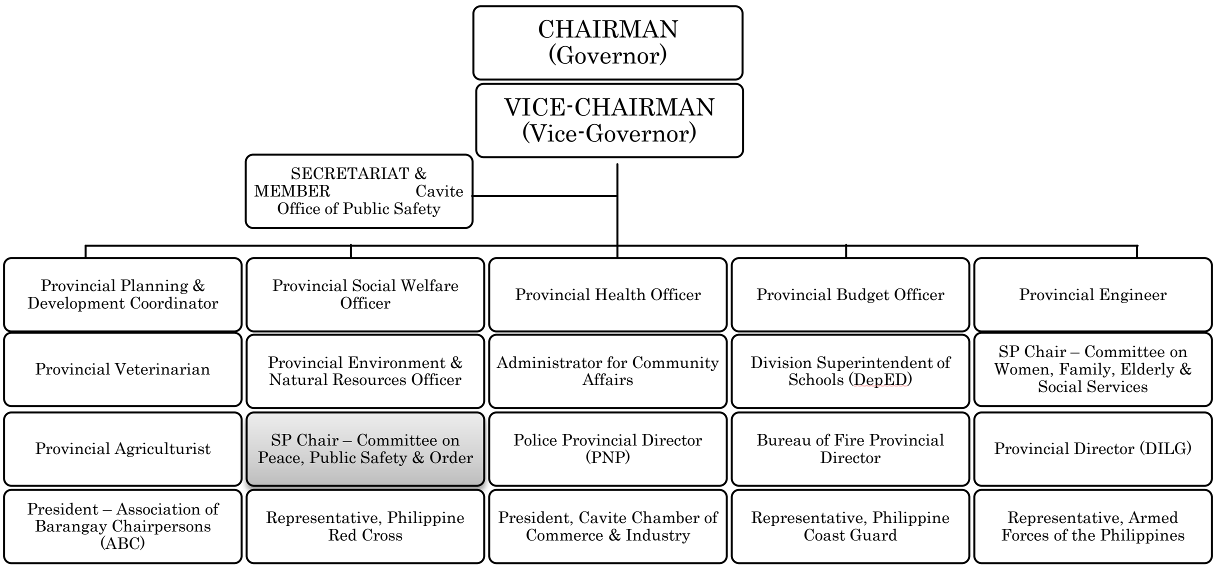


Figure 4.2.4 Disaster Management Organization of Cavite Province

(4) Laguna Province

The disaster management organization of Laguna Province is shown in Figure 4.2.5. The Provincial Disaster Risk Reduction and Management office is in charge of disaster management in Cavite Province. The Provincial Disaster Risk Reduction and Management Office works on research and planning, warning and training, and water search and rescue.

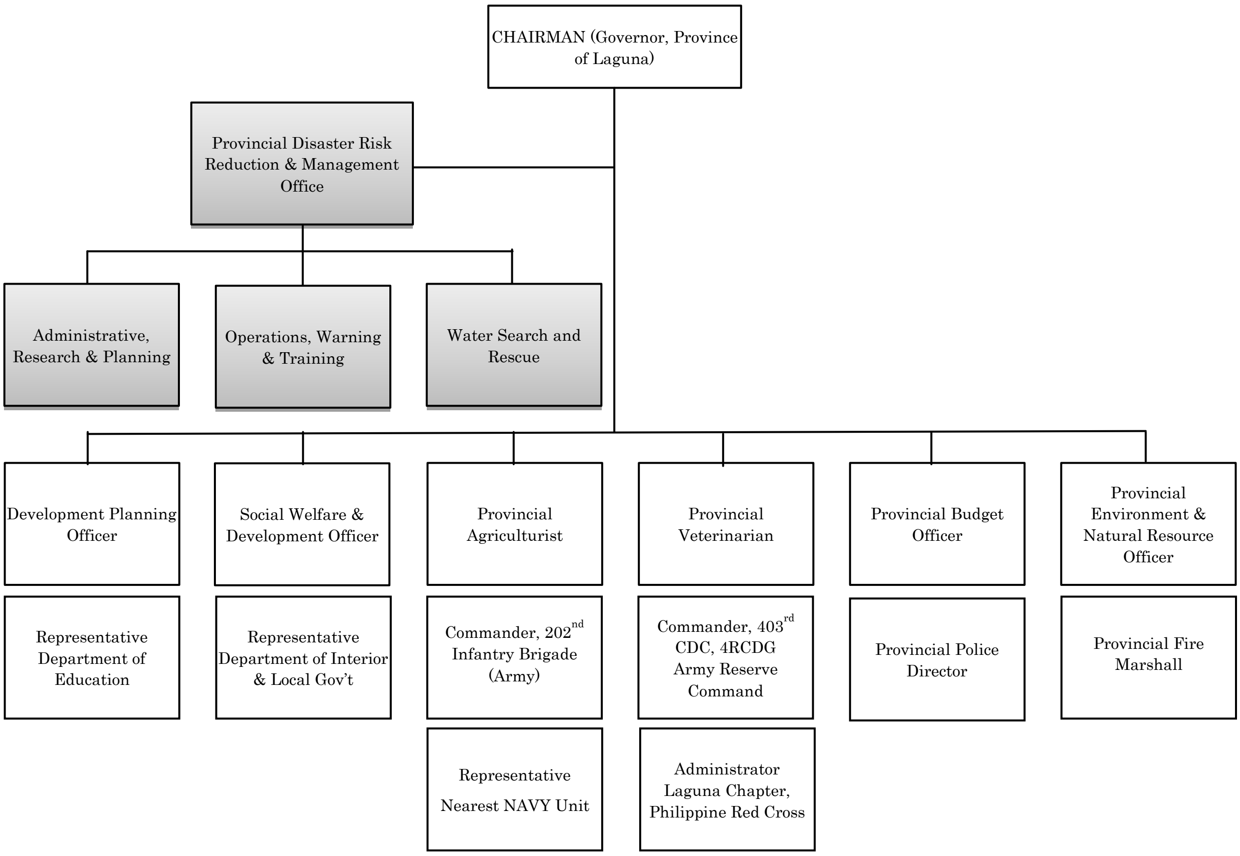


Figure 4.2.5 Disaster Management Organization of Laguna Province

4.3 Present State of Industrial Agglomerated Areas

For the formulation of the Area Business Continuity Plan, the Cavite Economic Zone was selected as the industrial park representing the others in the Industrial Agglomerated Areas. There are 42 industrial parks in the three provinces, i.e. Cavite, Laguna and Batangas. Japanese tenants are located in 17 of 42 industrial parks. The total number of the Japanese companies is 292. Of this, 96 Japanese companies are located in the Cavite Economic Zone, which accounts for the largest proportion.[1]

1 ASEAN-Japan Centre Website

4.3.1 Industrial Parks in the Industrial Agglomerated Areas

The JICA Study Team visited Cavite Economic Zone and Laguna Technopark for interviews. The following are summaries of these two parks.

Cavite Economic Zone (CEZ)

The Cavite Economic Zone is wholly-owned and governed by PEZA, which currently manages 2,900 companies with 912 thousands employees all over the Philippines. There are 292 tenants presently operating in CEZ. The companies are mainly from the electronics industry, which accounts for 99 tenants. This is followed by the fabricated metal products industry with 50 tenants and the garments/textiles and rubber/plastic industries with 35 tenants each. The rest include industries related to by paper/cardboard, machinery/equipment, office/computing machines, and printing, with a total of 17, 9, 9, and 6 tenants, respectively. Many industries are Japanese companies, which accounts for 32% of the tenant population. South Korean tenants have similar numbers.

Electric power is supplied to CEZ by Trans Asia Oil, which is an IPP that generates and sells electricity. Power transmission is conducted by the government corporation NGCP [2]. TRANSCO and MELARCO distribute electricity to the end user, PEZA. In January 2013, a power purchase agreement between the IPP and PEZA was signed for five years. PEZA contracts with each tenant for power supply and charges for distribution at a rate of PHP 0.6 per kWh, which includes direct costs and overhead costs.

Source: PEZA

Figure 4.3.1 Master Plan of the Cavite Economic Zone

Laguna Technopark, Inc. (LTI)

Laguna Technopark, Inc. is located in the government Priority Promotion Centre in the Calabarzon region near Metropolitan Manila.

1) 50 km from the Manila International Airport
2) 52 km from the Manila North Harbor

[2] National Grid Corporation of the Philippines, privatized to be in charge of the operation and maintenance of national transmission lines owned by Transco (state-run company).

3) 44 km from the Makati Central Business District, i.e. the largest financial center

In 1989, LTI was established as a joint venture between Ayala Land, Inc. (75% of investment) and the Mitsubishi Corporation (25% of investment). LTI is an operating Special Economic Zone with 220 tenants. Most of these tenants are Japanese. To date, there are 48% Japanese enterprises operating inside the LTI, which are mostly export manufacturing companies whose businesses activities vary from semi-conductors, automotive, pharmaceuticals, and home appliances[3]. The remaining 52% is from the countries including the Philippines, Korea, America, Italy, Ireland, Singapore, Germany, Australia, Canada, France, Russia, India, Spain, Malaysia, and the Netherlands. The actual number of Japanese-owned companies in Laguna Technopark is 90 to date[4]. Most of the tenants, i.e. 70%, are exporting companies. The leading manufacturers are from the automotive industry with electronic manufacturing companies coming as second.

Infrastructure at Laguna Technopark includes:

1) Highway–grade concrete roads
2) Digital hybrid fiber-optic telecommunication network capable of full video, data, internet and voice communications
3) Ample supply of industrial water and potable water sourced from deep wells
4) Available pipelines for the supply of industrial gasses
5) Sewer and drainage system
6) Power substation with one 133MVA and one 50MVA transformer
7) Easily accessible via the South Luzon Expressway and three roads
8) Fire brigade and security force owned and managed by the Laguna Technopark Association (membership system)
9) Bureau of Customs office
10) Administration office
11) Banking facility
12) Multi-purpose hall
13) Transport terminals

Typhoons (e.g. Milenyo[5] and Ondoi[6]) have caused damage to the sewerage system, wastewater treatment facility, and electricity supply system. Therefore, Melarco installed power substations consisting of transformers[7] dedicated to LTI to maintain a stable supply of electricity to the tenants. Routine inspections of the power supply system are conducted to minimize power outage caused by floods and typhoons, which may topple utility poles and break electric wires.

[3] Honda, Isuzu, Termo, Hitachi, Fujitsu-Ten, Takata
[4] Source: PEZA and LTI
[5] September 2006
[6] Second most devastating cyclone(September 2009)
[7] Two transformers: 133MVA and 50MVA

4.3.2 Japanese Manufacturer of Medical Products and Equipment

The main business is of this company is the manufacturing of syringes and needle. They hold the largest production share of syringes and needles within the company group at 60%, supplying the markets in Asia, the U.S. and the EU. There are 16 Japanese employees and 2,300 local employees, who commute by company buses from their areas of residence. The factory in Japan is the only alternative supply source for the products.

Regarding their Business Continuity Plan, the head office has created the basic structure. Having an alternative factory is the best solution, but this is not possible. The basic idea for the plan is to pursue temporary alternatives until the production and supply level is back to its normal state. If production stops completely in the Philippines, the Japanese factory will provide an alternative supply, and vice versa. However, before switching the supply source, the following current solution for inventory control should be achieved.

1) Raw materials, which take longer to produce, are to have an inventory reserve of two months.
2) Wrapping film, silicone, and solvents are purchased at the same time from the two sources for security purposes.
3) As metal molds are important tools for producing molded products, the manufacturer contracts with suppliers to be ready to reproduce and deliver such upon notice.

4.4 Transport Infrastructure Conditions

4.4.1 Roads

The population continues to concentrate around the Manila metropolitan area. Including the suburbs, the population is 21.29 million (as of 2011) and the population density is about 3 times that of Tokyo.

Although the transportation network supporting this population is still at an insufficient level, it is improving gradually through the development of circular/radial roads and highways, etc., traffic congestion is still serious.

The transport system in the Manila metropolitan area is still fundamentally composed of a road traffic system. However, there has been a gradual shift to a railed transport system since it was introduced to the area.

The SLEX (South Luzon Expressway) and Metro Skyway connect Laguna Province to the southern metropolitan area. Cavite Province is connected to the southern metropolitan area by the Manila-Cavite toll road.

Figure 4.4.1 Major Expressway

Table 4.4.1 Introductory Note

Name	Legend
Expressway (NLEX)	(blue)
Expressway (SLEX)	(red)
Manila-Cavite Expressway	(purple)
Southern Tagalog Arterial Road (STAR Tollway)	(light blue)
Metro Skyway	(green)
Subic-Clark-Tarlac Expressway (SCTEX)	(orange)

Source: JBIC, Investment Environment of the Philippines 2013

Table 4.4.2 Outline of Related Expressways

Name	Section	No. of Lanes	Length (km)	Year of Opening/ Extension
South Luzon Expressway (SLEX)	Calanba-Laguna	8, 6, 4	36 (60)	1977 / 2011
Manila-Cavite Expressway (CAVITEX)	Manila-Cavite	4	14	1999 / 2011
Southern Tagalog Arterial Road	SLEX-Batangas	4, 2	42	2001 / 2008
Metro Manila Skyway	Metro Manila	6, 4	20	1977 / 2009

Source: JBIC, Investment Environment of the Philippines 2013

Buses play an important role as a means of transportation in Manila. Almost all bus routes use EDSA Avenue, which is one of the beltways in Manila, and where the bus centers are located. Jeepneys, tricycles, and taxis are also used. Cycle rickshaws called pedicabs also serve as an important and popular means of transportation.

4.4.2 Ports

(1) Manila Port

The Manila Port consists of the North Harbor, South Harbor, the Manila International Container Terminal (MICT), and the grain terminal, which is located along the Pasig River and consists of multiple light cargo facilities.

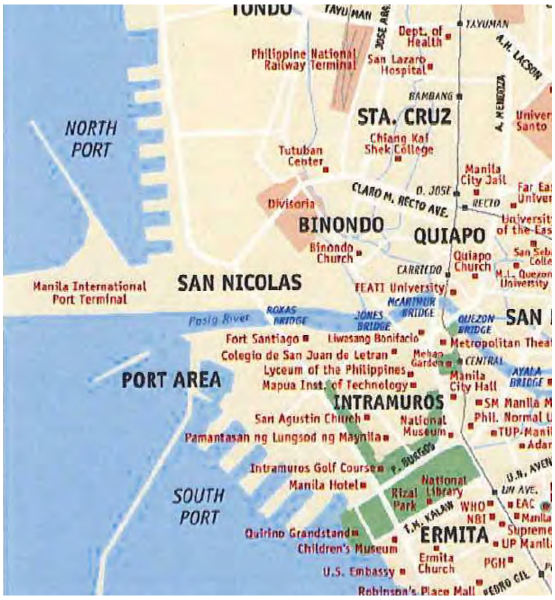


Figure 4.4.2 Manila Port

Table 4.4.3 Manila Port

Area	No. of Berths	Length (m)	Width (m)	Water Depth (m)	Remarks
North Port	9	220~250	80~100	5~8	Comb-shaped port, total length 1,200m
South Port	7	240~430	50~100	14	2 piers are for containers. International cargo is also handled. Total length: 975m Container yard: 30ha
MICT	6	—	—	10.5~12	Total length: 1,520m, Total area: 94ha Container yard: 58ha Cranes: 10

Source：Ministry of Land, Infrastructure, Transport and Tourism, Transportation Situation of the Philippines 2011

The volume of cargo handed at Manila Port is increasing yearly through the reinforcement of cargo-handling equipment.

Table 4.4.4 Shipping and Cargo Statistics: Port of Manila 2012

Item	Breakdown	North Port	South Port	MICT	Total
Number of vessels		5,329	5,671	1,862	12,862
Cargo Throughput (mT)	Total	19,174,424	11,130,626	19,966,465	50,271,515
	Domestic	14,482,959	4,232,355	1,054,242	19,769,556
	(Container)	10,902,311	1,482,220	1,054,242	13,438,773
	Foreign	4,691,465	6,898,271	18,892,293	30,482,029
	(Container)	0	5,973,041	17,940,202	23,913,243
	Transit	0	0	19,930	19,930
	Tranship	0	0	113,668	113,668
Passenger		766,942	161,500	0	928,442

Source: Interview by local consultant

It can be seen that demurrage time and level of ship congestion is increasing.

Table 4.4.5 Demurrage Time per Ship

Year	1998	2005	2010
No. of Hours	4.06 (2001)	3.15	7.69

Source: IC-Net Limited, Batangas Port Development Work (II)

(2) Batangas Port

Batangas Port currently has an area of 22.6 ha, and Phase I facilities are listed as follows.

Table 4.4.6 Batangas Port Facilities

No.	Usage	Quantity	Specification
1	Foreign General Cargo Berth	1	185m long, 10m deep
2	Multipurpose Berth	1	230m long, 10m deep
3	Domestic General Cargo Berth	3	470m long, 7.3mdeep
4	Ferry Berth	1	124m long, 4m deep
5	RORO Berth Pier Type	4	5m deep
6	RORO Berth Wharf Type	2	5m deep
7	Fatcraft Berth	7	4-70m long, 2-75m long, 1-120m long
8	Passenger Terminal	1	2 layers×2,132 m^2
9	Foreign General Cargo Transit Shed	1	3,892 m^2
10	Foreign General Cargo Open Area	1	1.3 ha
11	Domestic General Cargo Area 1	1	9,943.70 ha
12	Domestic General Cargo Area 2	1	3.4 ha

Source: PMO-Batangas Officers, Port Introduction Pamphlet

Currently, there is only one regular service route for container ships at Batangas Port. Therefore, there is little growth in cargo throughput. The cause of this is that there has been no shift in cargo handling from Manila Port to Batangas Port.

Table 4.4.7 Cargo at Batangas Port 2012

Item	Breakout	Total
No. of Vessels		5,671
Cargo Throughput (tons)	Total	11,130,626
	Domestic	4,232,355
	(Container)	1,482,220
	Foreign	6,898,271
	(Container)	5,973,041
	Transit	0
	Transship	0
Passengers		161,500

Source: Interview by local consultant

4.4.3 Railways

(1) Outline

The railways are four railways (4) in total: one national railway and three light rail lines.

Figure 4.4.3 Traffic Infrastructure in the Target Region

(2) Philippine National Railway: PNR

The railroad currently operates in only four directions from the Manila metropolitan area because of road network maintenance, natural disasters, decreased passengers, etc. The service is called Commute Express or Commex. 47,000 passengers are carried by 24 motor cars.

Table 4.4.8 PNR Operating Conditions

Line	Section length	Operation	Remarks
Manila-Legazpi	474km	1 round-trip per day	Bicol Train
Manila-Naga		2 trips per day	One way
Manila-Binan	40km	1 round-trip per day	Commuter train
Manila-Alaban		23 round trips per day	

Source: JBIC, Investment Environment of the Philippines 2013

(3) Rapid Transit Railway

The LRT (Light Railway Train) No. 1 and No. 2 lines, and the MRT (Metro Rail Transit) No. 3 line operate in the Manila metropolitan area.

LRT is falls under the Light Rail Transit Authority (LRTA), and MRT is under the management of the Department of Transportation and Communications (DOTC). The Metro Rail Transit Corporation (MRTC) is in charge of management. The number of passengers does not seem to be increasing.

Table 4.4.9 Outline of Rapid Transit Line

Name	Length (km)	Start Year	No of stations	Average No. of Passengers	Operation Interval at Rush Hour
LRT1	18	1985	20	Approx. 470,000/day	1 in 1 minute
LRT2	13	2004	11	Approx. 200,000/day	1 in 5 minutes
MRT3	17	2000	13	Approx. 500,000/day	1 in 3 minutes

Source: JBIC, Investment Environment of Philippines 2013

Table 4.4.10 Number of Passengers（million people）

Name	2010	2011
LRT1	155.87	156.66
LRT2	63.36	63.83
MRT3	153.15	158.81
Total	372.38	379.30

Source: LRTA and DOTC / Metrostar Express

4.4.4 Airports

The only airport in the Manila metropolitan area is the Ninoy Aquino International Airport (NAIA). It is a commercial airport managed by the Manila International Airport Authority (MIAA). There are two (2) runways: 3,737 m x 60 m, and 2,258 m x 45 m, and four (4) terminals as described below.

Although it is desirable to operate with 36 landings/departure per hour for one runway, in the summer, this number can reach 50 landing/departures. Therefore, nighttime use is being studied.

Table 4.4.11 Ninoy Aquino International Airport

Terminal	Use	Japanese Airlines using terminals	Remarks
Terminal 1	Only for international airlines	JAL	16 gates
Terminal 2	Centennial Terminal: only for Philippine Airlines (International and Domestic)		
Terminal 3	International and domestic mixture	ANA	
Terminal 4	Only for domestic airlines		Local airlines

Source: Wikipedia

The Ninoy Aquino international airport is becoming increasingly important every year, and growth has been remarkable in recent years. However, despite this growth, cargo volume is not stable, due to significant yearly changes. Recently, the government has been using two airports in the Manila Metropolitan area: the Ninoy Aquino International Airport and the Clark Airport. The Clark airport was used by 1.015 million passengers travelling internationally 2012. This is about four (4) times the number of the passengers in 2005 (224,000).

The Ninoy Aquino International Airport will function as a primary shelter for evacuees during times of disaster.

Table 4.4.12 Air Traffic Statistics: Manila and Clark

Airport		2008	2009	2010	2011	2012
Manila (NAIA)						
International						
	Passengers (x1,000)	11,273	11,203	12,380	12,969	14,140
	Cargo (x1,000 MT)	263	238	307	269	311
	Aircraft (x1,000)	60.5	64.4	67.6	144.8	159.7
Domestic						
	Passengers (x1,000)	10,980	12,905	14,940	16,583	19,750
	Cargo (x1,000 MT)	92	186	119	121	150
	Aircraft (x1,000)	144.7	158.4	168.6	290.7	386.8
Clark						
International						
	Passengers (x1,000)	491	560	608	725	1,015
	Cargo (x1,000 MT)	0.1	0.1	<0.1	<0.1	<0.1
	Aircraft (x1,000)	2.0	2.6	2.7	7.0	9.3
Domestic						
	Passengers (x1,000)	40	31	46	42	300
	Cargo (x1,000 MT)	<0.1	<0.1	<0.1	0	0
	Aircraft (x1,000)	0.6	0.6	0.4	0.6	3.5

Source: DOTC-Air Transport Planning

4.5 Lifeline Facilities and Public Services

4.5.1 Electricity

(1) Outline

In Metropolitan Manila and the Province of Cavite, the National Power Corporation (NPC) supplies electric power to the Manila Electric Company (MERALCO), which distributes electricity to the general public. First Laguna Electric Cooperative (FLECO) supplies electricity in the Province of Laguna, and MERALCO distributes in the other areas. It is an area equivalent to 25% of the population of Philippines, with 5,026,543 customers served (as of 2011).

MERALCO is supplied from the independent power producers (IPP) NPC TSCs and WESM. They are also making an effort to secure new suppliers for the long term.

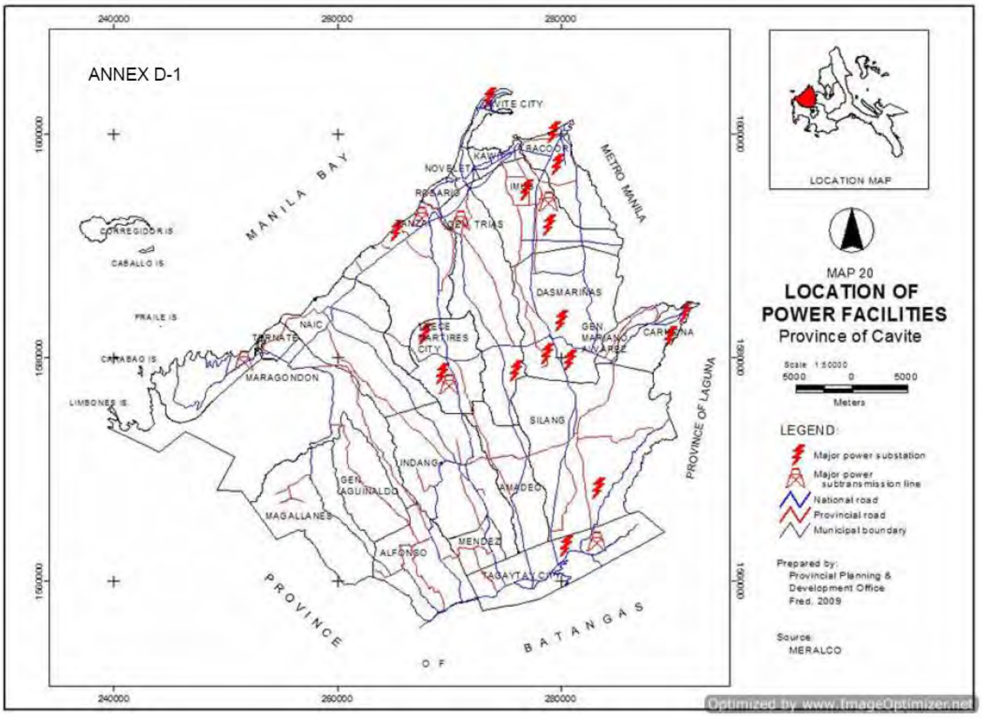
Table 4.5.1 MERALCO Electricity and Sales

Company	Power Distribution Area	Production (GWh)	Distribution Share (%)	Sales (100 million pesos)	Sales Share (%)
MERALCO	National Capital Region (NCR)	32,471	67	506	30

Source: JBIC, Investment Environment of the Philippines 2013

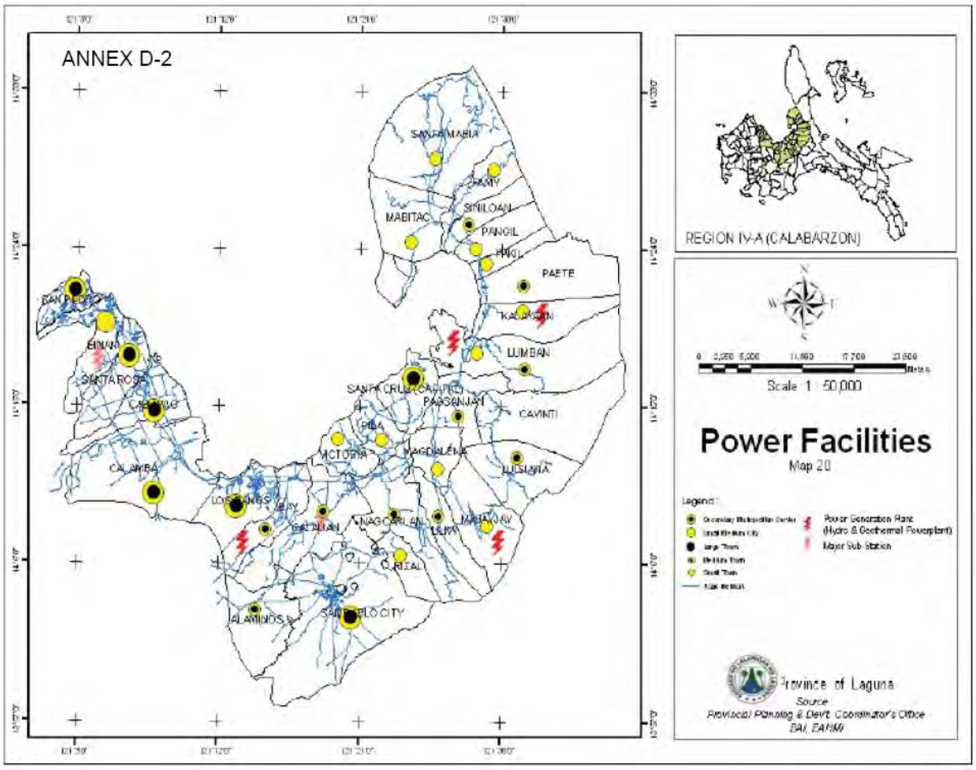
Source: MERALCO 2011 Annual Report

Figure 4.5.1 Distribution Area of MERALCO



Source: Interview by local consultant

Figure 4.5.2 Power Facilities in Cavite Province



Source: Province of Laguna, Provincial Development and Physical Framework Plan

Figure 4.5.3 Power Facilities in Laguna Province

(2) Natural Disasters

When the Typhoon Milenyo hit in 2006, the electric power supply was stopped for about ten days at the industrial park. This is because many utility poles outside were toppled. After this typhoon passed, electric power was cut off over two days, because electrical substation facilities and old power lines were damaged.

4.5.2 Water

The population with water service around the project area is as follows.

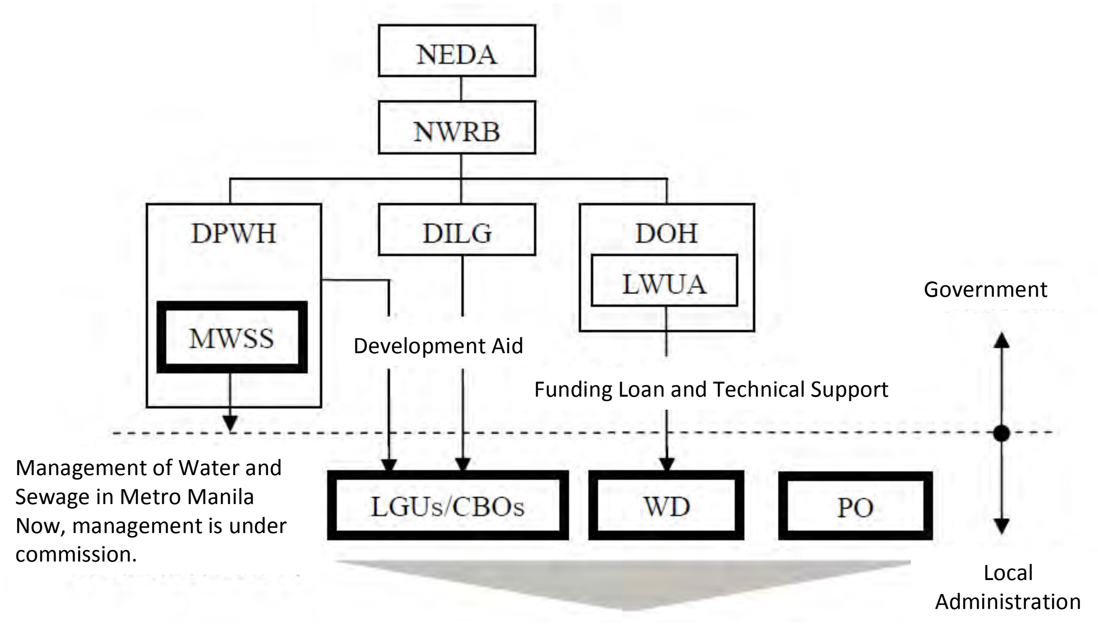
Table 4.5.2 Water Service Population by District in 2007

No.	Area	Approximate population	Ratio of the population to which safe water is supplied (%)	Representative City
NCR	NCR	12 million people	91	Manila
IV-A	CALABARZON	12 million people	89	Laguna, Cavite

Source: Ministry of Health, Labor and Welfare, International Water Promotion Report 2012.3

In the Philippines, the National Economic and Development Authority (NEDA) has formulated the National Development Policy, and the maintenance and management of water services are performed based on this policy. Moreover, the National Water Resource Board (NWRB) regulates water rates and use of water resources.

The Metropolitan Waterworks Sewerage System (MWSS) has jurisdiction over the water and sewage of the Metropolitan Manila. Other areas are managed by municipal corporations (Local Government Units: UGUs), the water service cooperatives (Community Based Organizations: CBOs) and the private sector companies (Private Operator: PO).



Source: Ministry of Health, Labor and Welfare, International Water Promotion Report 2012.3

Notes: DPWH: Department of Public Works and Highways
LWUA: Local Water Utilities Administration
DILG: Department of Interior and Local Government
DOH: Department of Health

Figure 4.5.4 Relationship between Government Organizations and Water Utilities

Manila Water Company, Inc. (MWCI) and Maynilad Water Services, Inc. (MWSI) engage in water supply services for Manila. In the West Zone, which is the target study area, Maynilad supplies water.

Table 4.5.3 Water Consumption in South Manila 2012

Vendor	Service area	Consumption (mil. m^3)	No. of Connections
MWCI	Makati	47.6	N.A.
MWSI	Muntinlupa	3.65	125,511
MWSI	Paranaque (Old Manila)	4.43	115,827

Source: Interview by local consultants

Source: Tokyo University, Water Project in the Philippines 2008

Figure 4.5.5 Service Area

In the Province of Laguna, there is no accurate data on water services. In the Province of Cavite, water is supplied to 253,300 locations by 18 water suppliers, which consists of public institutions and private companies. Of these locations, 40,778 are covered by MWSI. According 2012 statistics, 1.46 million m³ of water is supplied for 63,459 households.

Table 4.5.4 Water Service Population Ratio by Nationwide Level of Service

<table>
<tr><td colspan="5">Population which receives service by government endorsement 80%</td><td rowspan="3">Water supply by the other methods (Private wells, tanks, etc.) 20%</td></tr>
<tr><td colspan="3">Level III
(Door-to-door piped water supply）
45%</td><td>Level II
(Water supply by public taps)
10%</td><td>Level I
(Independent heads such as shallow wells)
25%</td></tr>
<tr><td>WD
20%</td><td>PO
5%</td><td>LGU-CBO
20%</td><td colspan="2">LGU-CBO
35%</td></tr>
</table>

Source: Ministry of Health, Labor and Welfare, International Water Promotion Report 2012.3

4.5.3 Communications

(1) Outline

In the Philippines, the diffusion rate of fixed-line telephones is low. Therefore, they have a high dependence on mobile phones as well as wireless communications, which is related to the quick spread of the internet.

The Philippine Long Distance Telephone Company (PLDT) and Globe Telecom monopolize the communications industry market. The National Telecommunications Commission (NTC) regulates and supervises the telecommunication business.

(2) Telephones

In the Philippines, there is only small number of subscribers to fixed-line telephones. In 2011, about 3.55 million people were subscribed, with a diffusion rate of 3.8%. This situation is greatly affected by geographical conditions, as the country consists of island groups. Conversely, there are 94 million mobile phone subscribers with a diffusion rate of 99.3%, or one mobile phone per person. A prepaid system, which uses cards, etc., to pay charges beforehand is commonly used. In the mobile communications market, two companies, Globe and Smart, which are subsidiary companies of PLDT, share 99% of the market.

Data fees are 50 pesos per day, which has caused an increase in the use social medias such as e-mail and chatting. Although Nokia is most widely used model of mobile phone, various models such as Samsung, Apple, and Blackberry are also used. It is expected that smart phone usage will increase greatly in the future.

Table 4.5.5 Nationwide Subscribers and Diffusion Rates for Fixed-line Telephone Services

Year	2007	2008	2009	2010	2011
Number of Fixed-line Telephone Subscribers (x 1,000)	3,940	4,076	6,783	6,783	6,782
Diffusion Rate of Fixed-line Telephones (%)	4.4	4.5	7.4	7.3	7.2

Source: ITU-World Telecommunication/ICT Indicators Database 2012

Table 4.5.6 Fixed-line Telephones in Laguna and Cavite 2011

Province	Items	Fixed-line Telephone	Public Calling Office (PCO)
Laguna	Total	257,525	471
	PLDT	110,881	-
	Digital	60,878	471
	Others	28,766	-
Cavite	Total	151,913	169
	PLDT	95,817	-
	Digital	52,096	169
	Others	4,000	-
Total		409,438	640

Source: Interview by local consultant

Table 4.5.7 Nationwide Subscribers and Diffusion Rates for Mobile Phone Services

Year	2007	2008	2009	2010	2011
Number of Mobile Phone Subscribers (x 1,000)	57,345	68.117	75,587	79,896	87,256
Diffusion Rate of Mobile Phones (%)	64.7	75.5	82.4	85.7	92.0

Source: ITU-World Telecommunication/ICT Indicators Database 2012

(3) Internet

In 2011, there were about 5.2 million internet subscribers (5.5% diffusion rate), and there are about 1.8 million broadband subscribers (1.9% diffusion rate). Although internet usage has spread well, broadband usage is not progressing due to high monthly charges.

The main internet sites used in the Philippines are: 1. Facebook, 2. Google, 3. Yahoo, 4. Wikimedia Foundation, and 5. Microsoft. The share rates of devices used for internet access are: desktop PC (61%), laptop PC (28%), and mobile devices (3%).

Table 4.5.8 Nationwide Subscribers and Diffusion Rates for Broadband Services

Year	2007	2008	2009	2010	2011
Number of Broadband Subscribers (x 1,000)	496	1,046	1,722	1,722	1,791
Diffusion Rate of Broadband %	0.6	1.2	1.9	1.8	1.9

Source: ITU-World Telecommunication/ICT Indicators Database 2012

(4) Broadcast Market

Terrestrial television broadcasting is offered by three commercial broadcasters (ABC-CBN, GMA and ABC) three state-run broadcasters (Peoples TV, Solar TV and IBC). Cable TV is offered by more than 1,000 companies. Broadcasting stations in Manila cover the provinces of Laguna and Cavite.

4.5.4 Gas

(1) Gas

In the Philippines, liquefied petroleum gas (LPG) is used at home and for taxis. Gas cylinders of about 11.2 kg are mainly used. Gas is commonly used by contacting one of the 23 sellers in Metropolitan Manila and having it delivered.

There are two sellers in Cavite. Department of Energy (DOE) data shows that there are nine LPG refinery plants in the Province of Laguna, with 13 in the Province of Cavite.

(2) Oil Depots

Oil depots in the region are as follows.

Table 4.5.9 Oil Depots in Metro Manila (NCR) and Region IV-A

Region	Province	City/ Municipality	No.	Storage Capacity (in 1,000 barrels, MB)
Total NCR			25	2,077
NCR		Manila	8	1,645
		Mandaluyong	3	144
		Muntinlupa	1	2
		Paranaque	1	94
		Pasay	1	33
		Taguig	2	5
		Pasig	3	50
		Navotas	1	76
		Caloocan	2	1
		Valenzuela	3	28
Total REGION IV-A*			15	10,623
Region IV-A (Calabarzon)	Cavite	Rosario	1	77
		Naic	1	100.93
	Laguna	Alaminos	1	1
	Batangas	Mabni	2	326
		San Pascual	2	1,783
		Calaca	1	504
		Batangas City	4	767
		Tabangao	2	7,065
	Quezon	Candelaria	1	0.5
*Includes refinery storage capacity.				

Source: Interview by local consultant

4.5.5 Waste

(1) Outline

Management of waste in the Metropolitan Manila area is based on guidelines formulated by the National Solid Waste Management (NSWMC). The Department of Environment and Natural Resources (DENP) implements policy, and the Metro Manila Development Authority (MMDA) performs comprehensive management from the collection of waste to waste disposal.

The amount of waste generated in the Metropolitan Manila area is 8,400 to 8,600 tons per day, with 0.7 kg generated per general household.

Sixteen municipalities in Laguna operate open dumpsites. Private entities also provide waste disposal services. There are two sanitary landfills and one controlled dumpsite operated by private entities. Laguna, like Cavite, has no data on the volume of generated waste.

In Cavite Province, since there is no sanitary disposal landfill site, waste disposal is a pending issue among residents. Although the present throughput for waste treatment is unknown, statistics from 2002 show a volume of 1,540 m^3/day. The Cavite municipal government has taken on the challenge of implementing waste treatment. Although the local government of Cavite uses their own independent disposal methods, these methods do not satisfy Republic Act 9003. Thus, for the time being, efforts are being made to reduce the quantity of the garbage from households.

(2) Composition of Municipal Waste

The composition of waste by its source is as follows.

Table 4.5.10 Composition by Source

Place of Discharge	Ratio (%)
Homes	74.50
Restaurants	8.18
Commercial Establishments	10.24
Markets	6.13
Schools and Offices	0.75
Street Cleaning	0.42
Rivers	0.11

Source: Tokyo Environmental Public Service Corporation（2003, MMDA)

The composition of municipal waste is as follows.

Table 4.5.11 Composition of Waste

Name of Waste	Ratio (%)
Kitchen Waste	45
Paper	17
Plastics	16
Metals	5
Grass and tree clippings, etc.	7
Leather and rubber goods	1
China and stones	1
Cloth	4
Glass	3
Other	1
Total	100

Source: Tokyo Environmental Public Service Corporation（2003, MMDA)

(3) Final Disposal Site

All waste goes to landfill disposal sites, with no intermediate treatment. Data from NSWMC shows that there are 21 sanitary landfill sites, 73 open dump sites, and 36 controlled dump sites in Metropolitan Manila, Region III (Central Luzon), and Region IV-A (CALABARZON, including Cavite and Laguna).

Table 4.5.12 Final Disposal Sites in Metro Manila

Name of Facility	Start of Operation	Type	Area (ha)	Capacity (ton/day)
Montalban Solid Waste Disposal Facility – Rodriguez, Rizal	June 2002	Controlled	14	1,321.12
Barangay Tanza, Navotas	Oct. 2002	Controlled	11	430.00
Lingonan, Valenzuela City	1998	Controlled	14	270.00
Payatas, Quezon City	1973	Opened	21	1,294.00
San Pedro, Laguna		Controlled	14	467.00
Catmon, Malabon		Opened	14	195.00
Pier 18, Tondo, Manila		Opened	-	186.00
Pulang Lupa, Las Pinas		Controlled	7	228.00
			Total	4,391.12

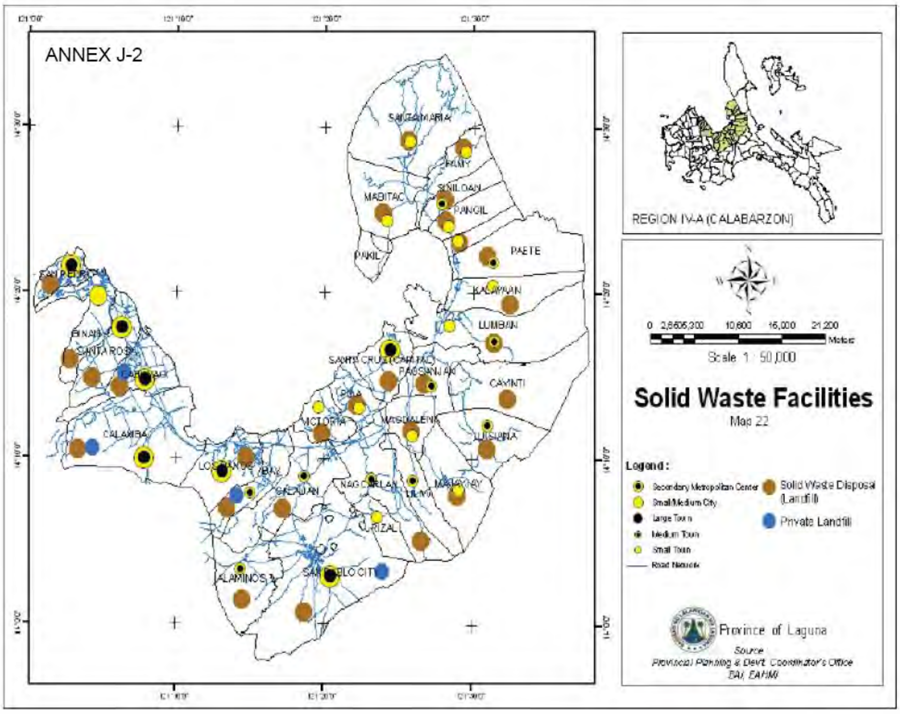
Source: Tokyo Environmental Public Service Corporation（2003, MMDA)

NSWMC has the following statistics limited to Laguna and Cavite, in addition to those shown above.

Table 4.5.13 Number of Solid Waste Management Facilities: Laguna and Cavite 2011

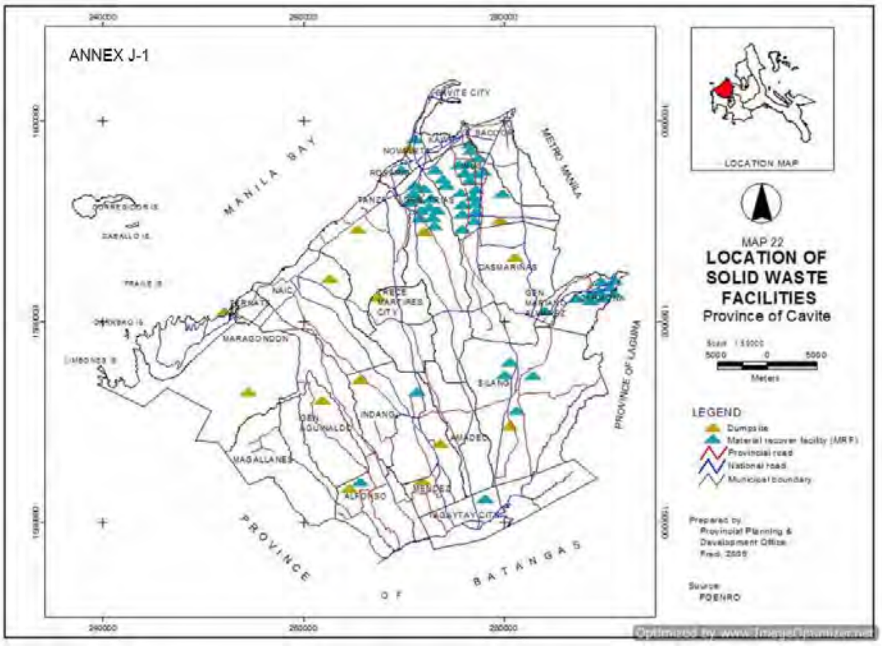
Province	Open Dumpsite	Material Recovery Facilities	Solid Waste Treatment		
			Number	Total Area (ha)	Total Capacity (ton/day)
Laguna	12	128	4	>10.7	>350
Cavite	5	55	1	800	55

Source: NSWMC



Source: Province of Laguna, Ecological Profile

Figure 4.5.6 Solid Waste Facilities in Laguna Province



Source: Interview by local consultant

Figure 4.5.7 Solid Waste Facilities in Cavite Province

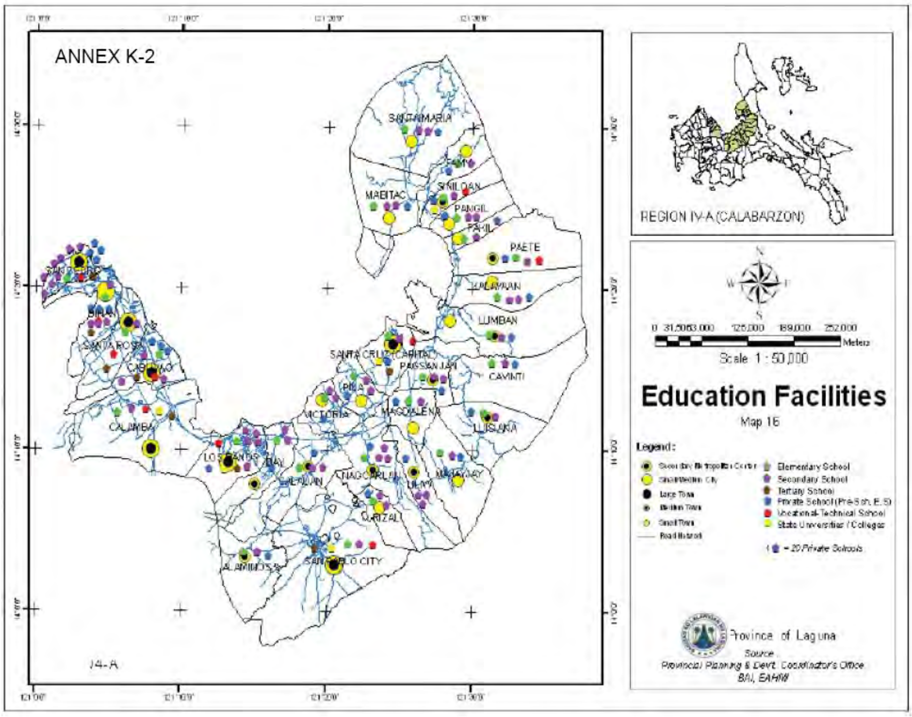
4.5.6 Schools

The number of schools and enrollment are as follows.

Table 4.5.14 Number of schools and enrollment

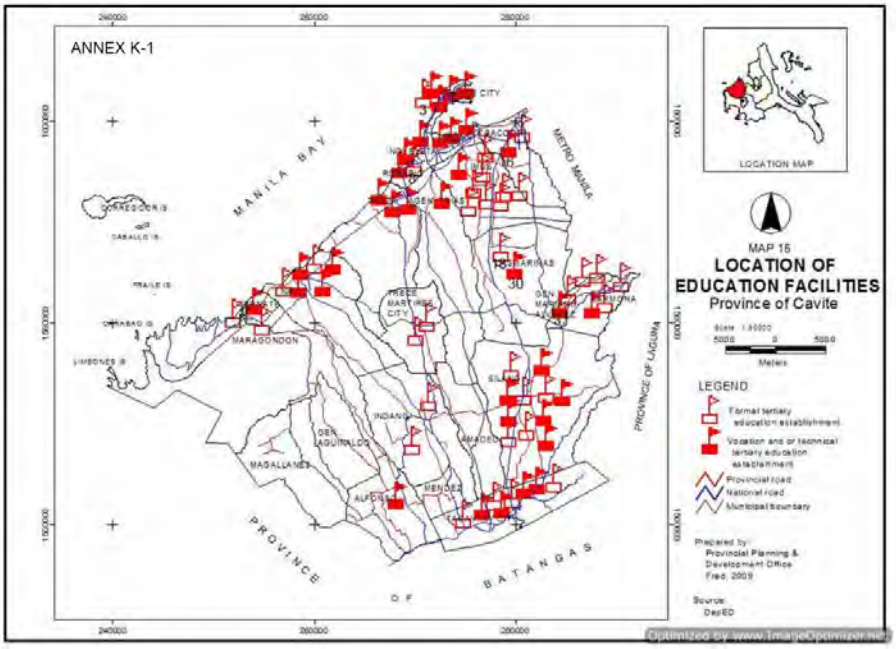
	Laguna Province 2008-2009		Cavite Province 2012		Total	
	Schools	Students	Schools	Students	Schools	Students
Primary/Elementary	757	190,409	1,122	445,036	1,879	635,445
Public	473	-	373	350,650	846	-
Private	284	-	749	94,386	1,033	-
Secondary	251	94,300	513	242,751	764	337,051
Public	105	-	81	74,641	186	-
Private	146	-	432	78,684	578	-
Tertiary (College and Univ.)	73	-	69	-	142	-
Public	16	-	16	-	32	-
Private	57	-	53	-	110	-

Source: Interview by local consultant



Source: Province of Laguna, Provincial Development and Physical Framework Plan

Figure 4.5.8 Education Facilities in the Province of Laguna



Source: Interview by Local Consultant

Figure 4.5.9 Education Facilities in the Province of Cavite

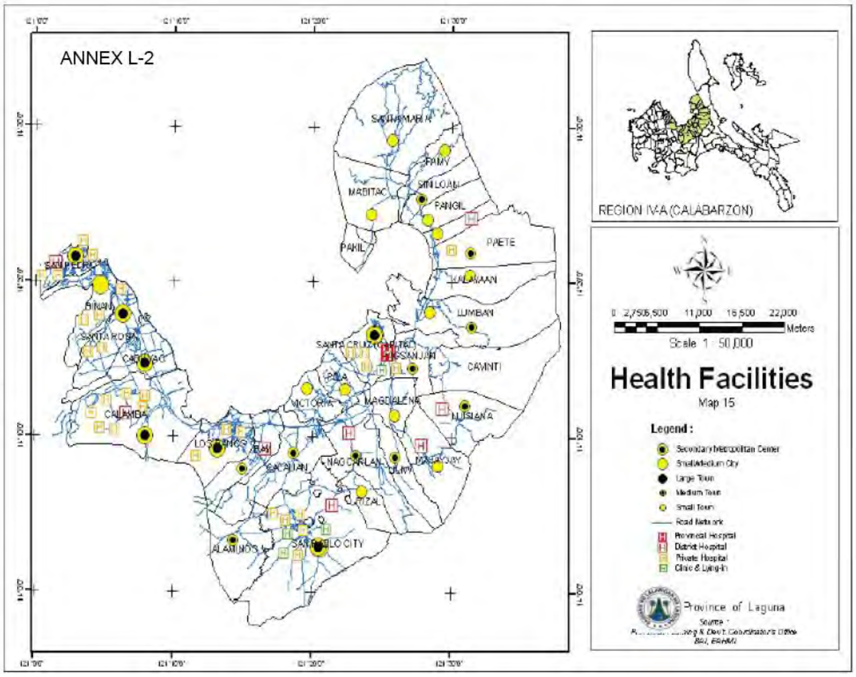
4.5.7 Hospitals

There are 102 hospitals in Laguna and Cavite Provinces.

Table 4.5.15 Number of Hospitals 2009

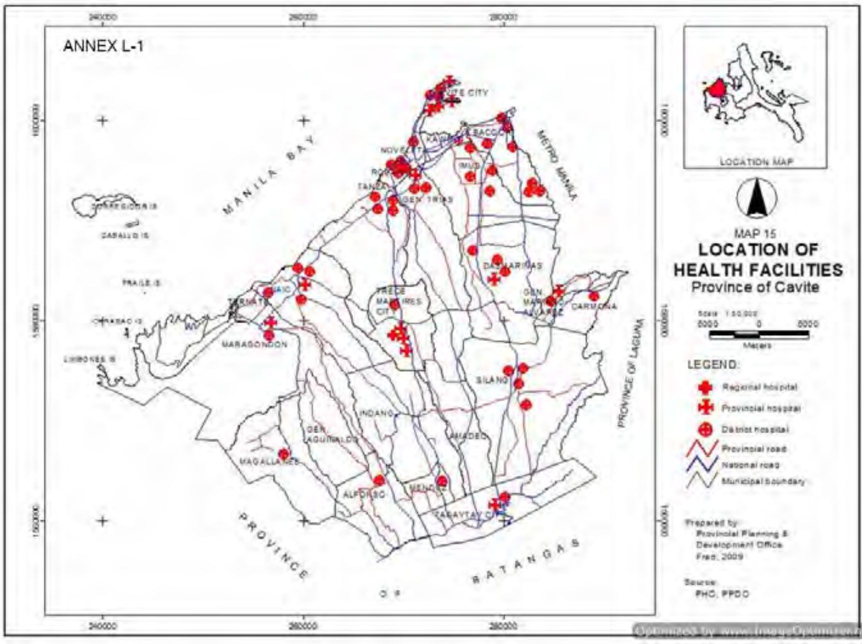
Item	Laguna	Cavite	Total
Total	49	53	102
Government Owned	9	12	21
Private	40	41	81
Number of Beds	1,600	2,312	3,912

Source: Interview by local consultant



Source: Province of Laguna, Provincial Development and Physical Framework Plan

Figure 4.5.10 Health Facilities in the Province of Laguna



Source: Interview by local consultant

Figure 4.5.11 Health Facilities in the Province of Cavite

4.6 Economic Relations with Neighboring Regions and Japan

4.6.1 Overview of the Economy of Pilot Area

The pilot area is known as the Calabarzon region (located south of Manila and composed of the provinces of Cavite, Laguna, Batangas, Rizal and Quezon), and investment is being made in activities such as the construction of industrial parks in the region. With this region, Japanese companies, particularly in the automobile, machinery, and electronics industries, are currently concentrated in the industrial parks of the Batangas region, including the First Philippines Industrial Park (FPIP) and in Lima Technology Center (LTC). The Murata Manufacturing Company, Brother Industries, Canon and SHIMANO are operating in FPIP, and companies such as BANDAI, Furukawa Electric, and Epson are located in LTC. Conversely, there are few openings in the industrial parks in Cavite and Laguna provinces, and thus it is almost impossible to move into the area.

At the Port of Manila, which serves as an important port infrastructure in the capital region, imports account for 70% and exports account for 30% of the total cargo movement. The port is operating at full capacity on a consistent basis. In Batangas, roadway infrastructure connecting to the port of Manila has been improved, and the Port of Batangas is also beginning to be utilized. Similarly, the Port of Subic located north of Manila is also being improved. It is though that increased utilization of these ports will contribute to the improvement of logistical efficiency in Metropolitan Manila.

Traffic congestion is especially serious in the central area of Metropolitan Manila, and takes about 6-7 hours to reach central Manila from the industrial parks in Batangas province (e.g. Lima Technology Center). Conversely, the Port of Batangas is located at a distance of 35 km, and if it is utilized, cargo could be shipped in a little over one hour, making the economic advantage obvious. However, the low import volume at the Port of Batangas makes the operation of logistics companies inefficient.

If the Port of Subic and Port of Batangas become available, in addition to the Port of Manila, alternative logistics route will be secured, and the advantages are obvious even from the point of view of BCP. However, the frequency and cargo handling volume of liner services is low under current circumstances, and to date, there has not been much economic benefit.

4.6.2 Major Economic Policy

In terms of economic development plans in the Philippines, a national level plan known as the Philippine Development Plan (PDP) and a regional level plan known as the Regional Develop Plan (RDP) have been established. Both function to propose economic policy frameworks and are closely linked to one another.

With respect to the details of the development process of the plan, a preliminary draft of the PDP was prepared and circulated among regional offices for review, and then confirmed after their opinions were reflected. After that, RDP is to be established based on PDP. A Regional Development Council is established in each regional office of NEDA, and the opinion of the region will be reflected through the Governor, who shall serve as a Council member.

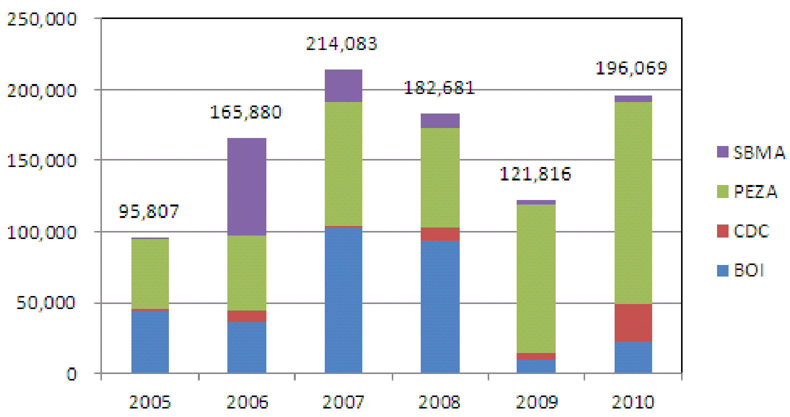
For details of the programs specified in the economic development plan, refer to the Provincial Development Physical Framework Plan (PDPFP) and Comprehensive Development Plan (CDP).

4.6.3 Economic Ties with Japan

In terms of trade value, Japan is the largest trade partner of the Philippines. Looking at the actual performance over the period of 2010-2011, Japan was the largest export destination in terms of export volume. Meanwhile, Japan is also the largest importer from the Philippines, along with the U.S.A. As for the trade with other countries, import from China has increased drastically, and is approaching the level of Japan and U.S.A.

Also, by examining the amount of foreign direct investment by country, Japan has become the largest investor in the Philippines. In terms of the cumulative amount of FDI approved over the past six years from 2006 to 2011, Japanese FDI has been the largest, accounting for almost one-fourth of the total.

The trends in total approved Foreign Direct Investments in 2005-2010 are shown below. Due to the negative economic impacts caused by the global economic recession, the total amount of FDI dropped in 2009, but recovered in the following year of 2010. Among the four executing agencies, PEZA takes a major role in promoting FDI from foreign countries.



Agency	2005	2006	2007	2008	2009	2010	Total
BOI	43,797	36,557	102,282	93,552	10,397	22,329	**308,913**
CDC	1,329	8,083	1,462	9,243	4,536	26,250	**50,903**
PEZA	49,842	52,338	87,376	70,355	103,421	142,167	**505,500**
SBMA	839	68,902	22,963	9,531	3,462	5,323	**111,020**
Total	**95,807**	**165,880**	**214,083**	**182,681**	**121,816**	**196,069**	**976,335**

Source: Invest Philippines 2012 (http://www.investphilippines.gov.ph/statistic2.html)

Figure 4.6.1 Total Approved Foreign Direct Investments by Promotion Agencies 2005-2010 [million pesos]

The trends of total approved Foreign Direct Investments by country of investor in 2005-2010 are shown below. Of the total FDI in 2005-2010, Japan (231.4 billion pesos) is on the top, followed by South Korea (158.0 billion pesos) and the United States (135.0 billion pesos).

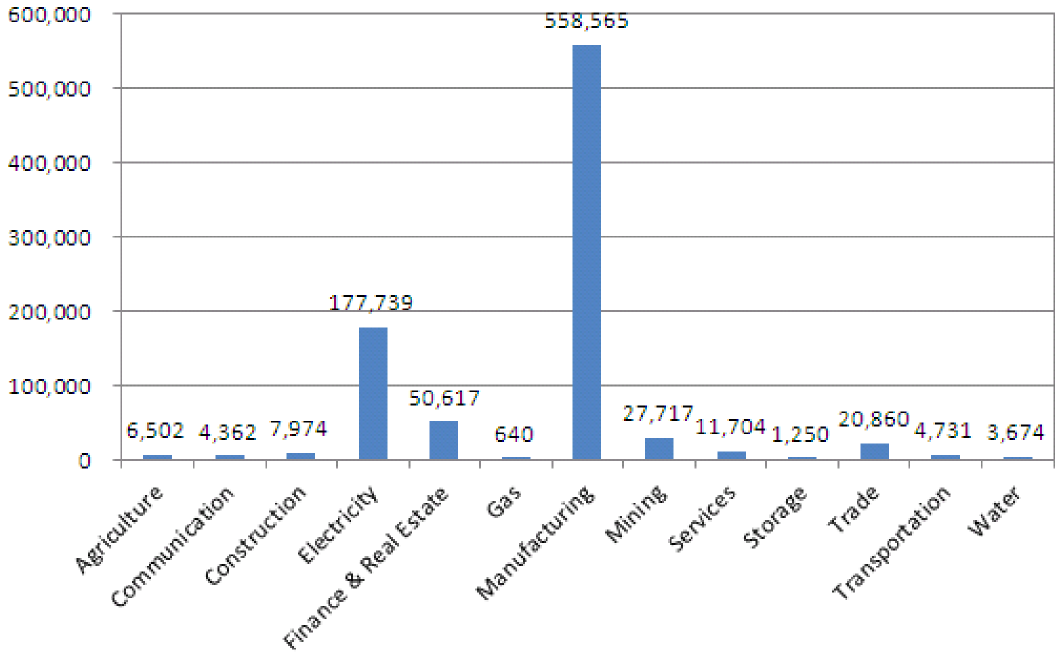
Table 4.6.1 Total Approved Foreign Direct Investments by Country of Investor 2005-2010 [million pesos]

Country	2005	2006	2007	2008	2009	2010	Total
Australia	563	689	705	1,347	799	615	**4,719**
Belgium	-	-	-	-	-	30	**30**
Bermuda	-	-	-	654	-	-	**654**
Br. Virgin Islands	658	5,450	670	2,111	1,176	7,654	**17,719**
Canada	-	-	-	582	312	157	**1,051**
Cayman Islands	13,817	384	521	3,616	-	10,638	**28,976**
China	195	17,935	1,822	2,307	2,392	5,657	**30,307**
Denmark	-	-	-	-	146	-	**146**
France	46	1,106	746	822	112	602	**3,433**
Germany	418	306	3,301	3,765	1,001	1,097	**9,887**
Hong Kong	93	553	1,464	1,135	3,923	59	**7,227**
India	-	-	-	-	634	1,857	**2,491**
Indonesia	-	11	-	-	-	-	**11**
Italy	8	18	21	-	-	-	**47**
Japan	27,539	20,066	38,587	16,116	70,737	58,333	**231,378**
South Korea	10,828	54,327	12,077	39,954	9,624	31,182	**157,991**
Luxembourg	-	-	-	-	726	-	**726**
Malaysia	69	856	7,562	112	96	754	**9,449**
Manx	-	-	-	-	-	-	**-**
Nauru	-	439	-	-	-	-	**439**
Netherlands	19,208	7,188	14,401	45,354	2,070	36,784	**125,005**
Norway	-	-	11,175	4,051	64	-	**15,290**

Singapore	890	6,396	44,246	6,565	3,468	7,284	**68,847**
Sweden	0	165	3	-	-	-	**169**
Switzerland	817	605	99	939	2,622	13,557	**18,637**
Taiwan	1,394	1,953	20,529	1,288	223	1,506	**26,892**
Thailand	1,535	522	187	38	2,482	1,173	**5,937**
UK	195	5,887	10,182	25,273	3,439	1,065	**46,041**
USA	14,913	38,199	36,089	19,721	12,947	13,159	**135,029**
Others	2,623	2,826	9,696	6,934	2,821	2,908	**27,808**
TOTAL	**95,807**	**165,880**	**214,083**	**182,681**	**121,816**	**196,068**	**976,335**

Source: Invest Philippines 2012 (http://www.investphilippines.gov.ph/statistic2.html)

The trends in total approved Foreign Direct Investments by industry in 2005-2010 are shown below. Of the total FDI in 2005-2010, manufacturing (558.6 billion pesos) is on the top, followed by electricity (177.7 billion pesos) and finance and real estate (50.6 billion pesos).



Industry	2005	2006	2007	2008	2009	2010	Total
Agriculture	291	2,381	125	91	2,406	1,209	**6,502**
Communication	-	2,963	1,307	92	-	-	**4,362**
Construction	34	766	6,817	33	93	231	**7,974.0,**
Electricity	10,864	439	74,620	81,279	2,071	8,467	**177,739**
Finance & Real Estate	203	7,627	9,296	11,557	16,433	5,501	**50,617**
Gas	90	-	533	-	17	-	**640**
Manufacturing	67,730	112,665	80,833	48,357	86,133	162,847	**558,565**
Mining	7,313	724	9,655	3,360	631	6,035	**27,717**
Services	8,783	17,386	27,740	36,010	10,891	10,894	**11,704**
Storage	1	13	1,223	13	-	-	**1,250**
Trade	107	19,591	368	322	153	319	**20,860**
Transportation	391	1,325	643	1,568	238	567	**4,731**
Water	-	-	922	-	2,752	-	**3,674**
Total	**95,807**	**165,880**	**214,083**	**182,681**	**121,816**	**196,069**	**976,335**

Source: Invest Philippines 2012 (http://www.investphilippines.gov.ph/statistic2.html)

Figure 4.6.2 Total Approved Foreign Direct Investments by Industry 2005-2010 [million pesos]

4.7 BCP Implementation Conditions

4.7.1 Major Natural Disasters and Disaster Management Awareness

In the Philippines, typhoons, floods, landslides and earthquakes are envisioned as the major natural disasters. Most businesses are not concerned with natural disaster risk. The necessity of preparing of plans for Disaster Risk Management (DRM) and emergency response is not yet well understood.

For most business people in Philippines, the concept of BCP is not well known, and they often do not make a distinction between BCM and DRM.

4.7.2 Implementation of BCP

(1) Implementation of BCP by Enterprises

At businesses in the Philippines, since people have not experienced extensive disaster around Manila, the awareness of risk management for natural disaster is quite low. General enterprises have yet to develop a Disaster Management Plan or Contingency Plan. Furthermore, most enterprises have not conducted activities for ensuring business continuity during disasters.

As an example of DRM implementation, manufacturing companies tend to consider disaster risk as part of their corporate crisis management. Moreover, some enterprises that deal with international business also consider their BCM and develop BCP.

Most SMEs fully rely on local authorities or large-scale companies to establish their disaster risk mitigation systems, since they cannot afford to do so themselves.

(2) Implementation of BCP by Utility Suppliers and Distributors

Utility companies providing electricity, water, and telecommunication have addressed crisis management or DRM relatively well. Some have already developed contingency plans for disaster and/or recovery plans.

In particular, major electricity companies have established disaster risk management systems and BCM. The individual structures of DRM and BCM are conducted in each of their branches, customer center, and data centers. Moreover, they plan to establish an inclusive disaster risk management system through the integration of individual structures.

There are no laws or regulations which obligate utility suppliers to conduct risk assessment and risk management for natural disasters.

(3) Implementation of BCP by Foreign Capital Companies and Japanese companies

Foreign capital companies which are located in industrial parks including automobile manufacturers, electronic manufacturers, and food manufacturers are regarded as advanced enterprises for corporate disaster management. Moreover, some enterprises that deal with international business are required to build contingency plans for disasters or BCP as part of international agreements and tendering.

However, even among foreign capital companies, only some enterprises can afford to conduct BCM for disaster risk. The implementation of BCM/BCP will likely be further addressed in the future.

4.7.3 Efforts for Implementing BCP

(1) Regulations or Guidelines for the Implementation of BCP

Along with the revision of the law on Disaster Risk Management in 2010, the government also revised the disaster management policy to place a high value on disaster preparedness and rehabilitation. Before the revision, the priority issue of governmental policy was emergency response. This revised law established the commitment that every local authority, including provinces, municipalities, towns and the barangay community level must develop a Disaster Risk Reduction Management Plan (DRRMP). However no specific laws or guidelines stipulating the implementation of BCM/BCP have been considered.

For private enterprises, no laws or regulations stipulating the implementation of disaster risk management have been established. Cooperation with national and local disaster risk management is expressly stipulated for every private enterprise and civil organization in the National Disaster Risk Reduction Management Plan (NDRRMP), and private enterprises are also required to implement risk management along with the national and local disaster risk management systems.

After the development of DRRMP among all local authorities, the Office of Civil Defense (OCD) plans to disseminate the preparedness plan for disaster risk, emergency response plan and also a post-disaster rehabilitation plan. Furthermore, they are considering making BCP a requirement in the DRRMP in the future.

(2) Private Sector Efforts in BCP Education and Dissemination

No particular efforts for spreading BCP implementation are being conducted in the private sector. Some conferences, review meetings or seminars pertaining to BCP have been held by private enterprises in conjunction with support from international authorities such as UNISDR. These conferences discussed efforts for raising awareness on the concept of BCP. As an example of efforts undertaken by private enterprises, an industrial symposium held regularly by a major retail company in Philippines has dealt with the implementation of business continuity for crisis management as the main issue for discussion.

4.7.4 BCP Implementation Problems

Infrastructures such as electricity and water distribution have not been adequately developed. In terms of road infrastructure, the main roads around Manila, except toll roads, are often flooded by heavy rain or storms, which negatively impacts business commuters. Since road networks often face heavy traffic congestion, it should be regarded as one of the problems for business continuity.

In addition, most local enterprises in the Philippines cannot afford to establish DRM and BCP in their present circumstances.

4.8 Current State of Disaster Risk Management

In order to review the current state of disaster risk management, questionnaire surveys were conducted by the local consultant.

4.8.1 Questionnaire Surveys

Questionnaires were prepared for five organizations deeply or markedly involved with Area Business Continuity Plans (A-BCP). The purpose of the questionnaires was to analyze the current practices and readiness of both A-BCP and individual BCP. A review of these questionnaires review will be used as a basis for formulating the framework of the JICA's Area Business Continuity Plan.

Focuses of the questionnaires are:

1) assessment of the 10 selected industrial parks;
2) disaster risk management applied by business enterprises as tenants of the Cavite Economic Zone;
3) assessment of lifeline utilities services;
4) assessment of traffic infrastructure operators;
5) disaster risk management applied by various levels of governments.

4.8.2 Reviews of the Questionnaire Surveys for Industrial Parks

The interviews with the industrial parks were facilitated by the Philippine Economic Zone Authority (PEZA) through the Office of Deputy Director General for Finance and Administration Mr. Justo Porfirio LL.Yusingco. The following firms were interviewed using the JICA-AHA Interview/Questionnaire for Industrial Parks Managers.

1) Laguna Technopark Inc. (Laguna Province)
2) Cavite Economic Zone (Cavite Province)
3) Northgate Cyberzone (Muntinlupa City)
4) Cavite Economic Zone II (Cavite Province)
5) Gateway Business Park (Cavite Province)

6) Golden Mile Business Park (Cavite Province)
7) People's Technology Complex (Cavite Province)
8) EMI-Special Economic Zone (Cavite Province)
9) Daiichi Industrial Park (Cavite Province)
10) First Cavite Industrial Estate (Cavite Province)

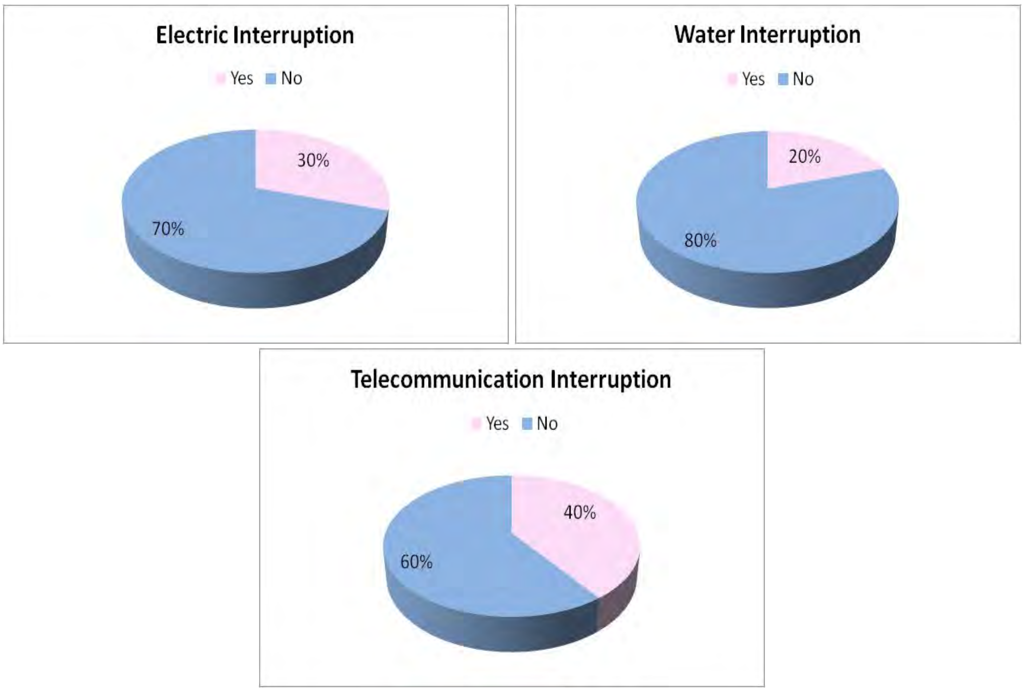
The following is a summary of the findings of the interview survey.

Dates of request and final collection:

1) Date of request: September 4, 2013
2) Date of final collection: September 20, 2013

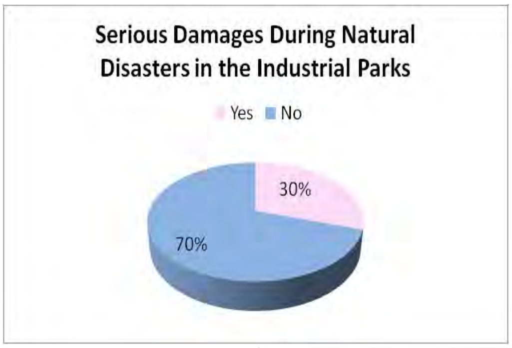
The results of the questionnaire survey for Industrial Parks are as follows.

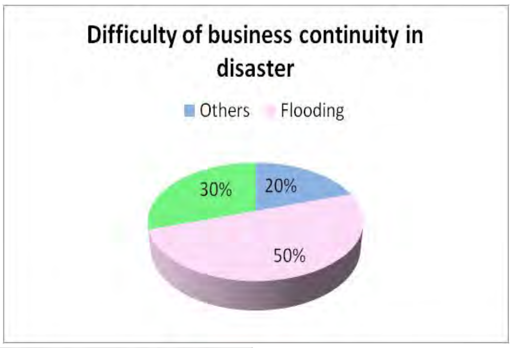
1) Interruption of lifeline utility services

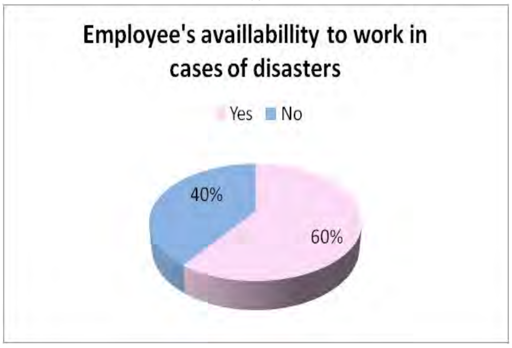


The majority of the industrial parks experienced no interruptions in lifeline utilities.

2) Incidents and natural disasters in the industrial parks







The majority have not experienced serious damage during disasters, while half stated that flooding is a problem. However, the majority have employees available to work during disasters.

4.8.3 Reviews of the Questionnaire Surveys for Business Enterprises

The tenant survey was similarly facilitated through the PEZA's Office of Deputy Director General for Finance and Administration, Mr. Yusingco. The questionnaire was delivered starting the first week of September. The following were the responses of the tenants in the three (3) industrial parks.

1) Cavite Economic Zone (CEZ): 22 out of 146 firms given questionnaires provided answers to the questionnaire survey.
2) Laguna Technopark Inc. (LTI): 13 out of 63 firms given questionnaires provided answers to the questionnaire survey.
3) Northgate Cyberzone (NC): 2 out of 11 firms given questionnaires provided answers to the questionnaire survey.

The low turnout is due to the following factors.

1) The short time duration of the study did not allow for in-person surveys.
2) The distribution of the questionnaire as agreed upon by the JICA-AHA Team with PEZA was through email, which increased the chances of no response.
3) Due to the strict confidentiality of the industrial parks, we were not given the distribution list to follow up on the initial email to the tenants. Only CEZ allowed us to have the list, and follow-up with the tenants was conducted during the last week of September 2013.

The following is the list of respondents by park.

1) Cavite Economic Zone (CEZ)

Table 4.8.1 Tenants in CEZ

No.	Name of tenant/business firm
1	ACE Mannix
2	Faith Achieve Plastics Corp.
3	M. UBIS Phils
4	NT Philippines, Inc. (Plant 2)
5	ALE Component Industries
6	HRD Singapore Pte. LTD.
7	Magnetron Phils Corp
8	S-A-N-G-T-O-P Solutions Co. Ltd., Inc.
9	Cavite Manufacturing Corp
10	Nippon Pulse Tech Phils.
11	Ant Steel Corporation
12	Reliance Apparel & Fashion Mfg. Corp.
13	Taesung Phils. Co., Inc.
14	Oakwave Phils., Corp.
15	IM Tech. Co., Inc.
16	DS Tech. Phils., Inc.
17	AMCA Packaging Solutions, Inc
18	J-Film Philippines, Inc.
19	Yukio Iimura Mfg. Inc.
20	Dai Shin Han Tech Corporation
21	Keon Yang Industrial Phils., Inc.
22	NANBU PHILIPPINES, INC.

Source: WCI (Local consultant in the Philippines)

2) Laguna Technopark Inc. (LTI)

Table 4.8.2 Tenants in LTI

No.	Name of tenant/business firm
1	Ichinomiya Elect Philippines Corp.
2	F-Tech. Phils. Mfg., Inc.
3	JX Nippon Mining & Metals Phils., Inc.
4	Honda Cars Phils., Inc.
5	Surtec Phils., Corp.
6	Imasen Philippine Mfg. Corp.
7	Swedish Match Phil., Inc.
8	EMS Components Assembly, Inc.
9	Terumo (Phils.) Corp.
10	Jfe Shoji Steel Philippines
11	Seafood Fukui Phils., Inc
12	Fujitsu Die-Tech Corp. Phils.
13	Toshiba Information Equipment Phils.

Source: WCI (Local consultant in the Philippines)

3) Northgate Cyberzone (NC)

Table 4.8.3 Tenants in NC

No.	Name of tenant/business firm
1	iHub
2	Plaza C
	Source: WCI (Local consultant in the Philippines)

The following is a summary of the findings of the survey of tenants in the three industrial parks.

Business Enterprises in CEZ

The following is a summary of the findings of the survey of tenants or business firms in CEZ.

1) Date of request and the final collection

Date of request: September 4, 2013

Date of final collection: September 30, 2013

2) Collection ratio (= Collected numbers divided by the total number of requests)

Out of 146 tenants, 21 companies responded.

22/146= 15%

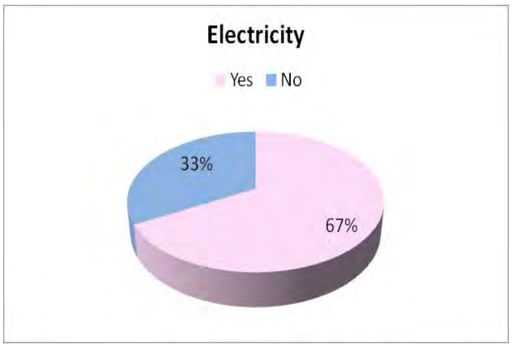
3) Reasons for the low collection ratio

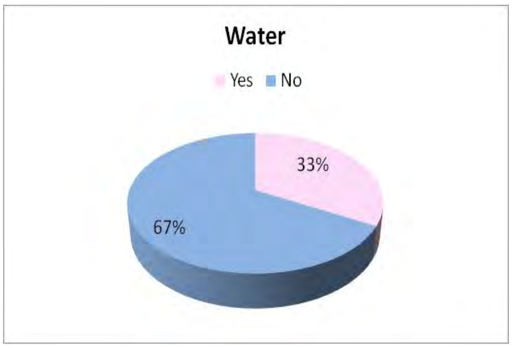
The questionnaires were distributed by email only. Many email addresses were invalid. The industrial park manager permitted email follow-up only much later. The initial questionnaire distributed lacked a letter of request and AHA pamphlet. Because of insufficient time, in-person follow-up was not possible.

4) Interruption of lifeline utility services

- ✓ Electricity interruption due to natural disasters was experienced by 14 out of 21 firms, with a weighted average interruption time of 15 hours.
- ✓ Water service interruption due to natural disasters was experienced by 7 out of 21 firms, with a weighted average interruption time of 14 hours.
- ✓ Communication service interruption due to natural disasters was experienced by 9 out of 21 firms, with a weighted average interruption time of 13 hours.

Interruption of Supply due to Natural Disaster





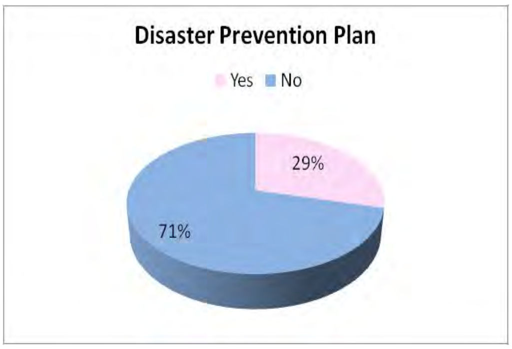
5) Normally used traffic infrastructure and roads

- ✓ Expressway: Cavitex (13/21)
- ✓ Port: Port of Manila (8/21)
- ✓ Airport: Ninoy Aquino International Airport (13/21)
- ✓ Railway: None

6) Alternative traffic infrastructures

- ✓ Roads and expressways: General Trias Drive (2/21)
- ✓ Alternative expressway: South Luzon Expressway
- ✓ Alternative port: Batangas Port
- ✓ Alternative airport: None

7) Disaster Prevention Plans, Business Continuity Plans and concerns



The Business Continuity Plan (BCP) is not well recognized among the tenants.

Business Enterprises in LTI

The following is a summary of the findings of the survey of tenants or business firms in LTI.

1) Date of request and the final collection

Date of request: September 4, 2013

Date of final collection: September 24, 2013

2) Collection ratio (= Collected numbers divided by the total number of requests)

Out of 63 tenants, 13 companies responded.

13/63= 21%

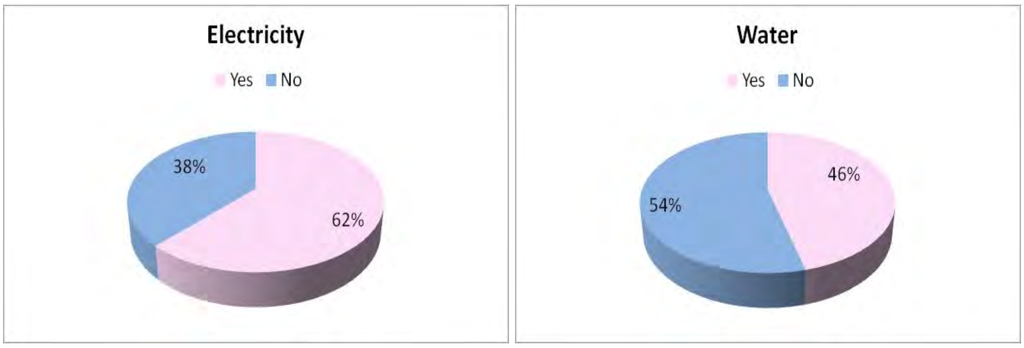
3) Reasons for the low collection ratio

The questionnaires were distributed by email only. The industrial park manager did not supply email address details of the respondents, making email follow-up impossible. Because of insufficient time, in-person follow-up was not possible.

4) Interruption of lifeline utility services

- ✓ Electricity interruption due to natural disasters was experienced by 8 out of 13 firms, with a weighted average interruption time of 11 hours.
- ✓ Water service interruption due to natural disaster was experienced by 6 out of 13 firms, with a weighted average interruption time of 3 hours.
- ✓ Communication service interruption due to natural disaster was experienced by 6 out of 13 firms, with a weighted average interruption time of 5 hours.

Interruption of Supply due to Natural Disaster



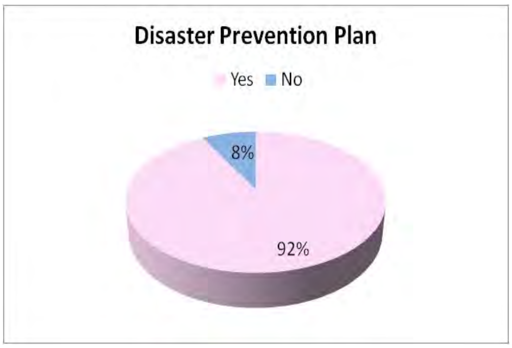
5) Normally used traffic infrastructure and roads

- ✓ Expressway: South Luzon Expressway (13/13)
- ✓ Port: Port of Manila (9/13)
- ✓ Airport: Ninoy Aquino International Airport (13/13)
- ✓ Railway: None

6) Alternative traffic infrastructures

- ✓ Roads and expressways: National Road, Muntinlupa (5/13)
- ✓ Alternative expressway: Coastal Road Expressway (2/13)
- ✓ Alternative port: Batangas Port (8/13)
- ✓ Alternative airport: Clark International Airport (6/13)

7) Disaster Prevention Plans, Business Continuity Plans and concerns



The Business Continuity Plan (BCP) is well recognized among the tenants.

Business Enterprises in NC

The following is a summary of the findings of the survey of tenants or business firms in NC.

1) Date of request and the final collection

Date of request: September 4, 2013

Date of final collection: September 09, 2013

2) Collection ratio (= Collected numbers divided by the total number of requests)

Out of 11 tenants, 2 companies responded. 2/11= 18%

3) Reasons for the low collection ratio

The questionnaires were distributed by email and through interviews only. The industrial park manager did not provide email address details of the respondents, making email follow-up impossible. Because of insufficient time, in-person follow up was not possible.

4) Interruption of lifeline utility services

- ✓ Electricity interruption due to natural disaster was experienced by 0 out of 2 firms.
- ✓ Water service interruption due to natural disaster was experienced by 0 out of 2 firms.
- ✓ Communication service interruption due to natural disaster was experienced by 0 out of 2 firms.

5) Normally used traffic infrastructure and roads

- ✓ Expressway: South Luzon Expressway (2/2)
- ✓ Port: South Harbor Port of Manila (1/2)
- ✓ Airport: Ninoy Aquino International Airport (2/2)
- ✓ Railway: None

6) Alternative traffic infrastructures

- ✓ Roads and expressways: None
- ✓ Alternative expressways: Aguinaldo Highway (1/2)

7) Disaster Prevention Plans, Business Continuity Plans and concerns

Both respondents have a Disaster Risk Reduction Management Plan and Business Continuity Plan.

The Business Continuity Plan (BCP) is well recognized among the tenants.

4.8.4 Reviews of the Questionnaire Surveys for Lifeline Utility Companies

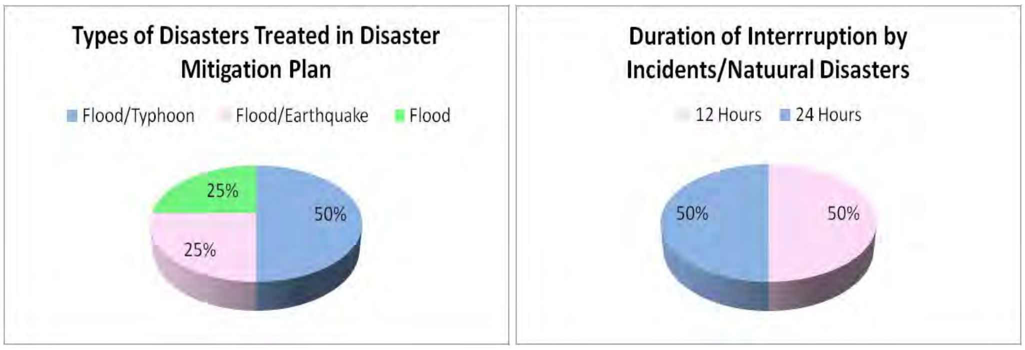
The following are the lifeline utility organizations which we were able to interview and from which secondary data was gathered.

1) Philippine Long Distance Telecommunication Company (PLDT), South Sub-Exchange Unit, Cavite
2) PLDT, Main Office, Laguna
3) Meralco, Alabang, Muntinlupa
4) Maynilad Water Services, Inc.

Other lifeline organizations were not able to respond to interview requests.

The highlights of the interviews are shown below.

Types of Disasters Treated in Disaster Mitigation Plan and Duration of Interruption



As indicated in the figure above, all the lifeline utility organizations have three types of disaster categories in their disaster mitigation plans. The duration of disaster interruption is from half a day to a whole day.

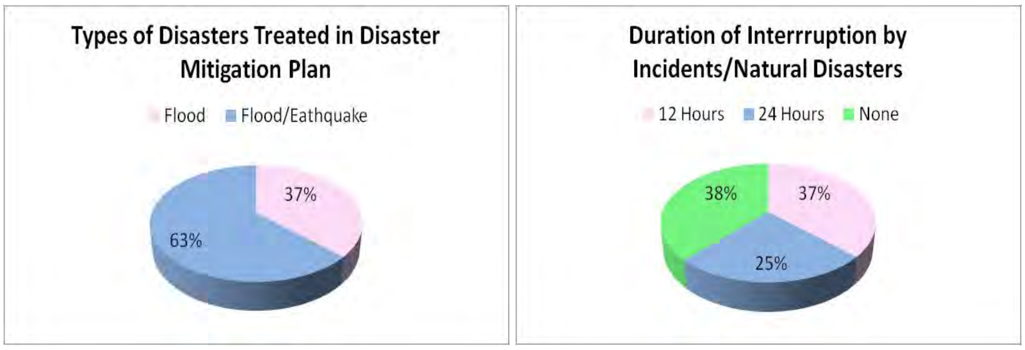
4.8.5 Reviews of the Questionnaire Surveys for Traffic Infrastructure Companies

The following are the traffic infrastructure organizations interviewed and from which data and information was gathered.

1) Department of Public Works and Highways, Cavite
2) Provincial Engineering Office, Cavite
3) City Planning and Development Office of Muntinlupa
4) City Engineer's Office, Muntinlupa
5) Muntinlupa Traffic Management Bureau
6) Provincial Engineering Office, Laguna
7) Manila North Harbor Port, Inc.
8) Philippine Ports Authority; Manila South Harbor/Manila Port

The highlights of the interviews are shown below.

1) Types of Disasters Treated in Disaster Mitigation Plan and Duration of Interruption



The traffic infrastructure organizations mostly indicated flooding as the primary type of disaster in their mitigation plan. The duration of interruption during disasters is by mostly from 12 to 24 hours.

2) Disaster Management Plan (DMP) and Business Continuity Plan (BCP)

Not all traffic infrastructure organizations have disaster management plans (DMP) or business continuity plan (BCP), unlike the lifeline utility providers. This could be due to the fact that all the transportation organizations are part of the government. In contrast, all the lifeline utility providers have both DMP and BCP.

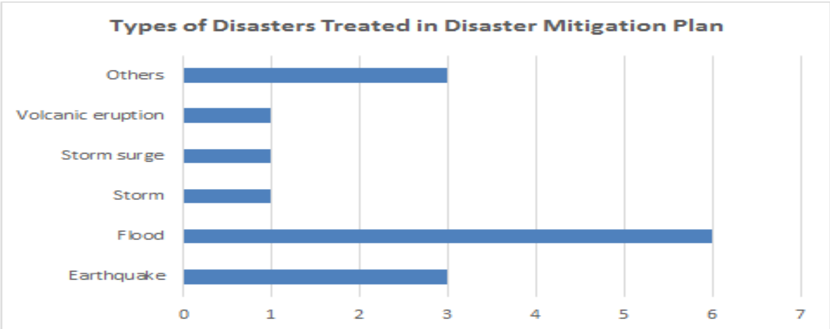
4.8.6 Reviews of the Questionnaire Surveys for Local Government

The following are the local government unit (LGU) organizations that we were able to interview and gather secondary data.

1) Binan City Disaster Risk Reduction and Management (DRRMO), Laguna
2) Sta. Rosa City DRRMO, Laguna
3) Provincial DRRMO/PG-COPS, Cavite
4) Muntinlupa City DRRMO, Metro Manila
5) Provincial DRRMO, Laguna
6) Municipality of Rosario DRRMO, Cavite

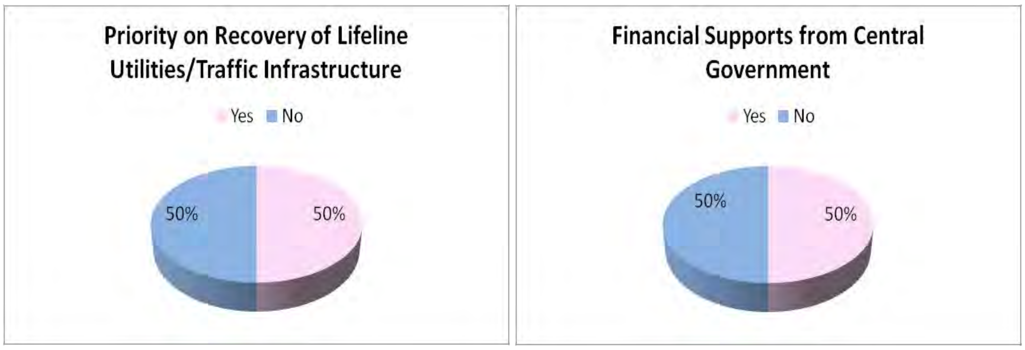
The highlights of the interview are shown below.

Types of Disasters Treated in Disaster Mitigation Plan



Most have indicated floods as the main type of disaster covered in their mitigation plans.

Response by Local Government during Disasters



Only half of the local government units (LGU) prioritize the recovery of lifeline utilities/traffic infrastructure for companies. Similarly, only half of the LGUs receive financial support from the national government to help these companies.

Appendix Details of Natural Hazard Assessments

A.1 Seismic Hazard Assessment

The methodology of seismic hazard simulation is roughly divided into deterministic methodology and probabilistic methodology. By the deterministic methodology, earthquake ground motion is calculated if the specific earthquake source fault has been activated. The earthquake ground motion distribution by the future possible earthquake can be calculated precisely, but to estimate when the calculated earthquake ground motion will be realized is difficult because it is impossible to predict the future earthquake by current technology. By the probabilistic method, the expected earthquake ground motion within a certain period at the study point is calculated considering all the earthquake sources around the study point reflecting the possibility of each sources. Therefore, the earthquake motion distribution by probabilistic method is not the estimation of the earthquake motion distribution by future probable earthquake but the ensemble of independent expected earthquake motion at each point. The deterministic method is commonly used for disaster management purpose and the probabilistic methodology is usually used for zoning in the building seismic code or earthquake insurance system etc.

The probabilistic method is adopted in the seismic hazard analysis for area BCP because the probability of the hazard is important. The hazard that has high possibility to occur in the lifetime of the industrial facilities is considered in area BCP, therefore to estimate the probability of the hazard is essential component in the analysis.

A.1.1 Methodology of Probabilistic Seismic Hazard Analysis

(1) Summary

The combination of earthquake ground motion at a certain point and the probability to experience at least the ground motion in a certain period is calculated by the probabilistic seismic hazard analysis method. The flow of the analysis is shown in Figure A.1.1.

The general steps of the analysis are as follows.

1) Set up the model of seismic activity around the study point. Not only the earthquakes that the source faults are clearly known but the earthquakes that the earthquake sources are not known and definite estimation of the magnitude and the location of future event is difficult should be included.

2) Estimate the probability of the magnitude, probability of the distance from the study point and the probability of the occurrence of the modeled earthquakes.

3) Set up the probability model to estimate the earthquake ground motion if the magnitude of the earthquake and the distance from the study point are given. The empirical attenuation equation and the dispersion of the equation are usually used.

4) Calculate the probability that the earthquake ground motion at the study point by modeled earthquake become larger than a certain value in a certain period.

5) Steps 1) to 4) are carried out for each modeled earthquake and all the probabilities are aggregated. The probability to experience a certain earthquake ground motion at least once in a certain period at the study point is calculated as a result.

McGuire, R. K. (2004)[1)] is recommended as a textbook of probabilistic seismic hazard analysis.

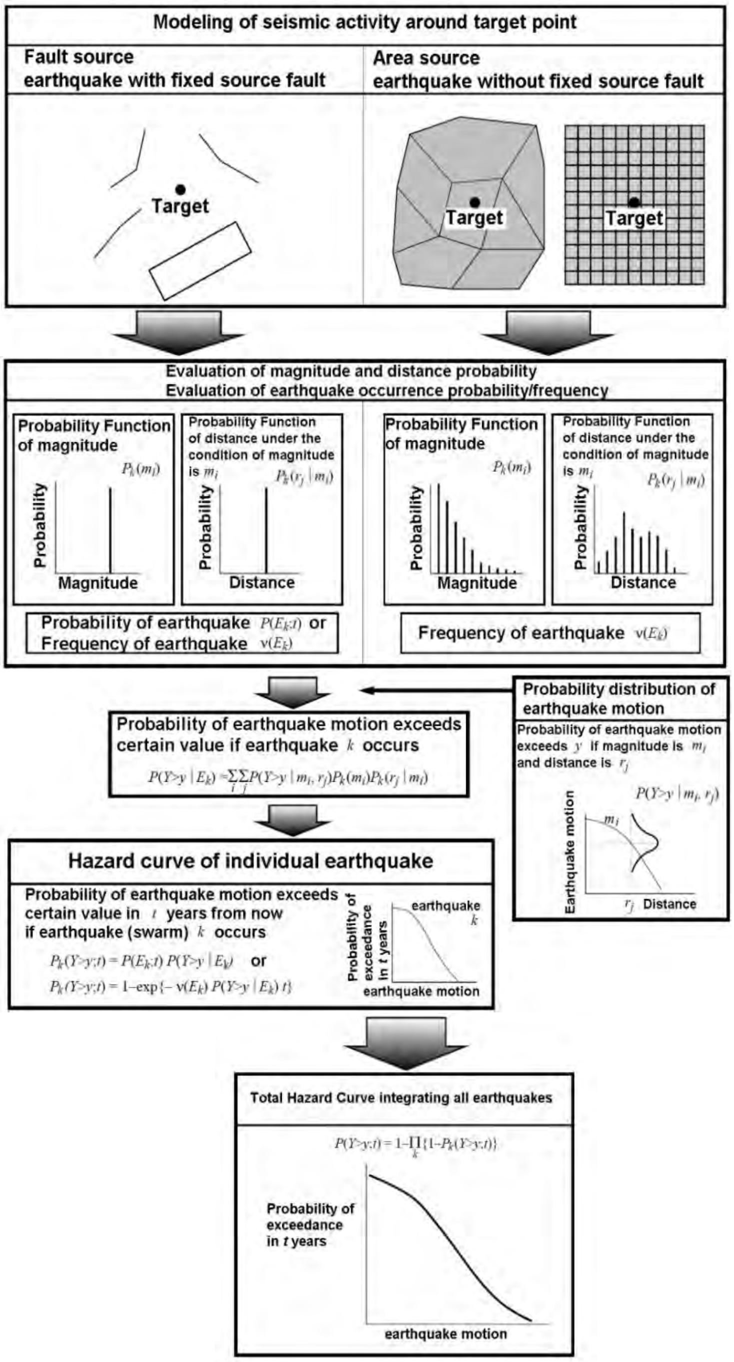


Figure A.1.1 Flowchart of probabilistic seismic hazard analysis (NIED(2005)[2)], original in Japanese)

(2) Software for analysis

As the probabilistic seismic hazard analysis involves complicated numerical calculation, many computing programs are developed and some of them are freely available. Among them, SEISRISK, FRISK, CRISIS, NSHMP and OpenSHA are famous but they are intended to be used by the researchers or the engineer with expert knowledge. Danciu et al. (2010)[3] compiled the precise information about the probabilistic seismic hazard analysis programs. Table A.1.1 is the general information of the major software for probabilistic seismic hazard analysis by Danciu et al. (2010).

Table A.1.1 Major software for probabilistic seismic hazard analysis

Software Name	Version	Developer	Availability	Documentation	GUI	Program Language
CRISIS	6.0 (2007)	Ordaz, M., et al	Free upon Request	User Manual	Yes	Visual Basic
EQRM	3.2 (2009)	Robinson, D. et al.	Open Source	User Manual	No	Python
FRISK88M	1.8	R. McGuire	Proprietary	User Manual	No	Fortran
MoCaHAZ	2004	S. Wiemer	Free upon Request	Self-Explained	No	MATLAB
MRS	3.0	R. Laforge	Free upon Request	User Manual	No	C
NSHMP	2008	Frankel et al.	Free-Download	Self-Explained	No	Fortran, C
OHAZ	2.1	B. Zabikovic	Free upon Request	User Manual	Yes	Java
OpenSHA	2009	E. H. Field et al.	Open Source	Self-Explained	No	Java
SEISRISK IIIM	1996	Bender , B Perkins, D.M, R. LaForge	Free-Download	User Manual	No	Fortran
SeisHaz	2005	M. Stirling et al	Proprietary	Self-Explained	No	Fortran

EZ-FRISK is the expanded commercial version of FRISK and offered by Risk Engineering Inc. The analysis by EZ-FRISK is comparatively easy because the earthquake source model and attenuation formula are provided with computing program. EZ-FRISK Ver. 7.62 was used in this study.

(3) Source model

The earthquake source model should include all the seismic activities within several 100km from the study point. The active faults in the area are modeled at first because earthquake basically occurs by the activity of the fault. However, not all the active faults are known or studied of the properties, the earthquakes that the earthquake sources are not known and definite estimation of the magnitude and the location of future event is difficult are modeled as the background seismic activities also. As the creation of the earthquake source model needs high grade capacity and expert knowledge, earthquake modeling is usually conducted in university or public research institute. Therefore, to conduct originally new probabilistic seismic hazard analysis, the earthquake source model should be given from academic organization.

As mentioned above, the source models provided with EZ-FRISK are used in this study.

(4) Attenuation formula

The so-called empirical attenuation formula is used to calculate the earthquake ground motion from the magnitude of the earthquake and the distance between epicenter and the study point. Many researchers proposed various attenuation formulas for several decades. They have different features based on the database and the algorithm that were used to create the formula, and they also have the limitation of applicability. It is desirable to use the attenuation formula that was intended to use the study site. The newer proposed attenuation formula is generally desirable to use because newer formula is derived based on the more precise recent earthquake observation records.

The empirical attenuation formula for ASEAN region is not known. In this study, following formula based on the world wide earthquake observation records are adopted.

[for shallow crustal earthquake]

- ✓ Abrahamson and Silva (2008)[4)]
- ✓ Boore and Atkinson (2008)[5)]
- ✓ Campbell and Bozorgnia (2008)[6)]
- ✓ Chiou and Youngs (2008)[7)]

[for deep plate boundary earthquake]

- ✓ Atkinson and Boore (2003)[8)]
- ✓ Youngs et al. (1997)[9)]

A.1.2 Amplification Analysis of the Surface Ground

(1) Summary

The earthquake ground motion is affected by not only the magnitude and the distance but by the ground condition around the study area. The seismic wave is amplified by the surface grounds and the extent of amplification is different depending on the structure of the surface ground. Some of the empirical attenuation formula includes the effect of surface ground amplification but another method is usually used to evaluate the wide area. At first, the earthquake motion at the bedrock is calculated by the empirical attenuation formula and the amplification of the surface ground is multiplied to get the surface ground motion.

There are several methodology to evaluate the amplification characteristics of surface grounds; for example, based on the surface soil, based on the average S wave velocity of surface soil layers and numerical response analysis using the ground structure model. The suitable method is selected considering the available data, necessary work and budget.

In this study, the method based on the surface soil is used. The method based on the average S wave velocity of surface soil layer is adopted.

(2) Ground classification and amplification factor

The classification of the ground and the amplification factor by FEMA (1995)[10)] is adopted in this study (see Table A.1.2 and Table A.1.3). They are developed in U.S.A. and used in many countries recently. The soil profile, average S wave velocity of upper 30 meters and N value are used to define the site class.

Followings are the adopted ground classification based on the geologic time read from collected geologic maps.

- ✓ Class B: Tertiary and before
- ✓ Class C: Pleistocene
- ✓ Class D: Holocene
- ✓ Class E: River deposit and marine deposit in Holocene

The average S wave velocity of the upper 30 meters is studied by Grutas and Yamanaka (2012)[11)] and JICA (2004)[12)] in the Philippines. These data are also used to define the site class.

Table A.1.2 NEHRP Classification

Site Class	Profile	Average S-wave velocity of the upper 30 meters	N value
A	Hard rock	> 1500 m/sec	
B	Rock	1500 ≥ Vs > 760 m/sec	
C	Very dense soil and soft rock	760 ≥ Vs > 360 m/sec	N > 50
D	Stiff soil	360 ≥ Vs > 180 m/sec	50 ≥ N ≥ 15
E	Soil	180 m/sec ≥ Vs	15 > N

Table A.1.3 NEHRP Amplification

Site Class B Spectral Acceleration	**Site Class**				
	A	**B**	**C**	**D**	**E**
Short-Period, S_{AS} (g)	**Short-Period Amplification Factor, F_A**				
≤ 0.25	0.8	1.0	1.2	1.6	2.5
0.50	0.8	1.0	1.2	1.4	1.7
0.75	0.8	1.0	1.1	1.2	1.2
1.0	0.8	1.0	1.0	1.1	0.9
≥ 1.25	0.8	1.0	1.0	1.0	0.9

A.1.3 Expression of the Results

(1) Methodology of expression

The calculated earthquake ground motion by the probabilistic method is expressed as follows.

a) The probability that the study site experiences a certain earthquake ground motion.

ex. The probability is 10% in 50 years to experience 100 gals or more.

b) The earthquake ground motion value for a certain probability.

ex. 100 gals or more will be experienced on the probability of 10% in 50 years.

The probability is expressed as the combination of the period and the probability in the period. If the seismic activity is uniform not depending on the year, probability can be expressed by annual probability.

In this study, the calculated results are expressed by the method b) above. It should be noticed that the earthquake motion distribution by probabilistic method is the ensemble of independent expected earthquake motion at each point and it is not related to the activity of a certain fault.

(2) Seismic Intensity

The calculated value is a physical quantity, such as peak ground acceleration or velocity. The seismic intensity is another expression of the strength of the ground vibration by the earthquake and more popularly understandable. The seismic intensity is also used to estimate the damage based on the past earthquake disaster experiences. In this study, peak ground acceleration is converted to seismic intensity in MMI scale following empirical formula by Trifunac and Brady (1975)[13].

$$\log PGA = 0.014 + 0.30*I$$

PGA: peak ground acceleration (gal), I: seismic intensity (MMI)

A.1.4 Simulation and Results

(1) Source model

The source model for the Philippines is shown in Figure A.1.2. The surface projection of source models along the plate boundary is shown in rectangular shape and the inland faults are shown as folded lines. The seismic activities that the location and the magnitudes are not identified in advance are modeled as the comparatively broad area sources.

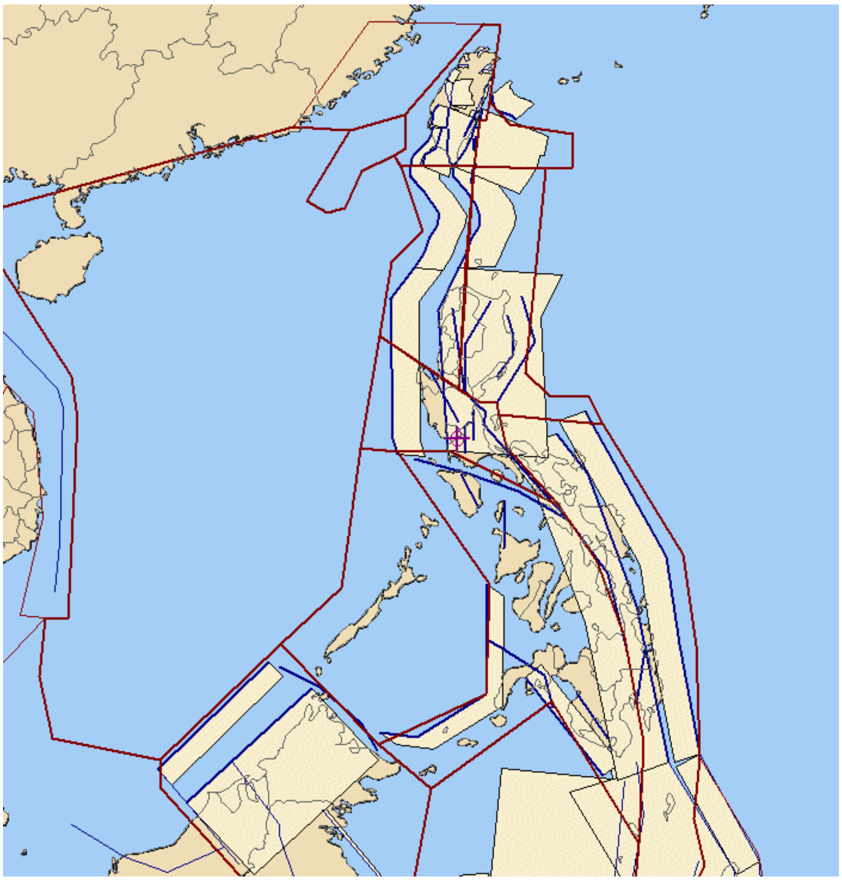


Figure A.1.2 Source model for the Philippines

(2) Baserock motion

The acceleration distribution on the ground with Vs=760 m/sec is shown in Figure A.1.3 to Figure A.1.6. The expected probability of occurrence is at least once in 50, 100, 200 or 500 years (50, 100, 200 or 500 years probability). The calculated acceleration is larger in north.

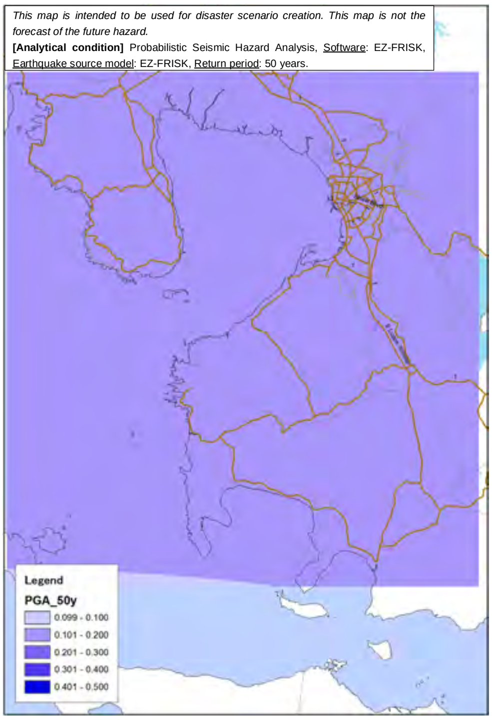


Figure A.1.3 Baserock acceleration distribution (expected for 50 years, unit: g)

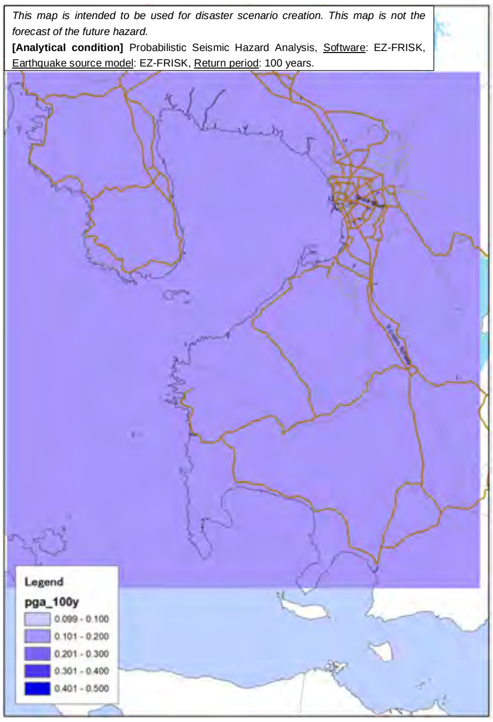


Figure A.1.4 Baserock acceleration distribution (expected for 100 years, unit: g)

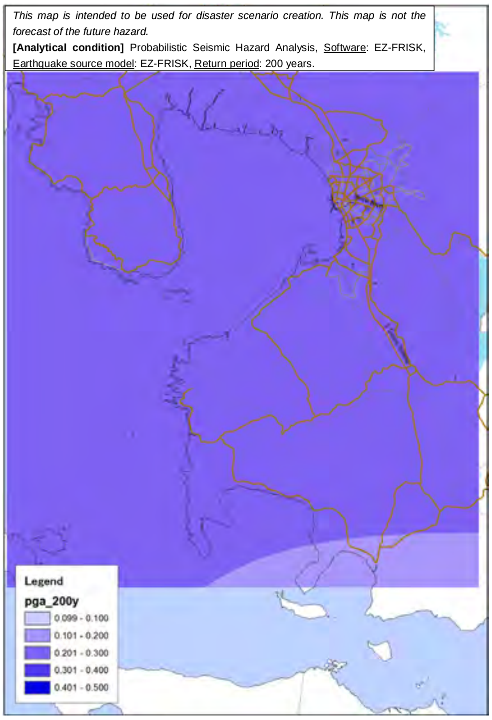


Figure A.1.5 Baserock acceleration distribution (expected for 200 years, unit: g)

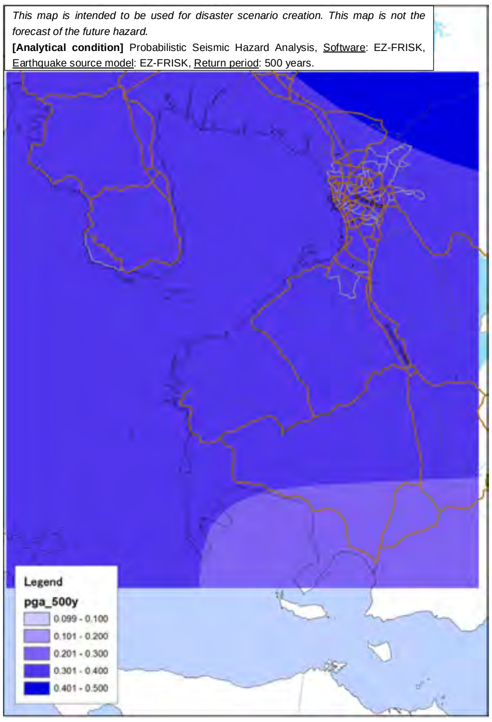


Figure A.1.6 Baserock acceleration distribution (expected for 500 years, unit: g)

(3) Ground classification

Following three data sets are used for the ground classification.

a) Proposed Vs30 value (average sheer wave velocity of the ground over 30m from surface) in Metro Manila, north of Cavite and Laguna by Grutas and Yamanaka (2012)[11)].

b) Vs30 value calculated from the database of the ground model by JICA (2004)[12)].

c) Geological maps with 1/50,000 scale by National Mapping and Resource Information Authority (NAMRIA)

The Vs30 values of a) and b) and the geological time read from c) are used for ground classification. If several classifications are possible, the geological classification with largest amplification value is adopted. The ground classification map is shown in Figure A.1.7.

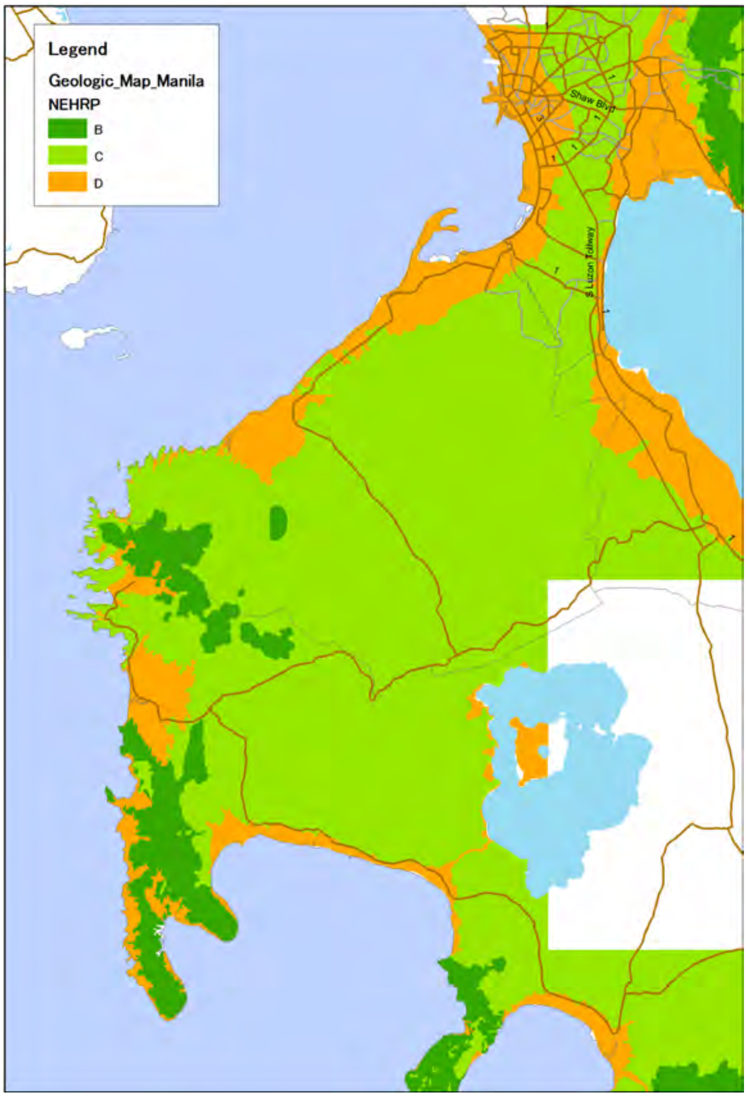


Figure A.1.7 Ground classification

(4) Surface motion

The acceleration at the ground surface is calculated multiplying the amplification factor to the acceleration value at the baserock. the results are shown in Figure A.1.8 to Figure A.1.11. The acceleration value is converted to seismic intensity in MMI scale by empirical equation and shown in Figure A.1.12 to Figure A.1.15

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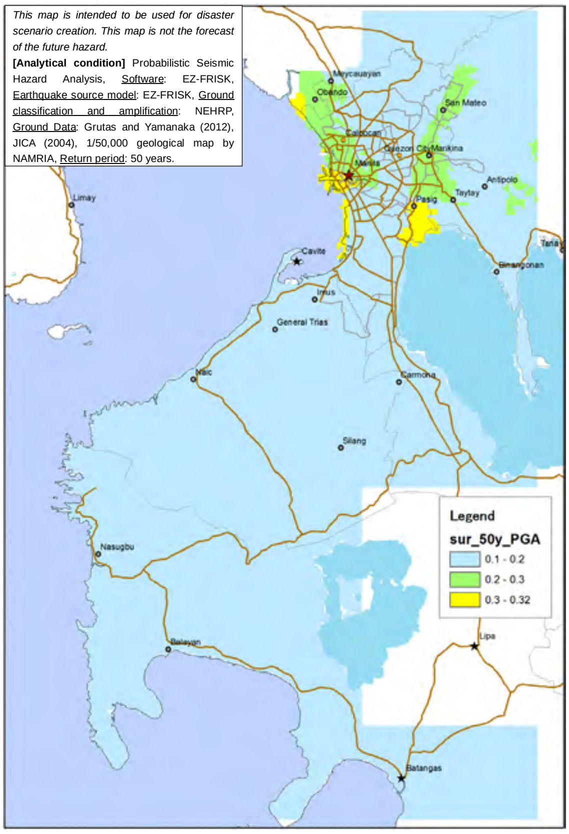

Figure A.1.8 Surface acceleration distribution (expected for 50 years, unit: g)

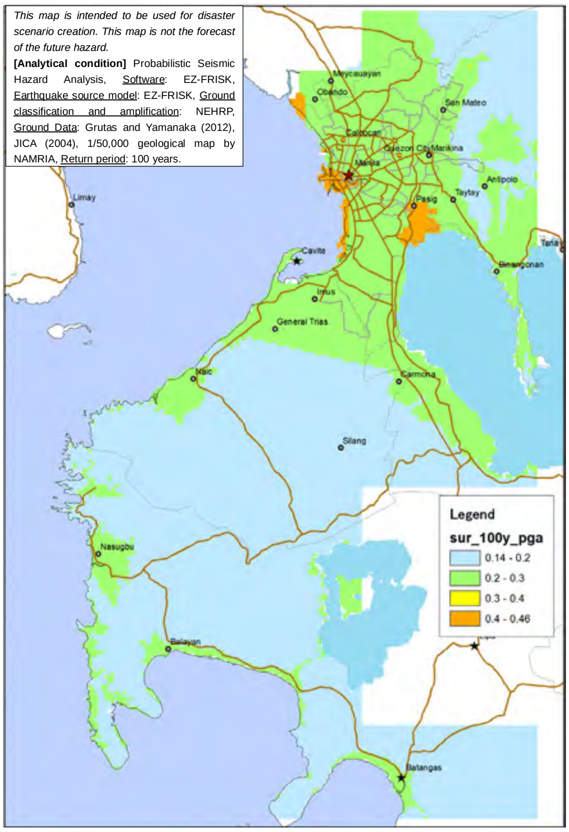

Figure A.1.9 Surface acceleration distribution (expected for 100 years, unit: g)

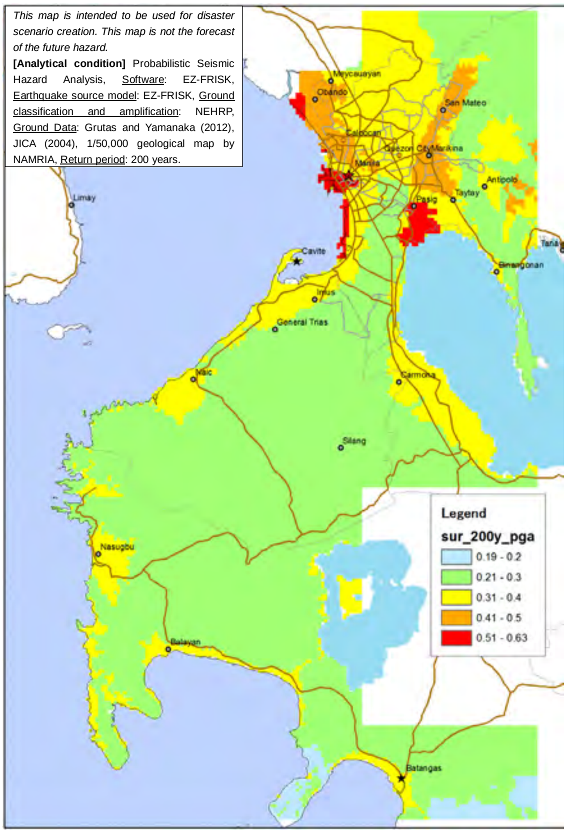

Figure A.1.10 Surface acceleration distribution (expected for 200 years, unit: g)

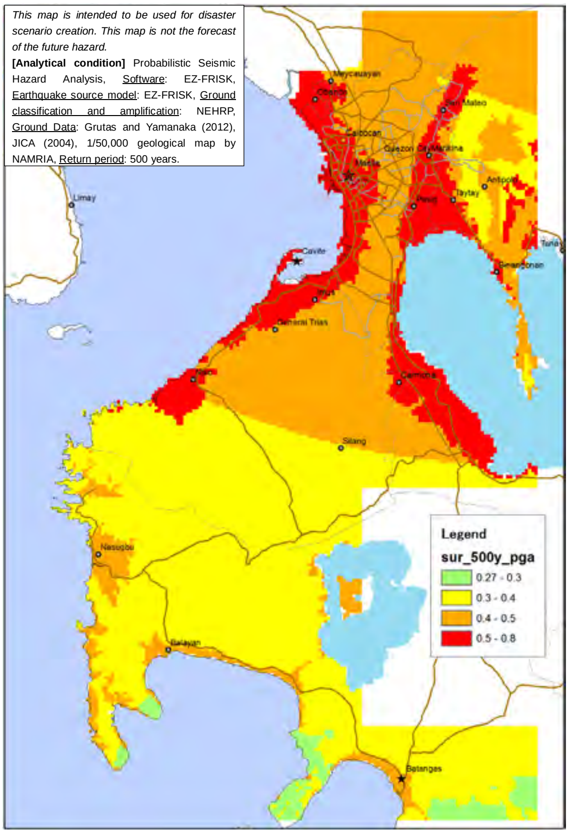

Figure A.1.11 Surface acceleration distribution (expected for 500 years, unit: g)

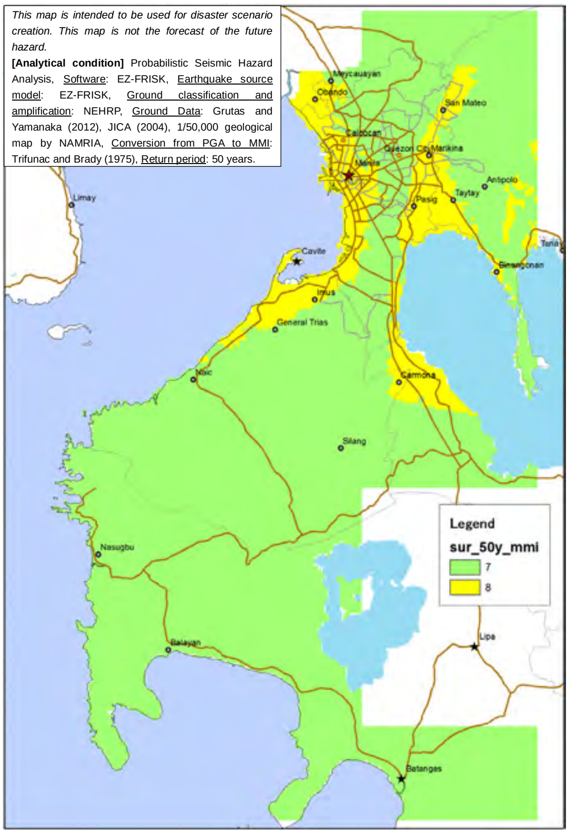

Figure A.1.12 Seismic intensity distribution (expected for 50 years in MMI scale)

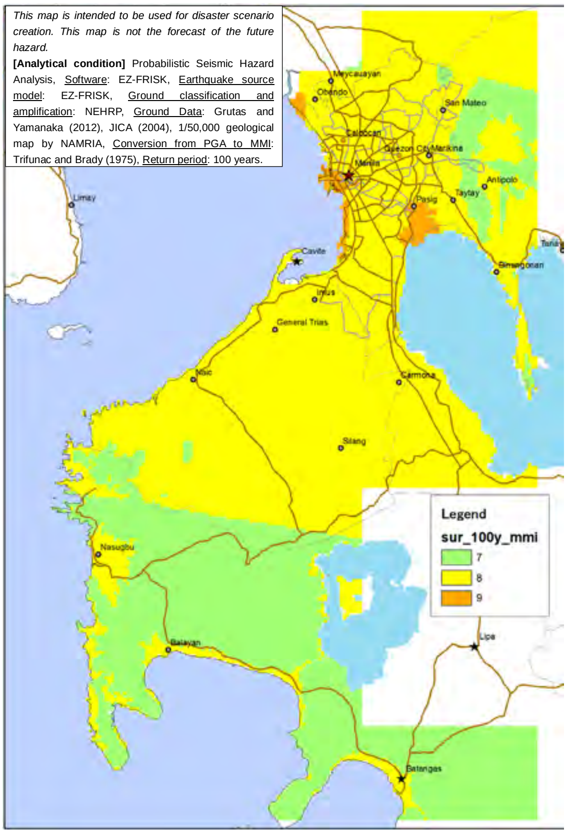

Figure A.1.13 Seismic intensity distribution (expected for 100 years in MMI scale)

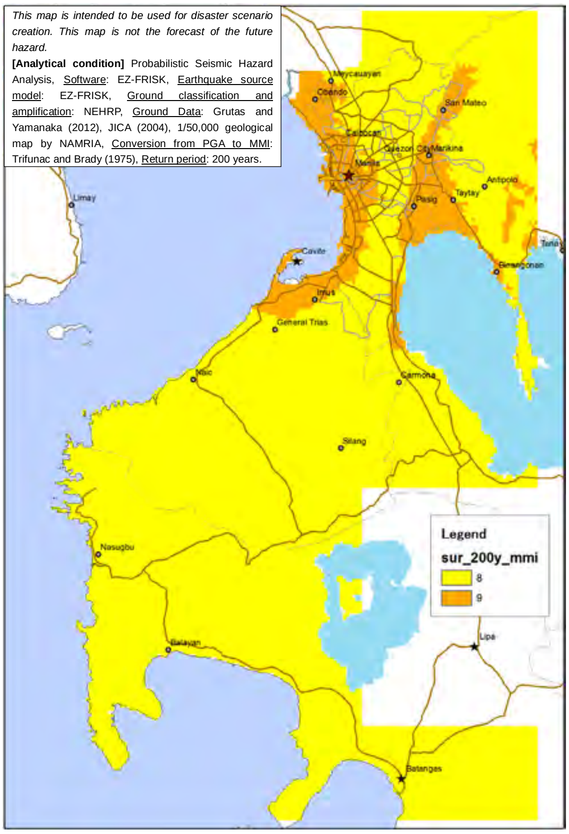

Figure A.1.14 Seismic intensity distribution (expected for 200 years in MMI scale)

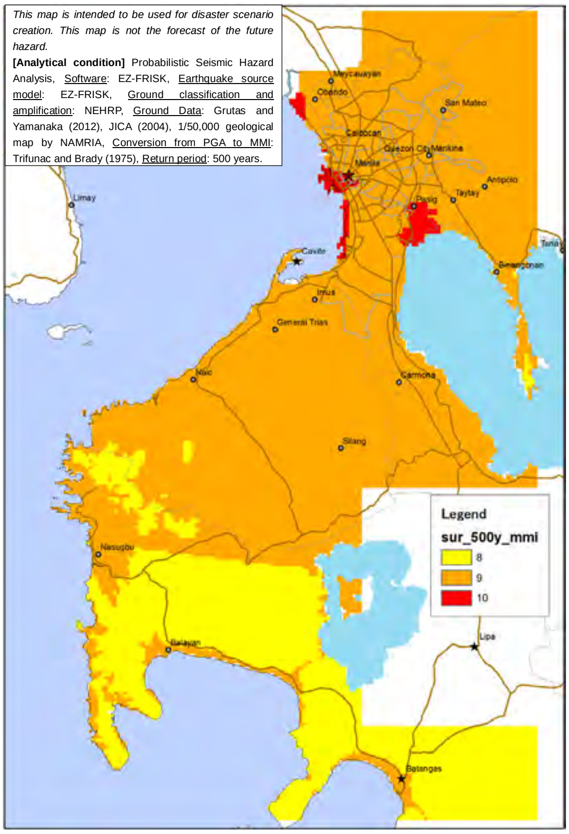

Figure A.1.15 Seismic intensity distribution (expected for 500 years in MMI scale)

(5) Liquefaction potential

The liquefaction potential in Metro Manila is evaluated using the ground model and the analysis method used in the study by JICA (2004)[12]. The liquefaction potential by the earthquake of 200 years probability is shown in Figure A.1.16.

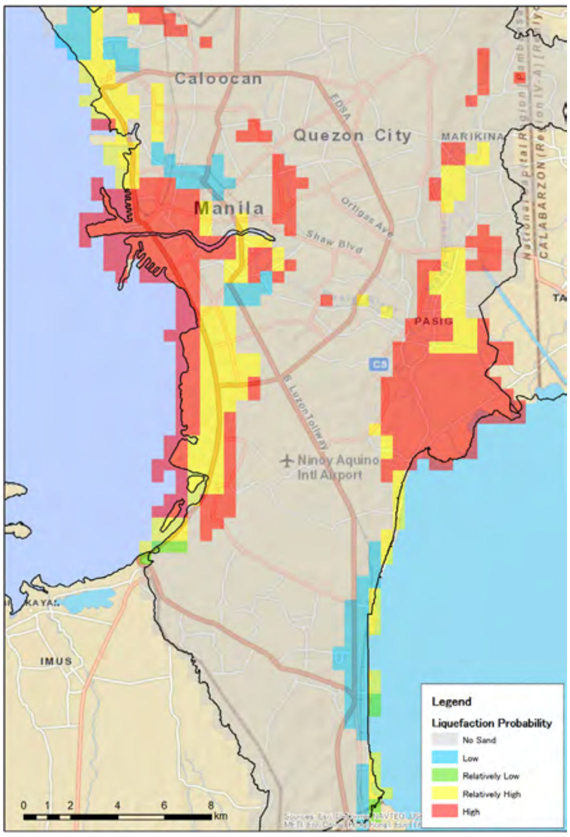

Figure A.1.16 Liquefaction potential in Metro Manila (expected for 200 years)

A.1.5 Evaluation of the Results

1) Probabilistic seismic hazard analysis

As the most software for probabilistic seismic hazard analysis is made based on the same theorem, there is no big difference between them except user interface. The largest component that may affect to the result is the earthquake source model. Not only the earthquake catalogue of recorded events and historical earthquakes, the active faults with no record of earthquakes in the history or the area source model should be considered. In this study, the earthquake source model included in the commercial analysis package is used. This source model was made based on the existing documents in the world and the accuracy is enough for the hazard assessment of the pilot study site in this project. However, the opinions about the active faults by the researchers are not usually same and the consensus between them is difficult in many cases. To consult the local researcher and reflect the opinion to the analysis may be necessary to assess the seismic hazard in smaller area.

2) Amplification analysis of the surface ground

There are plenty of analysis methods for amplification by the surface ground. The methodology that is adopted in this study is the comparatively easy to use. Basically, the structure of the soil layers of underground is necessary to know the amplification characteristics. In this study, the amplification factor is estimated based on the information that is available from geological maps. As the local researcher in the Philippines studied the ground condition of Cavite and presented in the scientific papers, the amplification in part of study area can be evaluated more precisely. The similar scientific research may has been conducted or will be conducted in other region in ASEAN. The research such information is effective for the assessment.

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12) JICA, 2004, Earthquake Impact Reduction Study for Metropolitan Manila, Republic of the Philippines, Final Report, Vol.3.
13) Trifunac M. D. and A. G. Brady, 1975, On the Correlation of Seismic Intensity Scales with the Peaks of Recorded Strong Ground Motion, Bull. Seism. Soc. Amer., Vol. 65.

A.2 Tsunami Hazard Assessment

The flowchart of tsunami simulation is shown in Figure A.2.1. The detailed procedure is described hereinafter and the results of simulation for three pilot areas are shown next.

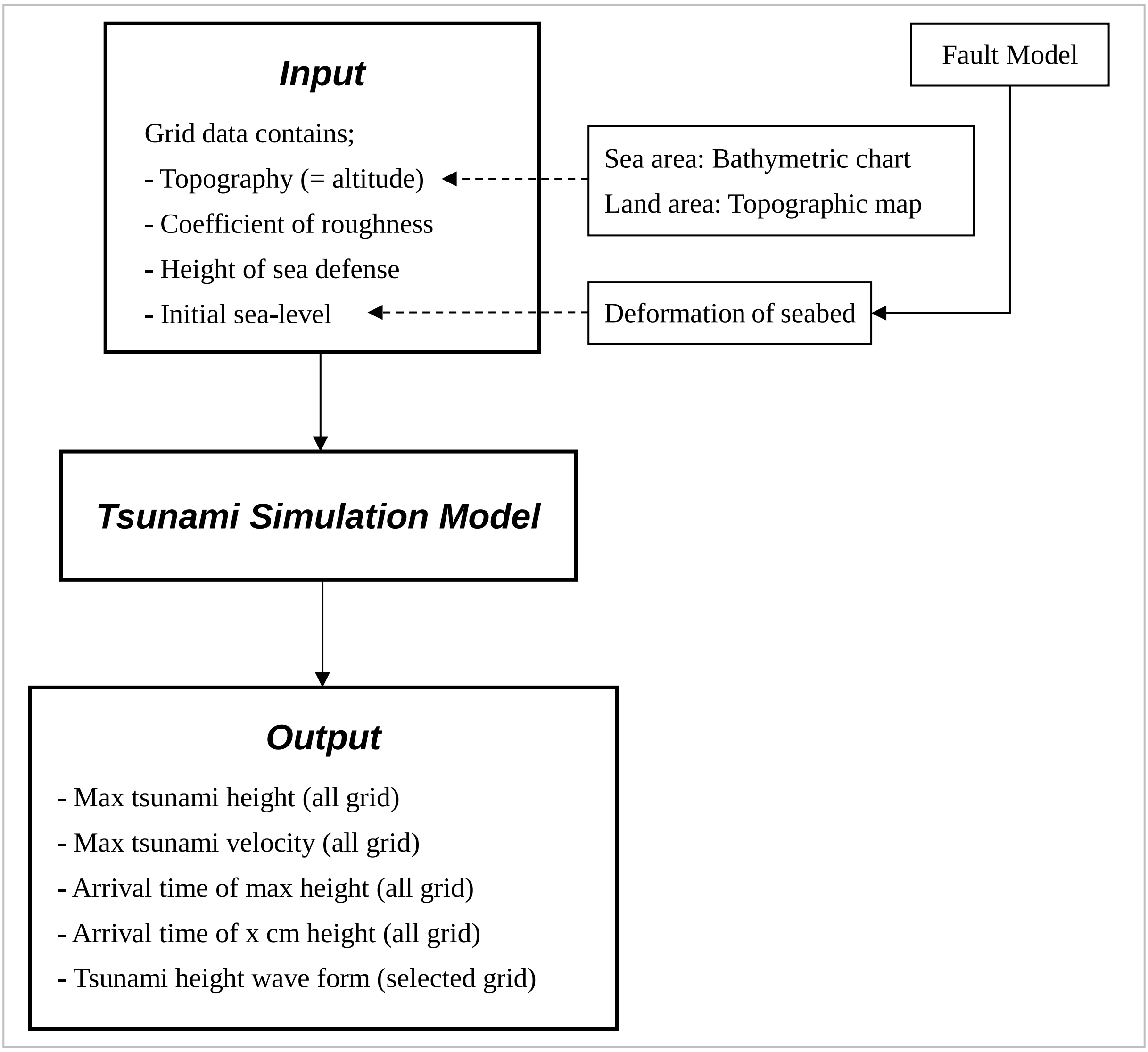

Figure A.2.1 Flowchart of tsunami simulation

A.2.1 Theory of Tsunami Propagation and Selection of Simulation Model

There are several theories to describe the behavior of tsunami such as linear long-wave theory, non-linear long-wave theory, linear disperse wave theory and non-linear disperse wave theory. Each of them is a theory based on the long-wave approximation which can be applied to the wave which wave length is long enough to the depth of water. The wave length of tsunami is generally from several 10 km to 100 km relative to the average depth of the ocean is 4 km. That is the reason why the long-wave approximation can be proper for tsunami.

Linear long-wave theory can be applied to the deep water area, over around 50 m in depth, where the amplitude of the wave is small enough to the depth of water and the friction on the sea floor can be neglected. On the other hand, non-linear long-wave theory can be applied to the shallow water area where the amplitude of the wave is not so small to the depth of water and the friction on the sea floor cannot be neglected and the case of tsunami runs up on the land.

The velocity of shorter wave is slower than longer wave. Therefore, when tsunami wave consists of several waves of different length, dispersion of short wave and long wave is observed. This difference in velocity by the wavelength is called dispersibility and the theory considering this dispersibility is the disperse wave theory. The simulation on the disperse wave theory is not so common at present, however in case of distant tsunami which occurs over 1,000 km far from the object site, linear disperse wave theory is to be applied. And when the effect of dispersibility is concerned at shallow water area, non-linear disperse wave theory is to be applied. Please see reference 1) and 2) when more detailed explanation of those theories are required.

Table A.2.1 shows the sample tsunami simulation models based on the long-wave theory and the disperse wave theory introduced above. Tsunami simulation program "TUNAMI" which is developed by Tohoku University based on the non-linear long wave theory is used in this study.

Table A.2.1 Tsunami simulation model

Program Name	Organization	Source	URL
Long Wave Theory			
TUNAMI	Tohoku University, Japan	Open	https://code.google.com/p/tunami/
STOC	The Port and Airport Research Institute, Japan	Open	http://www.pari.go.jp/cgi-bin/search-en/detail.cgi?id=2005060440205
COMCOT	Cornell University, USA	Open	http://ceeserver.cee.cornell.edu/pll-group/comcot.htm
GeoClaw	Washington University, USA	Open	http://depts.washington.edu/clawpack/geoclaw/
MOST	NOAA, USA	Closed	http://nctr.pmel.noaa.gov/model.html
ComMIT	NOAA, USA	Closed	http://nctr.pmel.noaa.gov/ComMIT/
Disperse Wave Theory			
Disperse Potential Model	National Defense Academy, Japan	Open	http://www.nda.ac.jp/cc/kensetsu/index-e.html
FUNWAVE	University of Delaware, USA	Open	http://chinacat.coastal.udel.edu/programs/funwave/funwave.html
NEOWAVE	University of Hawaii, USA	Open	http://www.ore.hawaii.edu/OE/index.htm
COULWAVE	Cornell University, USA	Closed	http://ceeserver.cee.cornell.edu/pll-group/doc/COULWAVE_manual.pdf

A.2.2 Input Data

General input data for tsunami simulation is as follows. These data is given to each grid which is explained below.

1) Topographical data
2) Roughness data

3) Sea defense data
4) Initial water height data (= deformation of sea-floor)

(1) Topographical Data

Topographical model for the area which includes the source region of the scenario earthquake, the objective area and the route of tsunami between them is required for tsunami simulation. Topographical model includes the topography of sea-floor, the topography of the land surface where tsunami might run up and sea defense structures. Orthogonal coordinate system is usually used for the modeled area of less than 1,000 km x 1,000 km and polar coordinate system is used for the wider area. The orthogonal UTM coordinate system is used for this analysis.

The simulation area is divided and covered by square grid and altitude and roughness data are given to each grid. Altitude describes topographic features and roughness is used for considering friction between water and sea-floor or land surface. The size of grid is properly defined considering the complexity of topography and the wavelength of tsunami. The grid size is usually defined from bigger to smaller according to the distance from coastlines, considering the condition that is the topography becomes more complex and shorter wave component becomes dominant at the nearer area to the coastlines. This methodology is called "nesting". The grid size is defined as, for instance, 1350m -> 450m -> 150m -> 50m from tsunami source region to the coast. Grid is connected with 1/3 size grid step by step in this case and this 1/3 connection is the most general way, however 1/2 connection and 1/5 connection is also used for nesting.

Topographical data is obtained from bathymetry chart and topographical map. Nowadays, digital data of those maps are often available. However, if there is no digital data, it is required to generate digital data by digitizing those maps. Table A.2.2 shows digital topographical data provided by international organization for free. Those data can be also used for the modeling. Following shows a case study preparing topographical model from source region to coastal area by GEBCO_08 data (Figure A.2.2) and from coastal area to the coastline and inland area by more detailed bathymetry chart (Figure A.2.3).

Table A.2.2 Open-source Data of Bathymetric Chart

Name	Explanation
GEBCO_08 Grid	- Organization: British Oceanographic Data Centre (BODC) - Topographic data of 30 sec grid covering sea-floor and land surface - URL: http://www.gebco.net/data_and_products/gridded_bathymetry_data/
SRTM30_PLUS	- Organization: Scripps Institution of Oceanography, University of California San Diego - Topographic data of 30 sec grid covering sea-floor and land surface - URL: http://topex.ucsd.edu/

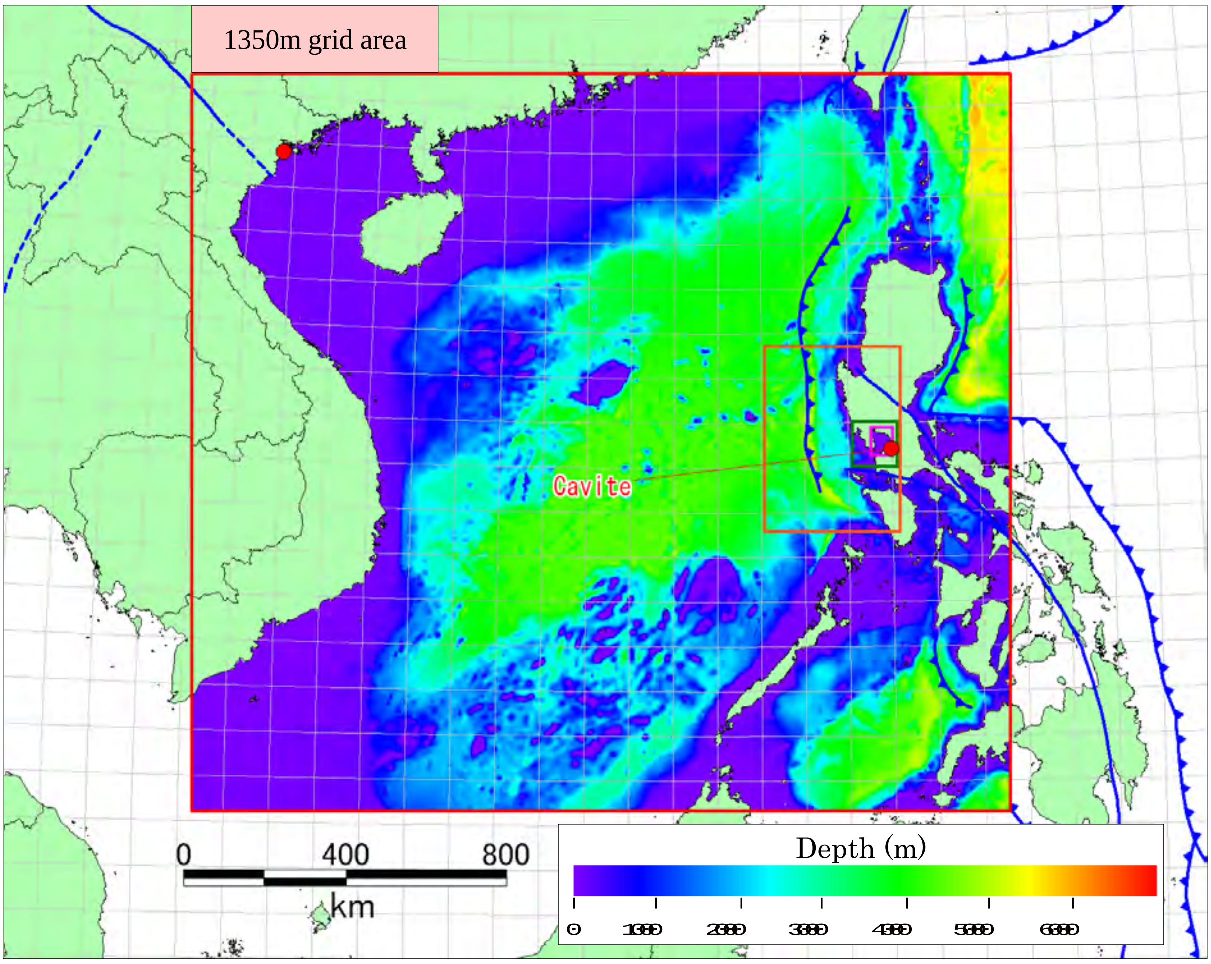

Figure A.2.2 Wide Area Topography Model by GEBCO Data (South China Sea Area)

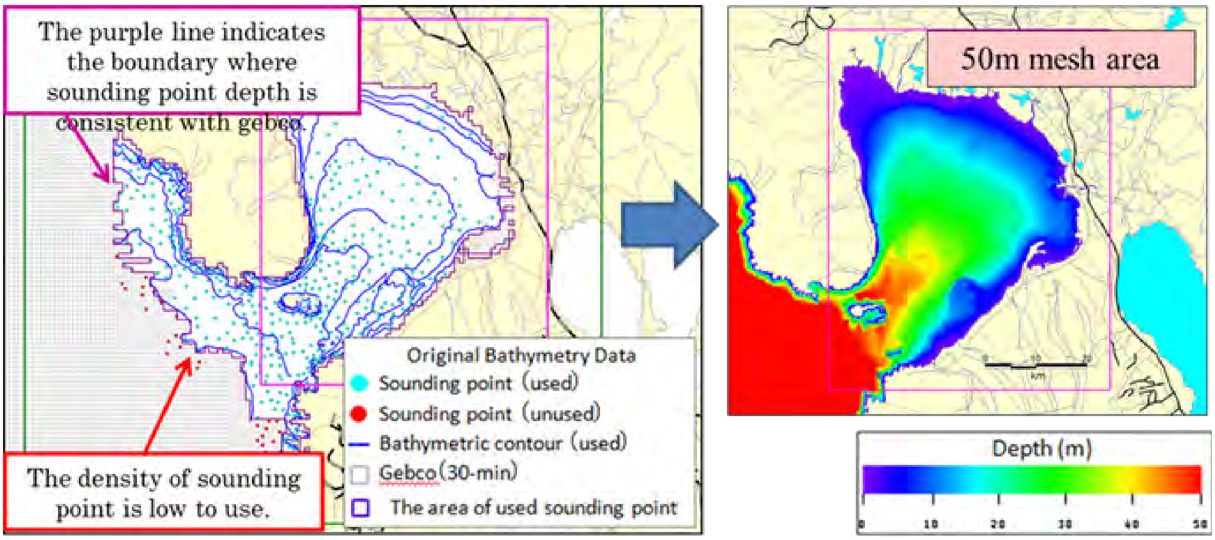

Figure A.2.3 Topography Model of Coast Area by Bathymetry Data (Manila Bay area)

(2) Roughness Data

The effect of friction for tsunami wave propagation is considered by Manning's roughness coefficient (n). "0.025" is often used as roughness coefficient for marine area. Table A.2.3[3)] and Table A.2.4[4)] show Manning's roughness coefficients for different types of ground surfaces.

Table A.2.3 Comparison of Manning's roughness coefficients [3)]

Fukuoka et al. (1994)		Aida (1977)		Goto and Shuto (1983)		Kotani et al. (1998)	
category	estimated roughness coefficient	category	equivalent roughness coefficient	category	estimated coefficient	category	setup roughness coefficient
80%	0.1			high density	0.01		
50 ～8	0.096	dense zone	0.07			high density residential zone	0.080
20 ～5	0.084	rather high density zone	0.05	mid density	0.05	mid density residential zone	0.060
0 ～2	0.056			low density	0.03	low density residential zone	0.040
road	0.043	other land zone	0.02			forest zone (inc. garden, tide protection forest)	0.030
						field zone (inc. waste land)	0.020
		Shoreline (inc. tide protection forest)	0.04			sea and river zone (w/o tide protection forest)	0.025

Table A.2.4 Manning values for land cover classes [4)]

Land cover class	Mannings n	Manning M in $m^{1/3} s^{-1}$	Source
Barren land/mud, sand, beach, roads	0.0310	32	b
Grassland	0.0360	28	b
Young Plantation	0.0370	27	b
Scrubland	0.0380	26	b
Cashew Plantation	0.0430	23	b
Other plantation	0.0430	23	b
Coconut plantation	0.0458	22	a
Semi open landscape	0.0550	18	b
Oil plantation	0.0573	17	a
Middle density urban area	0.0600	17	c,d
Melaleuca forest	0.0550	18	b
Rubber plantation	0.0609	16	a
Casuarina forest	0.0731	14	a
Inner beach forest	0.0744	13	a
High density urban area	0.0800	12.5	c,d
Other forest/rainforest	0.0850	12	c,e
Outer beach forest	0.0870	12	a
Mangrove forest	0.0951	11	a
Buildings non-resistant	0.0900	11	c,f
Buildings resistant	0.4000	2.5	c,f
Mangrove area 2005 (post-tsunami)			
Mangrove → water	0.0110	90	a,b,g
Mangrove → mud	0.0310	32	a,b,g
Mangrove → damaged understory	0.0310	32	a,b,g
Mangrove → sand	0.0310	32	a,b,g
Mangrove → inclined, roots remaining	0.0360	28	a,b,g
Mangrove → no damage	0.0951	11	a,b,g
Mangrove → indirect damage	0.0951	11	a,b,g

Values are derived from [a] measurement of tree stand parameters in the field followed by calculation of Manning's n according to Eq. (1); [b] measurement of stand parameters for different land cover classes in the field and subsequent estimation of Manning's *n*; [c] literature; [d] Kotani (1998) in Latief and Hadi (2007); [e] Arcement and Schneider (1989); [f] Gayer et al. (2010), Leschka et al. (2009); [g] + change detection/Ikonos

(3) Sea defense data

Embankment and other sea defense structures are modeled as a grid height data.

(4) Initial Water Height Data (=deformation of sea-floor)

Change of water height caused by fault movement should be prepared as an initial condition for tsunami simulation. Change of water height is assumed to be same as vertical component of sea-floor deformation. The sea-floor deformation is calculated as a displacement caused by a slip on the fault in the semi-finite elastic body using fault parameters shown in Table A.2.5.

The theory of above calculation is described in the following references like Mansinha and Smilie (1971) [5] or Okada (1992) [6] and others. The website of Cornell University[7] and National Research Institute for Earth Science and Disaster Prevention (NIED) [8] are also informative.

Figure A.2.4 shows a calculated deformation of sea-floor by the program named DC3D0 / DC3D [8] developed by Okada.

Table A.2.5 Example of fault parameters

Fault Parameter	Sample Value (corresponding to Figure A.2.4)
Depth (km)	18
Strike angle (degree)	177
Dip angle (degree)	24
Rake angle (degree)	90
Length (km)	313
Width (km)	70
Slip (m)	9.6

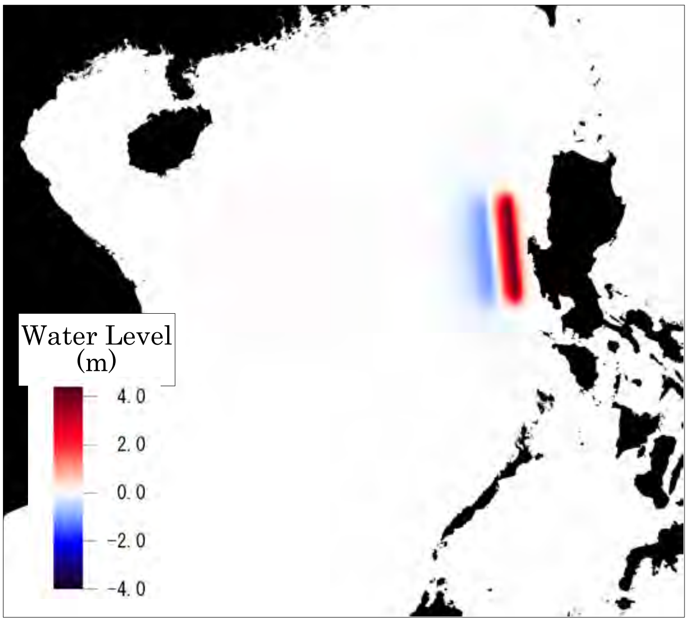

Figure A.2.4 Example of calculated vertical deformation

A.2.3 Output Data

The general output of the tsunami simulation is as follows. Output items are obtained for each grid.

1) Maximum water height or maximum inundation height (for all grid)

2) Maximum velocity (for all grid)
3) Elapsed time of maximum water height (for all grid)
4) Elapsed time of given water height (x cm, for instance) (for all grid)
5) Time history of water height (selected grid)
6) Time history of water velocity (selected grid)

Figure A.2.5 shows a sample result of tsunami simulation by the program "TUNAMI" developed by Tohoku University in Japan. The left side of Figure A.2.5 shows maximum water height distribution map and the right side of Figure A.2.5 shows time history of water height at the selected grid.

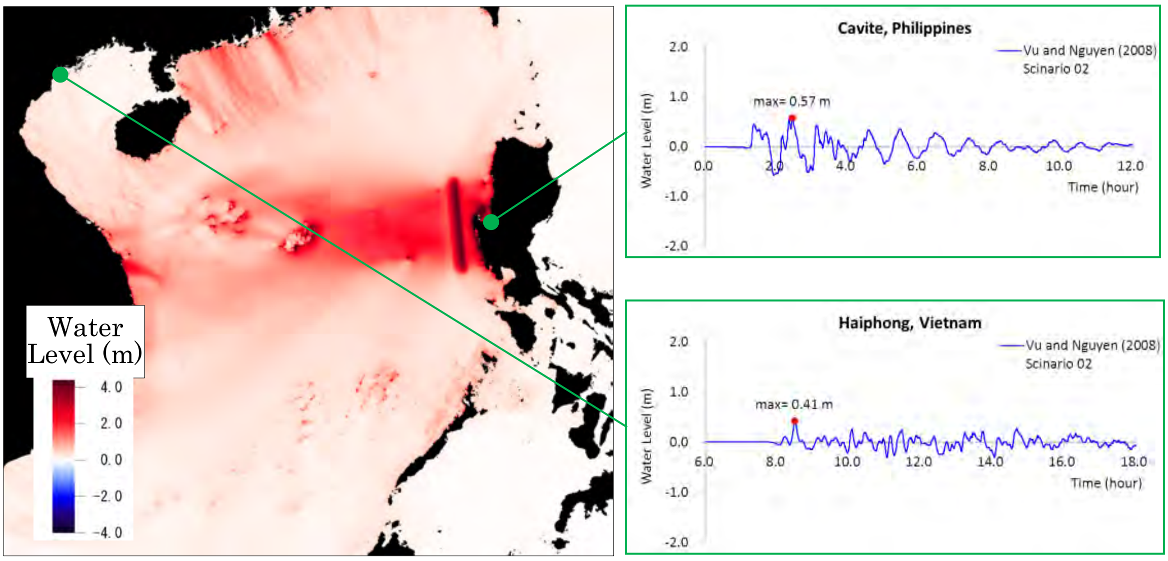

Figure A.2.5 example of tsunami simulation results

A.2.4 Return Period of Scenario Earthquake

The relationship of earthquake magnitude and return period is estimated by Gutenberg-Richter Low using earthquake data, often called earthquake catalog, around the targeted earthquake zone. It is well known that larger earthquake occurs less frequently. It was Gutenberg and Richter who formulate this relation as the following equation in 1941. It is the reason why this relation is called as Gutenberg-Richter Low or G-R Low.

$$\log n(M) = a - b M$$

or

$$\log N(M) = A - b M$$

The relation between occurrence frequency, n(M) dM, and cumulative frequency which is magnitude M and over, N(M), and 0.1 interval magnitude, dM = 0.1, is arranged in Table A.2.6 for the earthquake data which occurred during 1965 to 1999 in and around Japan area. Figure A.2.6 is the plot of the data with magnitude on x-axis and frequency on y- axis. The formula on the figure is a regression curve of M and N relation derived by the least square method.

M = 7.5 corresponds to N = 6.8 on the formula, for instance. It means that the occurrence frequency of the earthquake with magnitude 7.5 and over is 6.8 times on average in 35 years, during 1965 to 1999. And its annual probability is calculated as 6.8 / 35 = 0.19 / year. It is recognized that the earthquake with magnitude 7.5 and over is expected to occur 0.19 time on average in and around Japan area. On the other hand, inverse number of the annual probability, 1 /0.19 = 5.1 years in this case, is called recurrence time. Then it is expressed that the recurrence time of the earthquake with magnitude 7.5 and over is 5.1 years.

As described above, an annual probability or a recurrence time of the scenario earthquake can be estimated using G-R Low in and around the scenario earthquake area.

Table A.2.6 Number of Shallow Earthquakes Occurred in and around Japan (1965 - 1999) [9)]

M	$n(M)dM$	$N(M)$	M	$n(M)dM$	$N(M)$	M	$n(M)dM$	$N(M)$
8.2	0	0	7.1	5	18	6.0	52	224
8.1	1	1	7.0	5	23	5.9	56	280
8.0	0	1	6.9	4	27	5.8	79	359
7.9	1	2	6.8	2	29	5.7	91	450
7.8	2	4	6.7	9	38	5.6	94	544
7.7	1	5	6.6	14	52	5.5	134	678
7.6	0	5	6.5	14	66	5.4	138	816
7.5	3	8	6.4	18	84	5.3	199	1015
7.4	2	10	6.3	18	102	5.2	256	1271
7.3	0	10	6.2	30	132	5.1	343	1614
7.2	3	13	6.1	40	172	5.0	407	2021

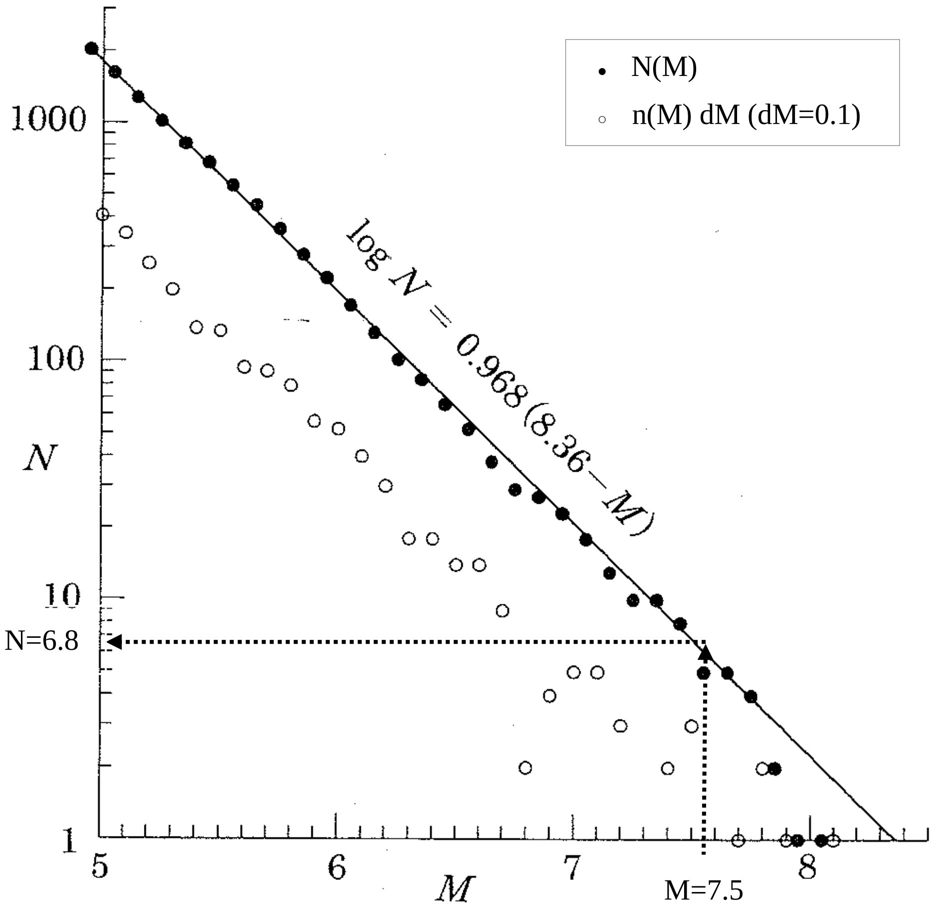

Figure A.2.6 Data Plot of Table A.2.6 [9)]

A.2.5 Results of Simulation

(1) Collection of Existing Information

The following information and data are collected for setting scenario earthquake and conducting tsunami simulation.

<u>Literatures related to scenario earthquakes</u>

- EMILE A. OKAL et al. (2011) [10)]: Tsunami Simulations for Regional Sources in the South China and Adjoining Seas
- Vu Thanh Ca1 et al. (2008)[11)]: Tsunami risk along Vietnamese coast
- Nguyen Hong Phuong et al. (2013)[12)]: Simulation of a Worst Case Tsunami Scenario from the Manila Trench to Vietnam

<u>Literatures related to earthquake environment</u>

- Earthquake Impact Reduction Study for Metropolitan Manila, Republic of the Philippines Final Report (2004)[13)]: JICA, MMDA, PHIVOLCS

<u>Data related to bathymetric feature</u>

- Wide area: GEBCO_08 Grid
- Vicinity of objective area: Topographical map by NAMRIA (National Mapping and Resource Information Authority)

(2) Setting of Scenario Earthquake

1) Statistical analysis of earthquake (Gutenberg-Richter Law)

The earthquake data along the Manila Trench is picked up from the data[14)] as shown in **Figure A.2.7** and the return period of the earthquake is estimated by statistical analysis based on the Gutenberg-Richter Law. The estimated result is shown in Figure A.2.8. Followings are the results obtained by the analysis.

- ✓ Formula-1: G-R Law parameters are derived from the data during 1980 to 2002 as "b = 1.0" and "a = 5.2".
- ✓ Formula-2: In case of drawing envelope assuming "b = 1.0", "a = 6.0" is estimated.
- ✓ Formula-3 (reference): In case of drawing envelope for all data, "b = 0.9" and "a = 5.2" are estimated.

Magnitude of the earthquake along the Manila Trench with 100 years return period is estimated to be 7.2 to 8.0 from Formula-1 and Formula-2.

On the other hand, the return period of the earthquakes with magnitude 8.0 is estimated to be 100 to 630 years and 1,000 to 6,300 years for magnitude 9.0.

2) Setting of scenario earthquake

The west side of Luzon Island where Cavite is located faces the South China Sea where fewer earthquakes occur than the Pacific Ocean. In addition, Cavite is located inside the Manila Bay. Therefore, there is almost no record of large tsunami disaster around the area. In this study, the possible tsunami that may cause impact to the study area, though the possibility is very low, is simulated considering that the result will be used in the future.

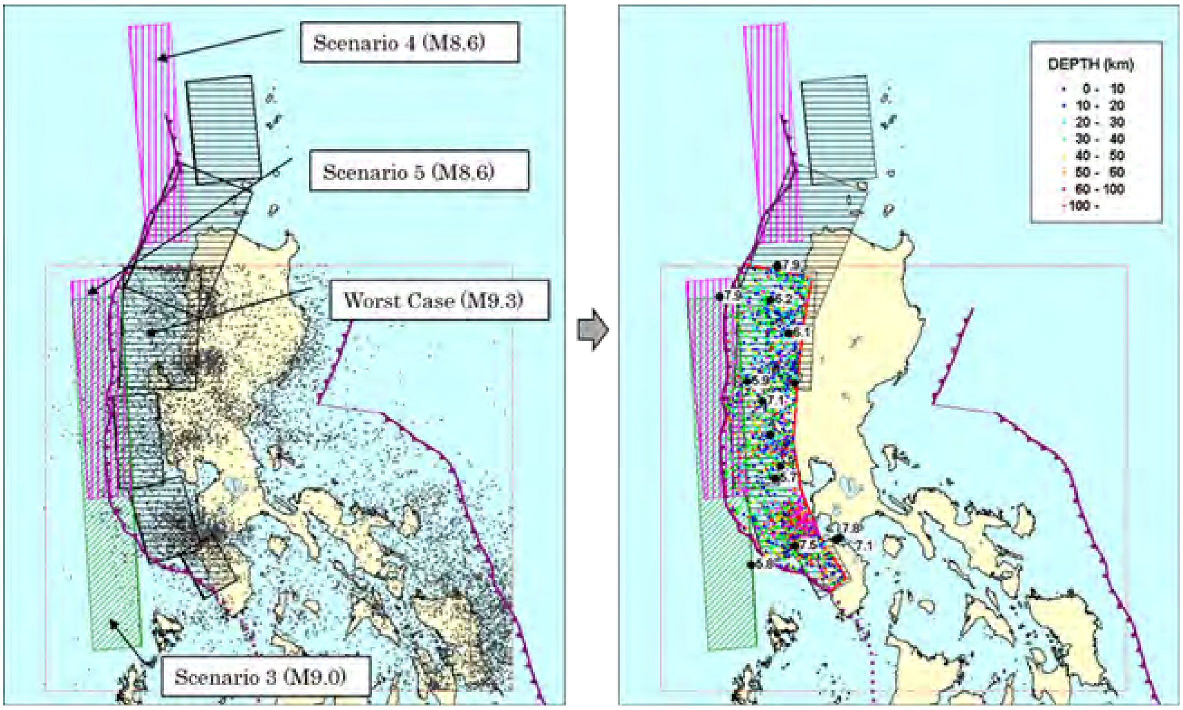

Figure A.2.7 Epicenter Data along Manila Trench used for Statistical Analysis

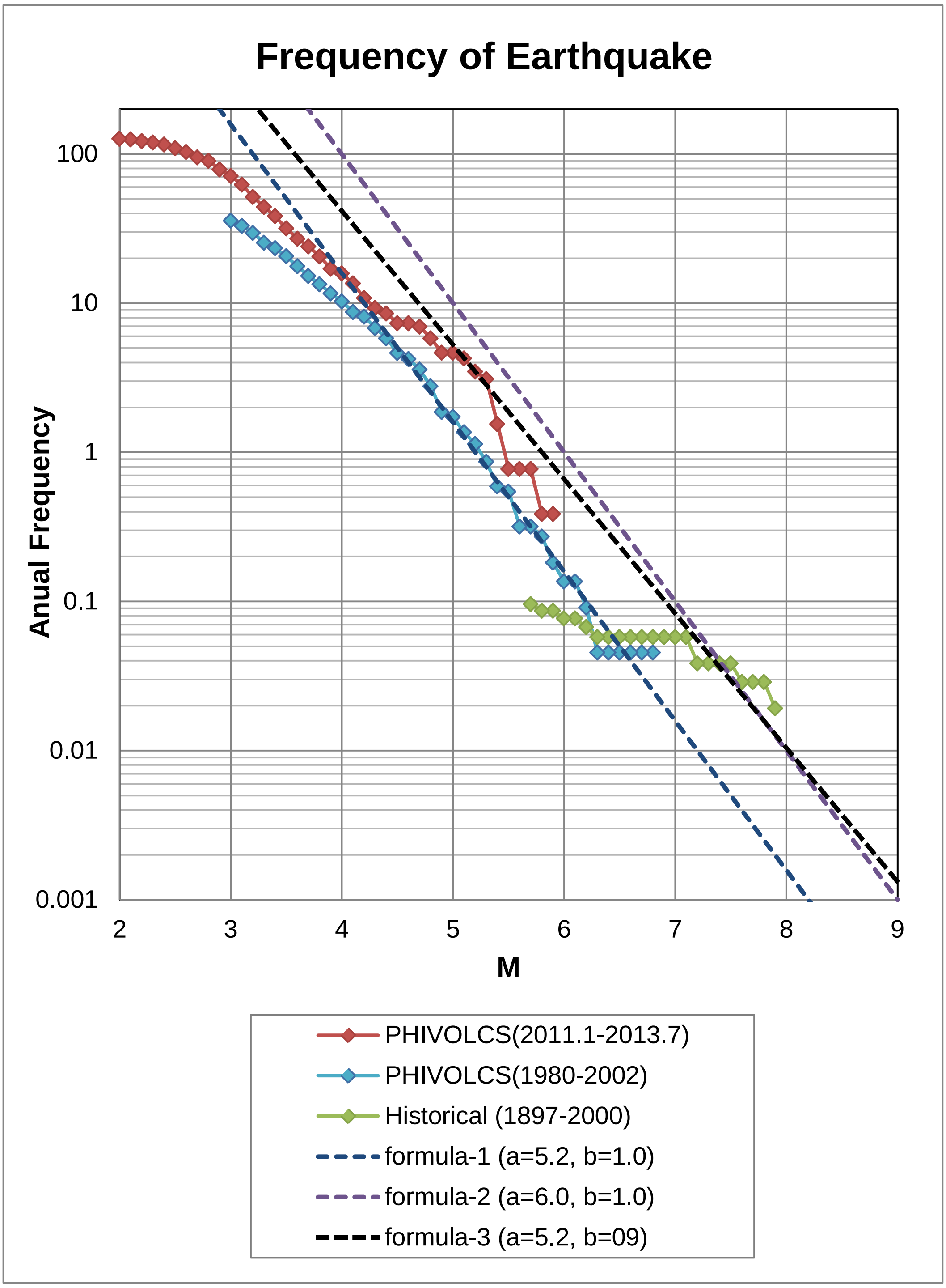

Figure A.2.8 Return Period of the Earthquakes along Manila Trench (Gutenberg–Richter law)

(3) Analysis and Results

1) Setting of tsunami (earthquake) model

Scenario earthquakes which may affect to the objective area are selected from the existing researches [10)11)12)]. Table A.2.7 shows fault parameters of scenario earthquakes. The locations of the scenario earthquakes are shown in Figure A.2.9 to Figure A.2.11.

Table A.2.7 Source Model

Scenario No.	Mw	Depth (km)	Strike (degree)	Dip (degree)	Rake (degree)	Length (km)	Width (km)	Slop (m)
1[11]	8.0	12	177	24	90	151	47	5.3
2[11]	8.5	18	177	24	90	313	70	906
3[11]	9.0	27	177	24	90	646	101	17.5
4[10]	8.6	10	355	35	57	400	90	6.0
5[10]	8.6	10	355	24	72	400	90	6.0
6	8.0	10	355	24	72	151	47	5.3
Worst Case [12]	9.3	0	35.4	10	90	190	120	25.0
		0	22	20	90	250	160	40.0
		0	2	28	90	220	160	40.0
		0	356	20	90	170	90	28.0
		0	344	22	90	140	110	12.0
		0	331	26	90	95	80	5.0

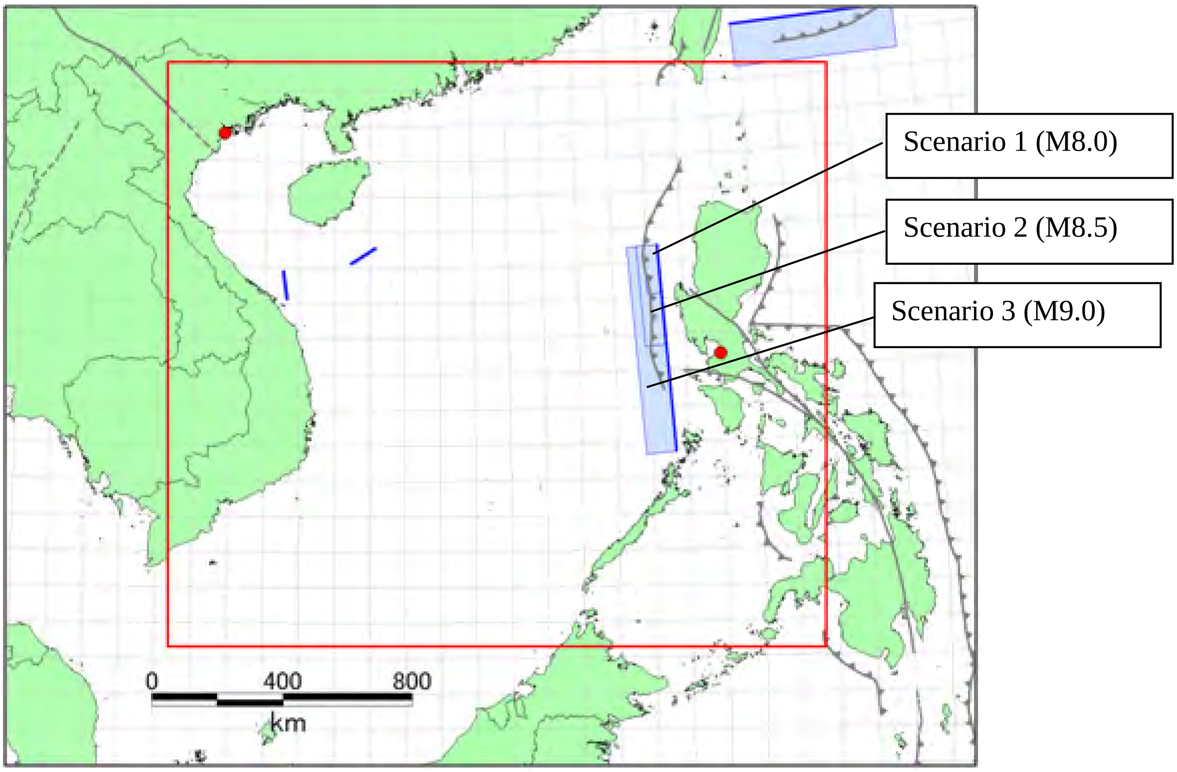

Figure A.2.9 Tsunami Source Model (Scenario 1 - 3)

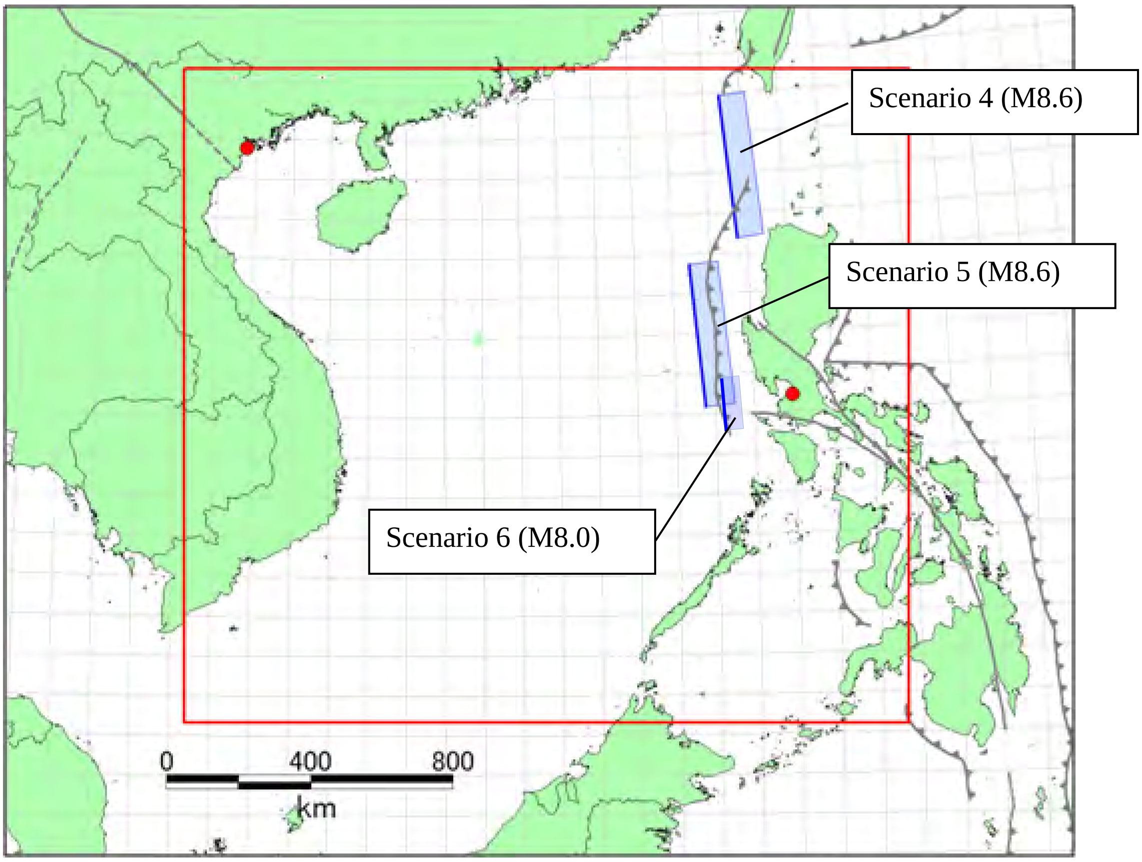

Figure A.2.10 Tsunami Source Model (Scenario 4 - 6)

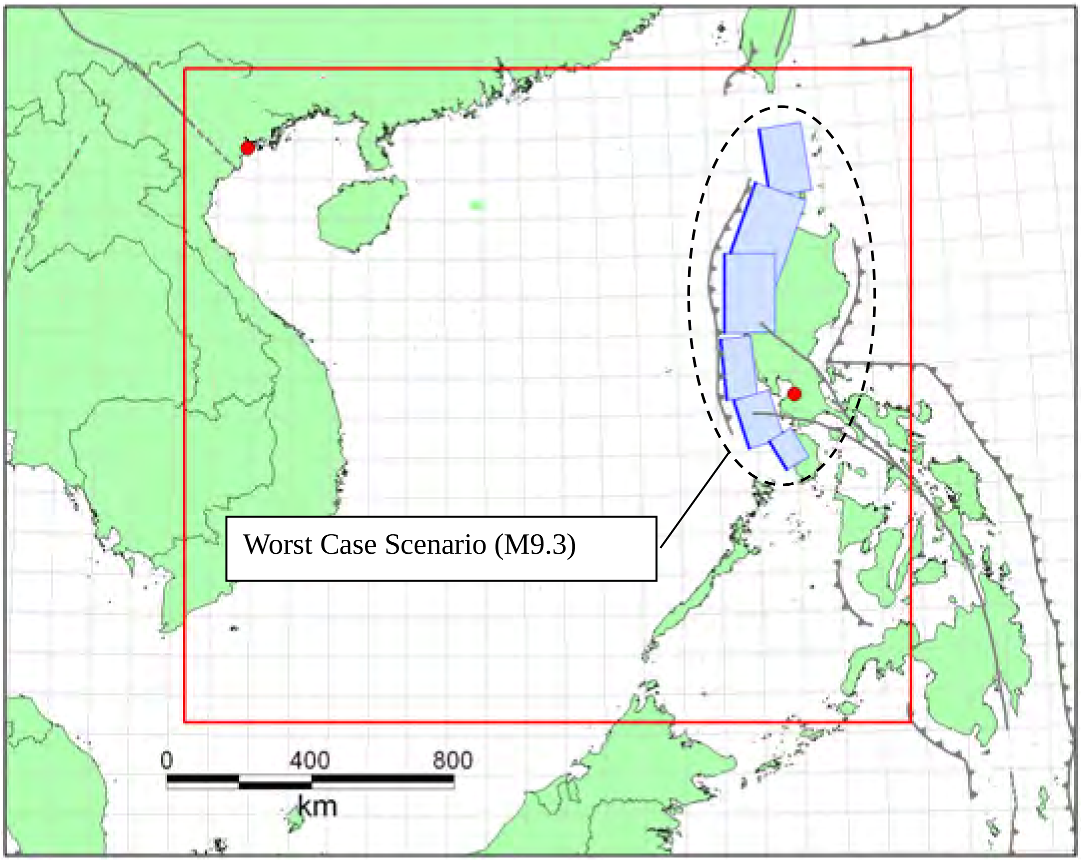

Figure A.2.11 Tsunami Source Model (Worst Case Scenario)

2) Selection of tsunami simulation model

Tsunami simulation program "TUNAMI" which is developed by Tohoku University based on the non-linear long wave theory is used for the analysis. Analysis period is set to be 24 hours after earthquake occurrence.

3) Preparation of Input data

UTM coordinate system is used. Square grids are adopted for topographical model. The size of grids are defined as 1350m, 450m, 150m and 50m, from tsunami source region to the coast based on the nesting method.

Topographical data

The depth of the grids in the ocean area with the size of 1350m, 450m and 150m and the inland 50m grids are generated based on "GEBCO_08 Grid" data prepared by BODC (British Oceanographic Data Centre).

The point water depths in the topography map prepared by NAMRIA (National Mapping and Resource Information Authority) are digitized and used for creating the depth data of the 50m grids in the Manila Bay.

Figure A.2.12 shows the wide area topographical model prepared from "GEBCO_08 Grid". Figure A.2.13 shows the topographical model around the Manila Bay prepared from topographical map.

Roughness data

Roughness coefficient "0.025" is used for ocean and land area.

Sea defense data

Embankment and other sea defense structures are not considered in this study.

Initial water height data (= deformation of sea-floor)

Deformation of sea-floor is calculated by Okada's program "DC3D0 / DC3D" with using fault parameters of scenario earthquakes and the vertical component of the deformation of sea-floor is given to corresponding grid as initial water height.

Calculated deformation of sea-floor is shown in Figure A.2.14, Figure A.2.17, Figure A.2.20, Figure A.2.23, Figure A.2.26, Figure A.2.29 and Figure A.2.32.

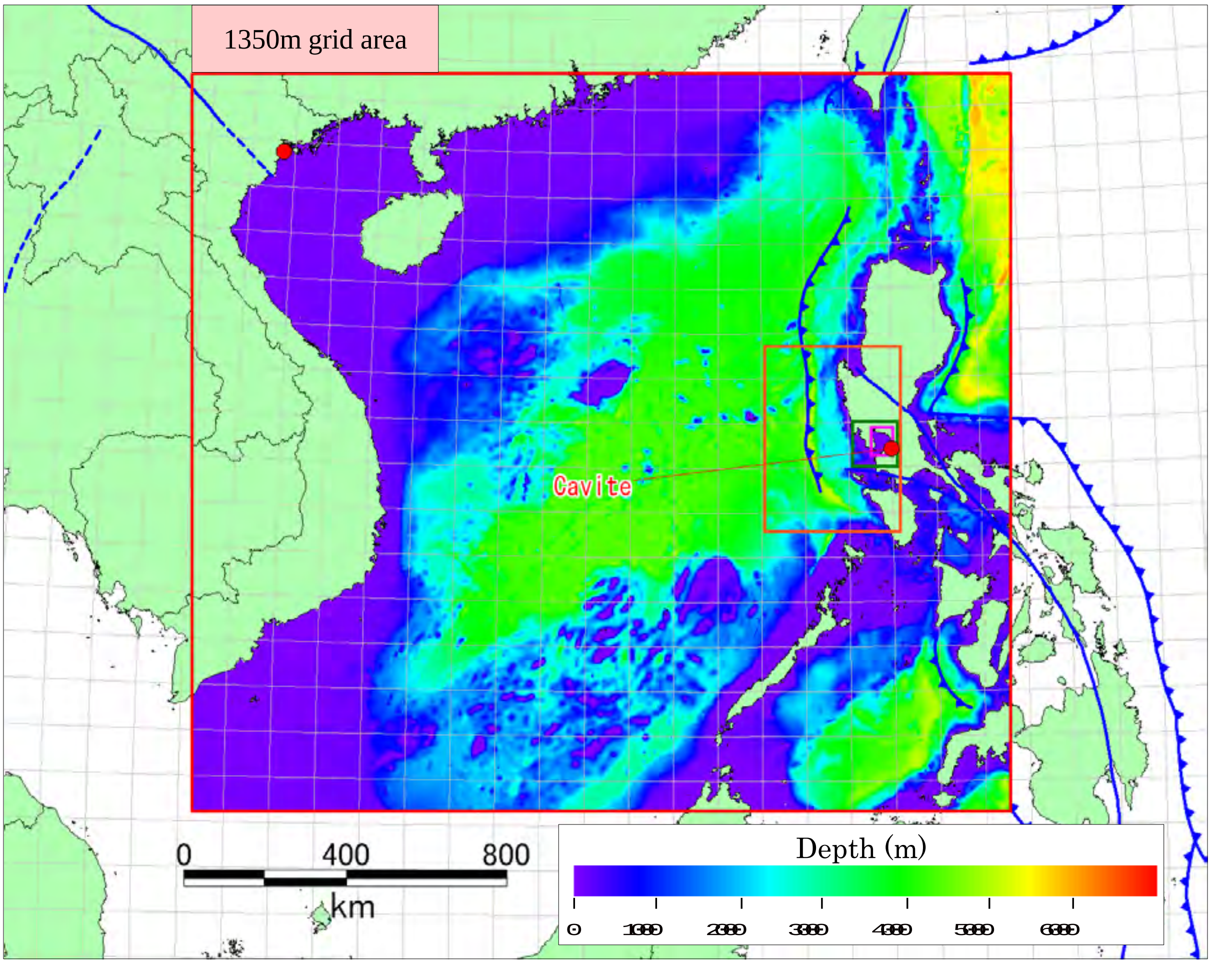

Figure A.2.12 Wide Area Topography Model by GEBCO Data (South China Sea Area)

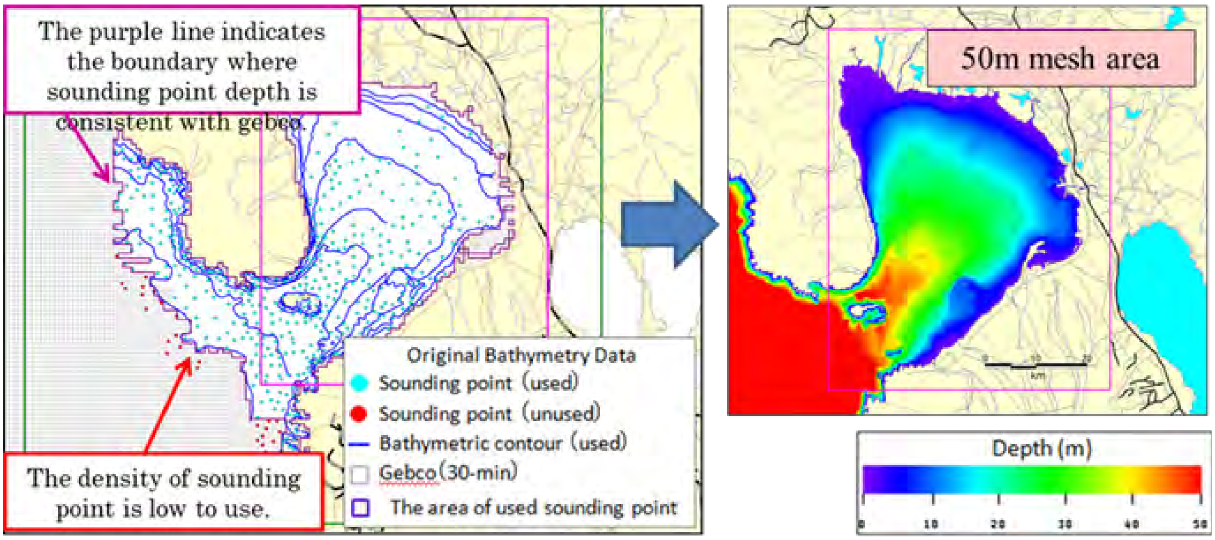

Figure A.2.13 Topography Model of Coast Area by Bathymetry Data (Manila Bay area)

4) Tsunami simulation

Figure A.2.14 to Figure A.2.34 show the results of the simulation for Scenario 1 to 5 and the Worst Case Scenario. Table A.2.8 shows the maximum tsunami height at Cavite and the expected return period calculated from magnitude of each scenario earthquake.

Cavite is located inside of the Manila Bay, therefore tsunami height is not so high compared to the open ocean. It is estimated that the tsunami heights by the earthquakes with magnitude around 8.5 which occur along the Manila Trench are less than 1 m by the simulation (Scenario 2, 4, 5, 6). If earthquake of magnitude 9.0 occurs, the tsunami height may become larger than 2 m (Scenario 3 and Worst Case Scenario); however the probability of such a huge earthquake may be once in several thousand years.

Table A.2.8 Maximum Tsunami Height at Cavite for Each Scenario

Scenario No.	Mw	Return Period (year)	Max. Tsunami Height (m)
1	8.0	100 ～63	0.12
2	8.5	300 ～2	0.57
3	9.0	1000 ～6	2.66
4	8.6	400 ～2	0.24
5	8.6	400 ～2	0.66
6	8.0	100 ～63	0.34
Worst Case	9.3	2000 ～	2.98

Simulation result of Scenario 1

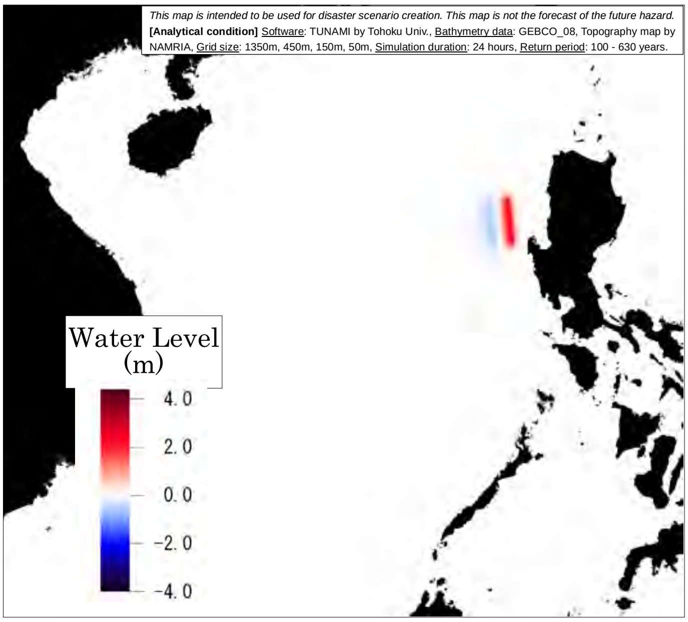

Figure A.2.14 Vertical deformation (Scenario 1)

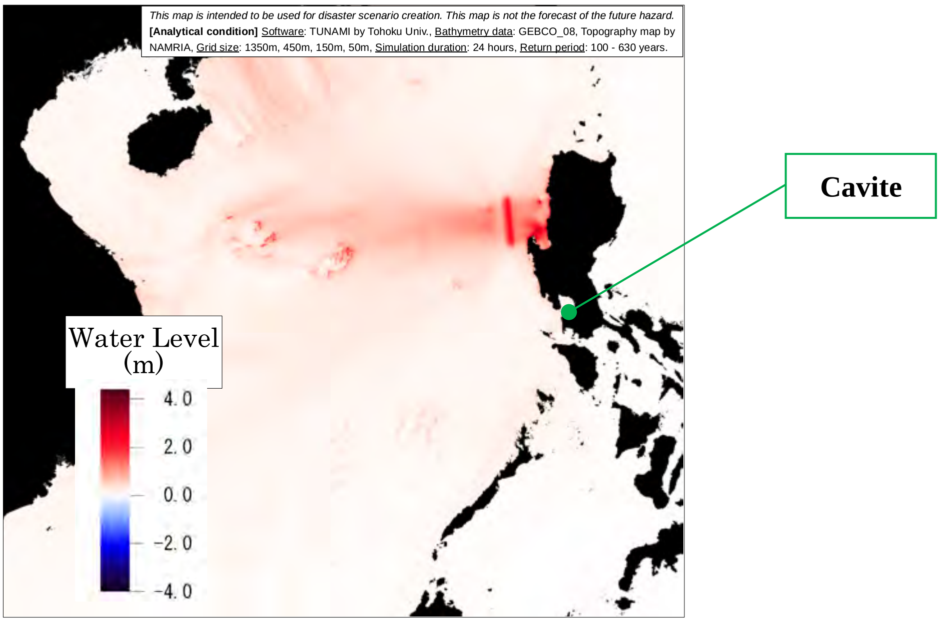

Figure A.2.15 Maximum Water Height (Scenario 1)

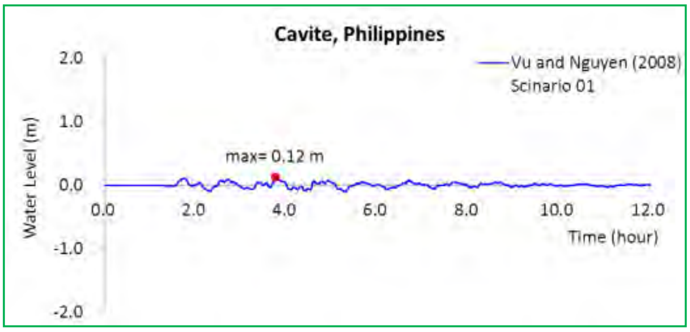

Figure A.2.16 Wave form of Tsunami Height at Cavite (Scenario 1)

Simulation result of Scenario 2

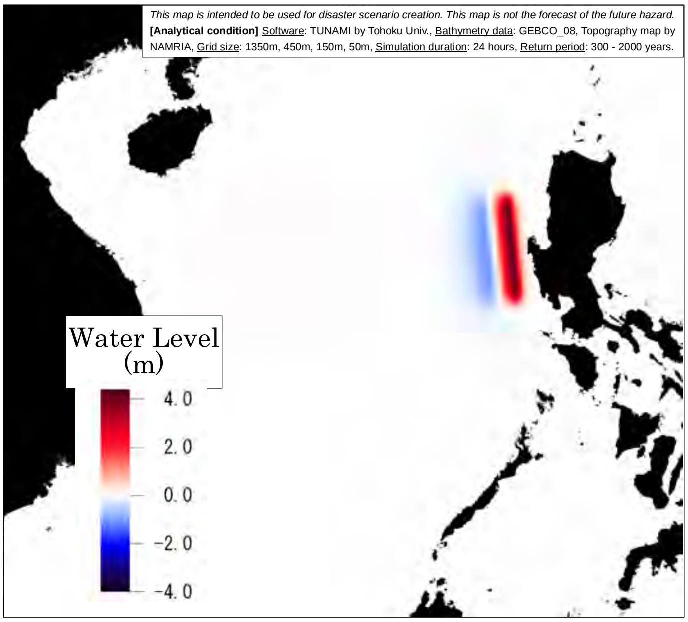

Figure A.2.17 Vertical deformation (Scenario 2)

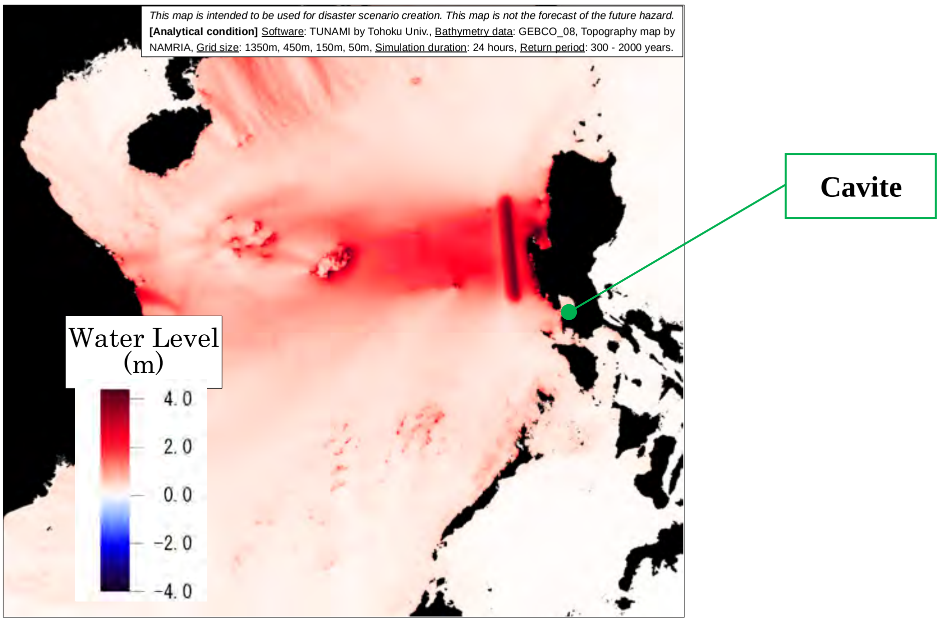

Figure A.2.18 Maximum Water Height (Scenario 2)

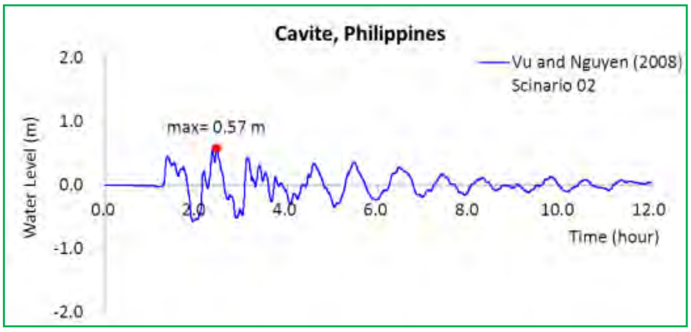

Figure A.2.19 Wave form of Tsunami Height at Cavite (Scenario 2)

Simulation result of Scenario 3

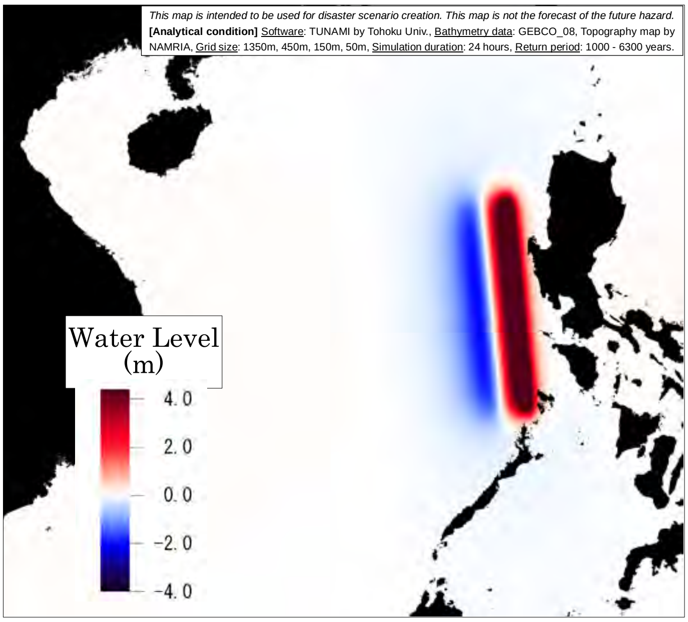

Figure A.2.20 Vertical deformation (Scenario 3)

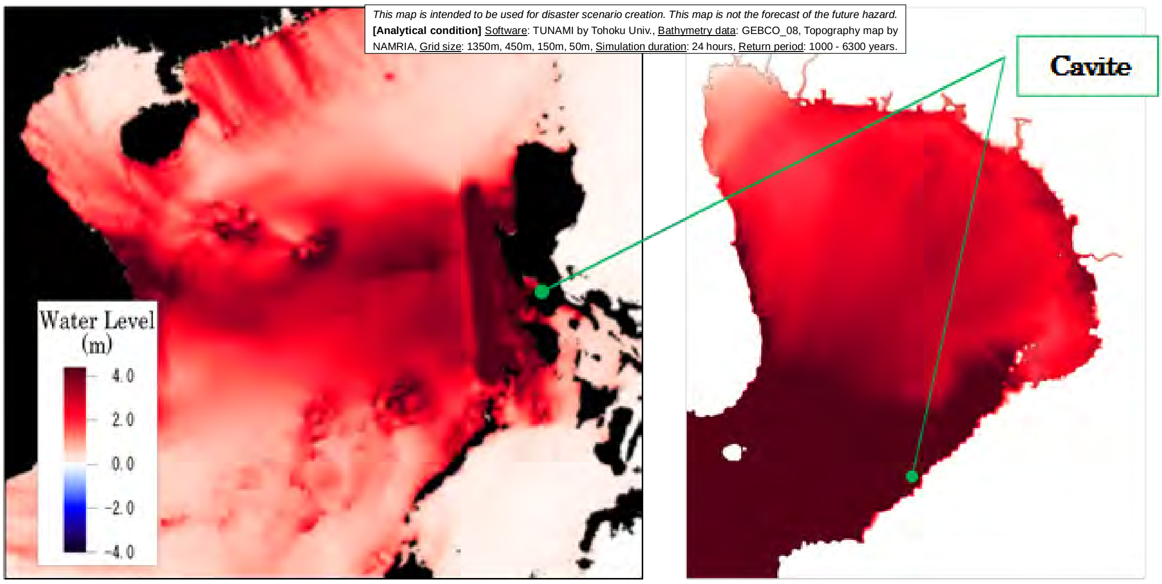

Figure A.2.21 Maximum Water Height (Scenario 3)

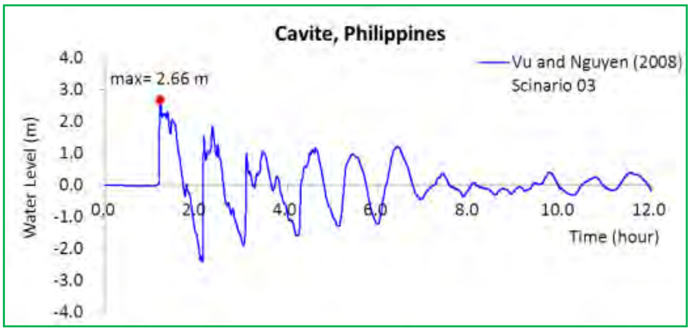

Figure A.2.22 Wave form of Tsunami Height at Cavite (Scenario 3)

<u>Simulation result of Scenario 4</u>

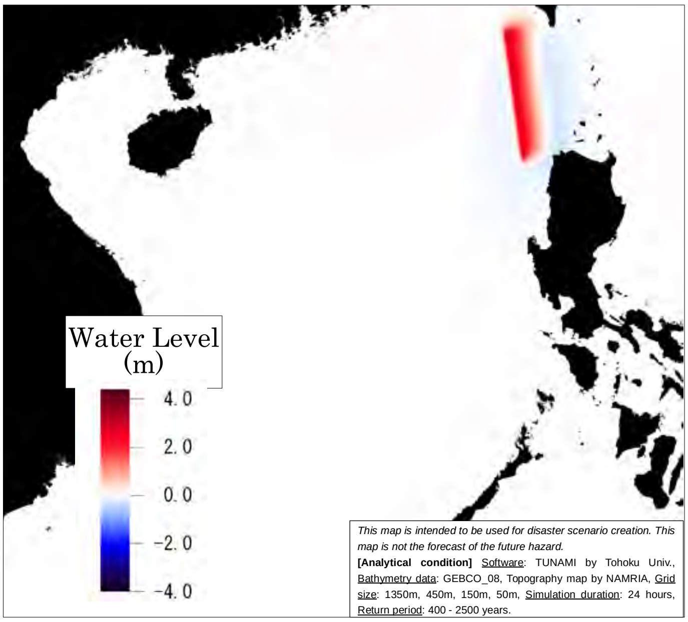

Figure A.2.23 Vertical deformation (Scenario 4)

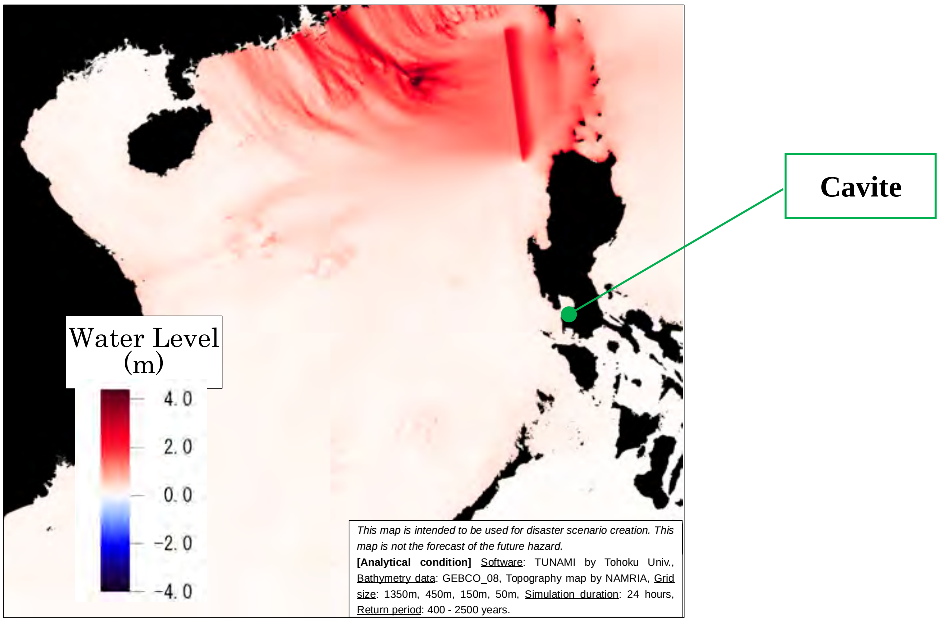

Figure A.2.24 Maximum Water Height (Scenario 4)

Figure A.2.25 Wave form of Tsunami Height at Cavite (Scenario 4)

Simulation result of Scenario 5

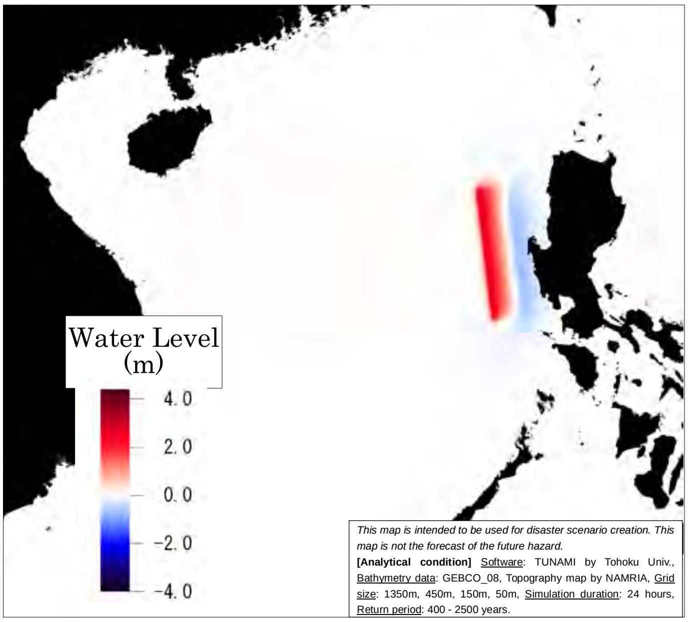

Figure A.2.26 Vertical deformation (Scenario 5)

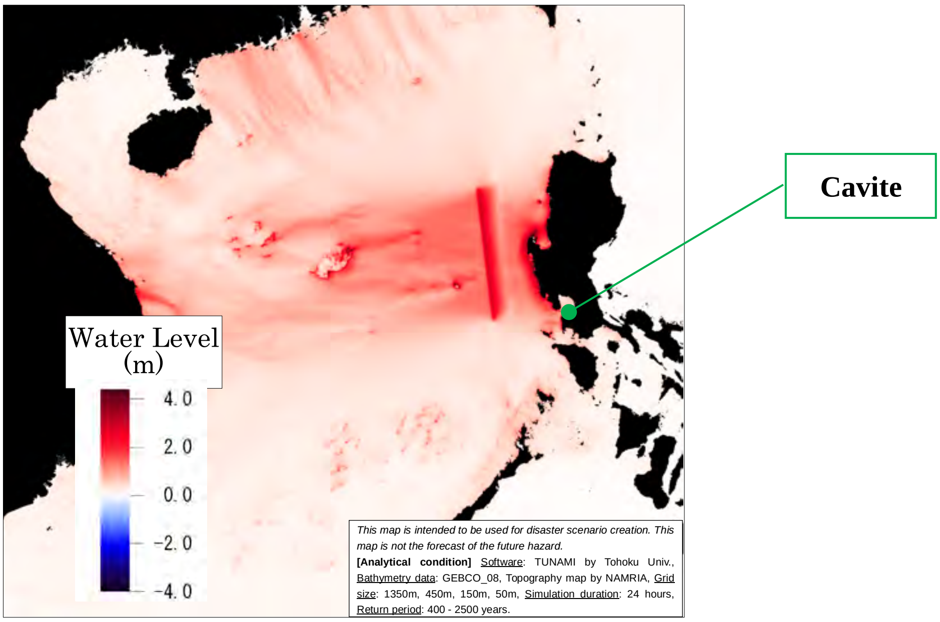

Figure A.2.27 Maximum Water Height (Scenario 5)

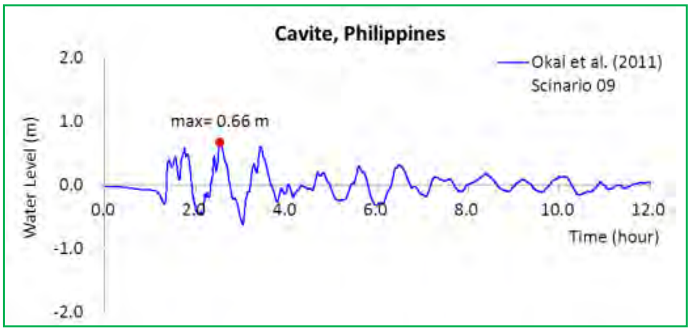

Figure A.2.28 Wave form of Tsunami Height at Cavite (Scenario 5)

Simulation result of Scenario 6

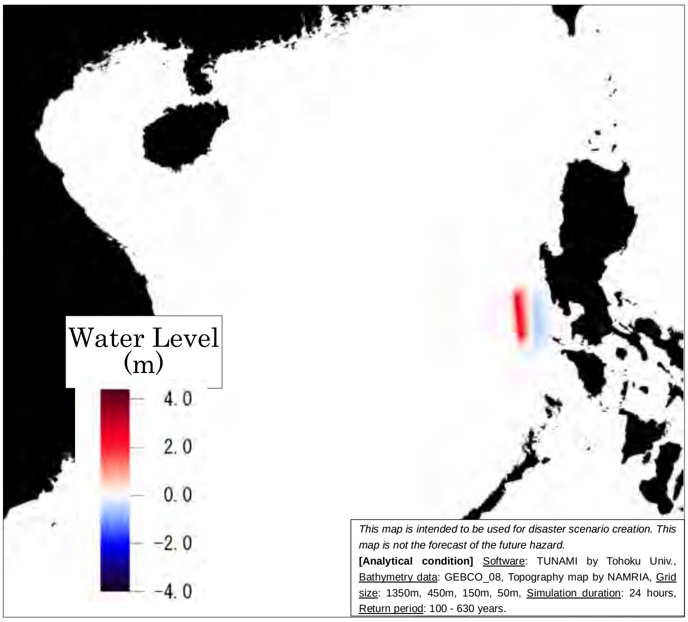

Figure A.2.29 Vertical deformation (Scenario 6)

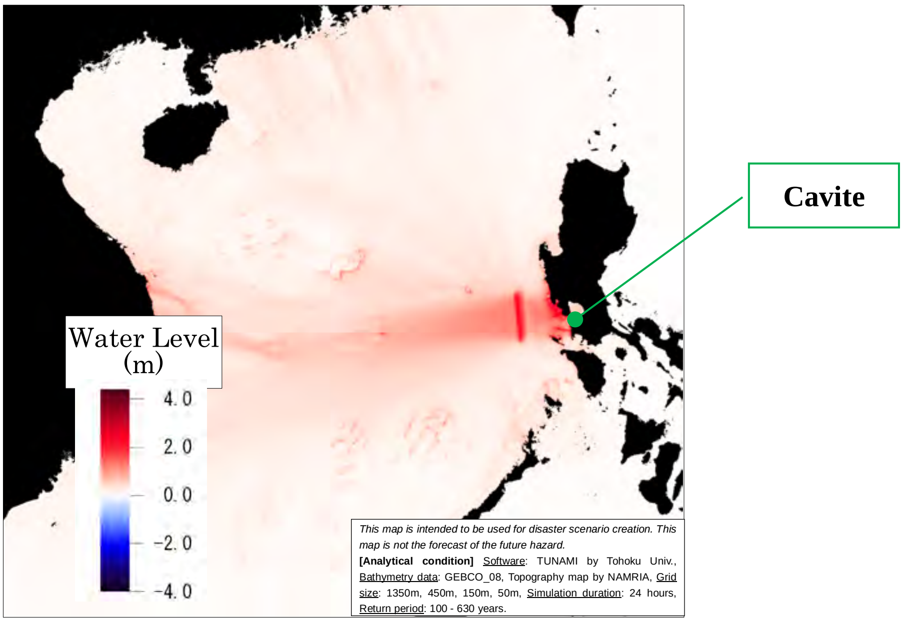

Figure A.2.30 Maximum Water Height (Scenario 6)

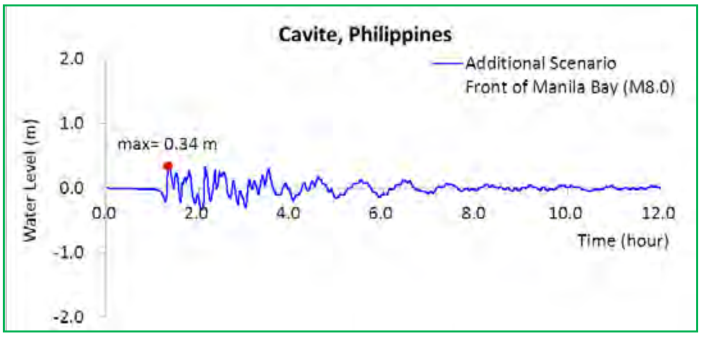

Figure A.2.31 Wave form of Tsunami Height at Cavite (Scenario 6)

Simulation result of Worst Case Scenario

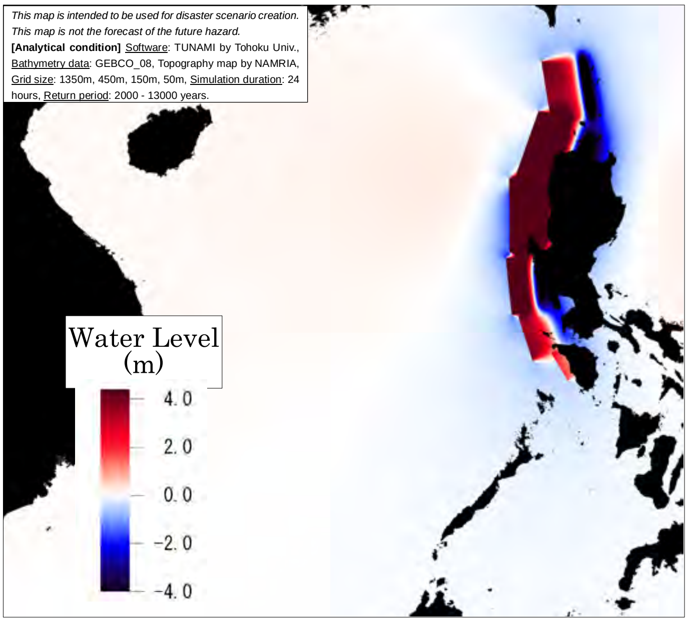

Figure A.2.32 Vertical deformation (Worst Case Scenario)

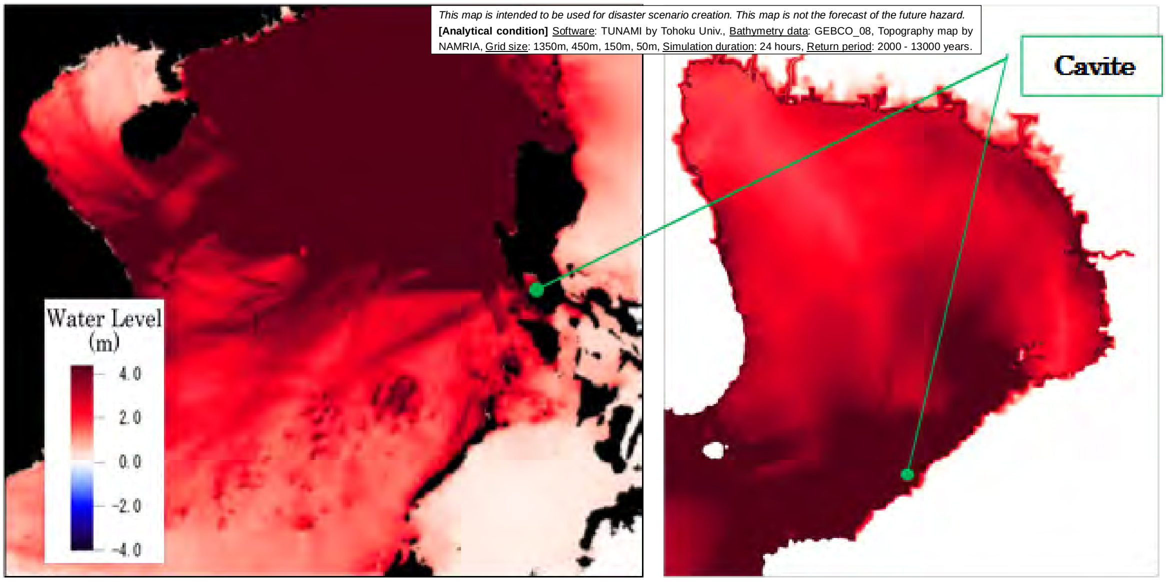

Figure A.2.33 Maximum Water Height (Worst Case Scenario)

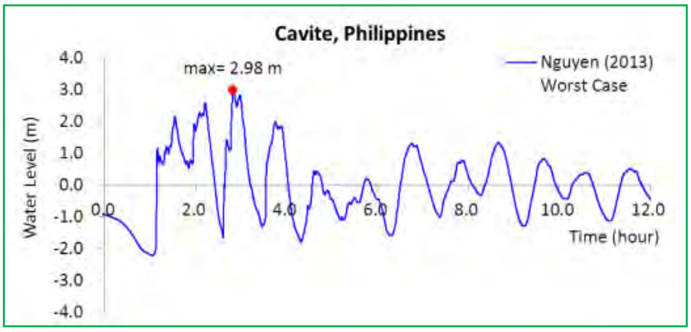

Figure A.2.34 Wave form of Tsunami Height at Cavite (Worst Case Scenario)

A.2.6 Evaluation of the Results

1) Return period of the tsunami

The probabilistic analysis methodology for tsunami is not established as for the earthquake. The main reason is that there is no simple simulation method for tsunami compared to the earthquake. The earthquake motion can be evaluated by attenuation formula using only the magnitude of the earthquake and the distance from the epicenter to the study point; however simple formula to estimate tsunami is not exist because the influence of the bathymetry and the shape of the shore line have a great influence to the tsunami. Therefore, the tsunami simulation for the previously decided probability of occurrence like the other hazards is not possible. In this study, the tsunami was simulated based on the existing fault models in the existing scientific papers, and the probability of the occurrence of the earthquake at the fault was estimated based on the earthquake catalogue around the fault separately. The tsunami simulation in this study is not the probabilistic analysis but the simulation of tsunami by the existing fault model and the evaluation of the probability of fault activity.

2) Bathymetry data

The open source bathymetry data of around 1km grid is used to make the bathymetry model. The quality of the data is enough to be used to make offshore bathymetry model. The bathymetry data near the coast should be more precise, for example 50m grid data is necessary. The chart or bathymetry map are digitized and used in this study. The precise bathymetry data is sometimes unavailable or not exist at all. This limitation may become an obstacle to the tsunami simulation.

3) Run-up

The run-up is not simulated in this study because the precise and accurate elevation model, height of dyke, land cover and distribution of the buildings are necessary. The high level of technique is also required for precise analysis. The hurdle to realize the run-up simulation for Area BCP is high.

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A.3 Flood Hazard Assessment

A.3.1 Overview

The flood/inundation analysis model for Cavite Lowland was already built in previous JICA Study, *The Study on Comprehensive Flood Mitigation for Cavite Lowland Area, 2007 - 2009*. In this study, the analysis model build in previous JICA study shall be used for evaluation of natural disaster. The following table shows the outline of the model.

Table A.3.1 Outline of Flood/Inundation Model for Cavite Lowland Area

<table>
<tr><th>No.</th><th>Items</th><th>Descriptions</th></tr>
<tr><td>1</td><td>Target area</td><td>Eastern part of state of Cavite in Philippine including Imus River Basin, Sun Juan & Ylang Ylang River Basin and Canas River Basin.
Total area is 407.4km^2</td></tr>
<tr><td>2</td><td>Rainfall Analysis</td><td>Sample: annual maximum 2 days rainfall (average rainfall of watershed)
Number of samples: 25 (from 1978 to 2006)
Probability density function: Logarithm-Pearson distribution type III

Probable Rainfall
<table>
<tr><th>Return Period (year)</th><th>2-days rainfall (mm)</th></tr>
<tr><td>2</td><td>191</td></tr>
<tr><td>3</td><td>224</td></tr>
<tr><td>5</td><td>258</td></tr>
<tr><td>10</td><td>295</td></tr>
<tr><td>20</td><td>326</td></tr>
<tr><td>30</td><td>342</td></tr>
<tr><td>50</td><td>360</td></tr>
<tr><td>100</td><td>383</td></tr>
<tr><td>200*</td><td>412</td></tr>
</table>
* re-calculated in this study</td></tr>
<tr><td>3</td><td>Runoff Analysis</td><td>Model: Quasi Linear model
MIKE-11 (one-dimensional unsteady flow model, DHI[1]) was employed for flood routing analysis
Land use condition: 2003</td></tr>
<tr><td>4</td><td>Inundation Analysis</td><td>Model: MIKE-FLOOD (DHI)
MIKE-11 (for flood routing analysis) and MIKE-21 (inundation analysis)
Boundary condition
Upper: Calculated hydrograph with the runoff model
Lower: Observed tidal level in Manila bay and Cavite port</td></tr>
<tr><td>5</td><td>Accuracy of the model</td><td>In order to ensure the reasonability of the model, hydrological parameters were tuned. This model can re-produce the flood/inundation condition by typhoon Milenyo in 2006 which was record-high flood in those days.</td></tr>
</table>

A.3.2 Design Flood Scale

Design disaster scale shall be determined considering central and/or local government policies, opinion of resident, feasibility of countermeasures and so on. Here, flood analysis under four cases including 50, 100, 200-year (probable rainfall) and record-high rainfall shall be conducted for reference. Other studies on natural disaster (earthquake, tsunami and storm surge) would be done for same probability.

[1] Danish Hydraulic Institute, DHI http://www.dhigroup.com/

A.3.3 Result of Flood/Inundation Analysis

The inundation maps are shown in next pages. According to the analysis, it could be said that Cavite industrial estate is not damaged even by flooding of 200-year scale. Northern part of coastal line could be inundated by flooding and road traffic could be closed. However, from the past result[2], interrupting time of traffic by inundation was evaluated to be a few days (average interrupting time was 1.5 days) and an influence of prohibition of traffic could be small.

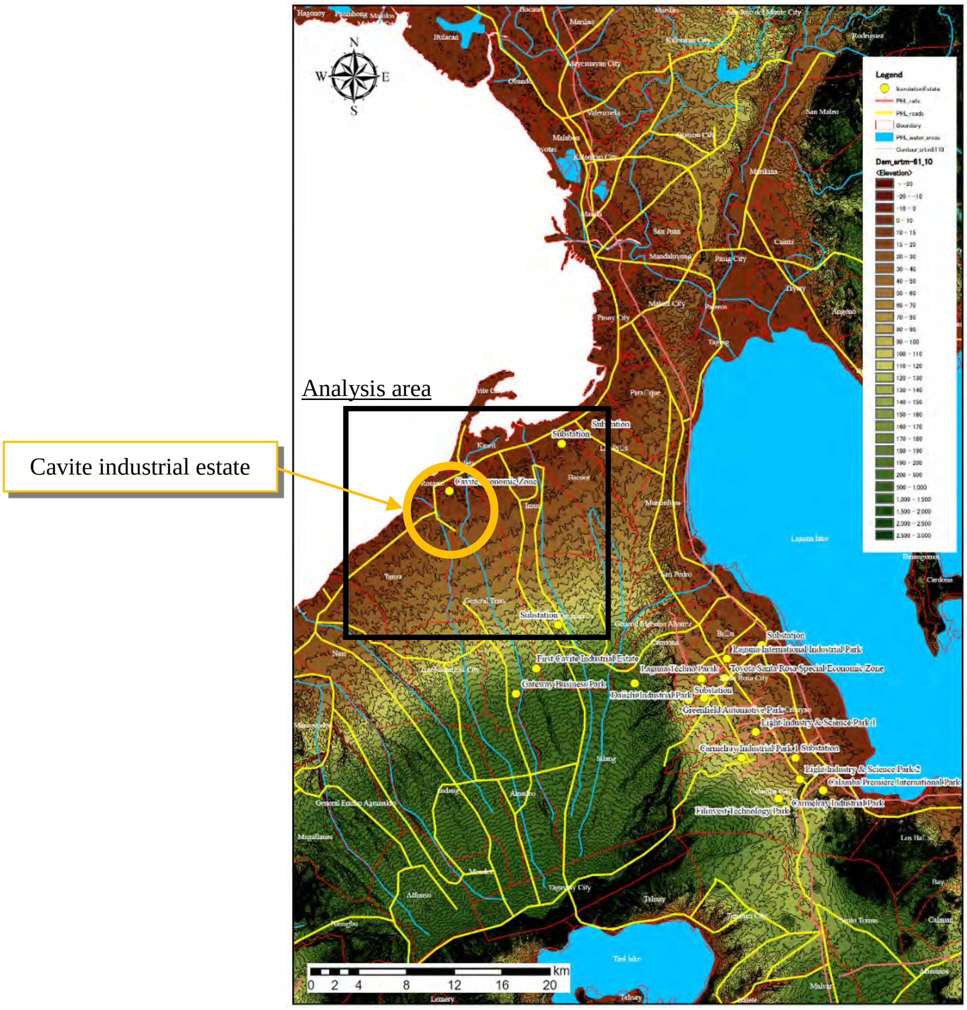


Figure A.3.1 Target Area for Flood/Inundation Analysis (Cavite Lowland)

2 The Study on Comprehensive Flood Mitigation for Cavite Lowland Area, 2007 - 2009

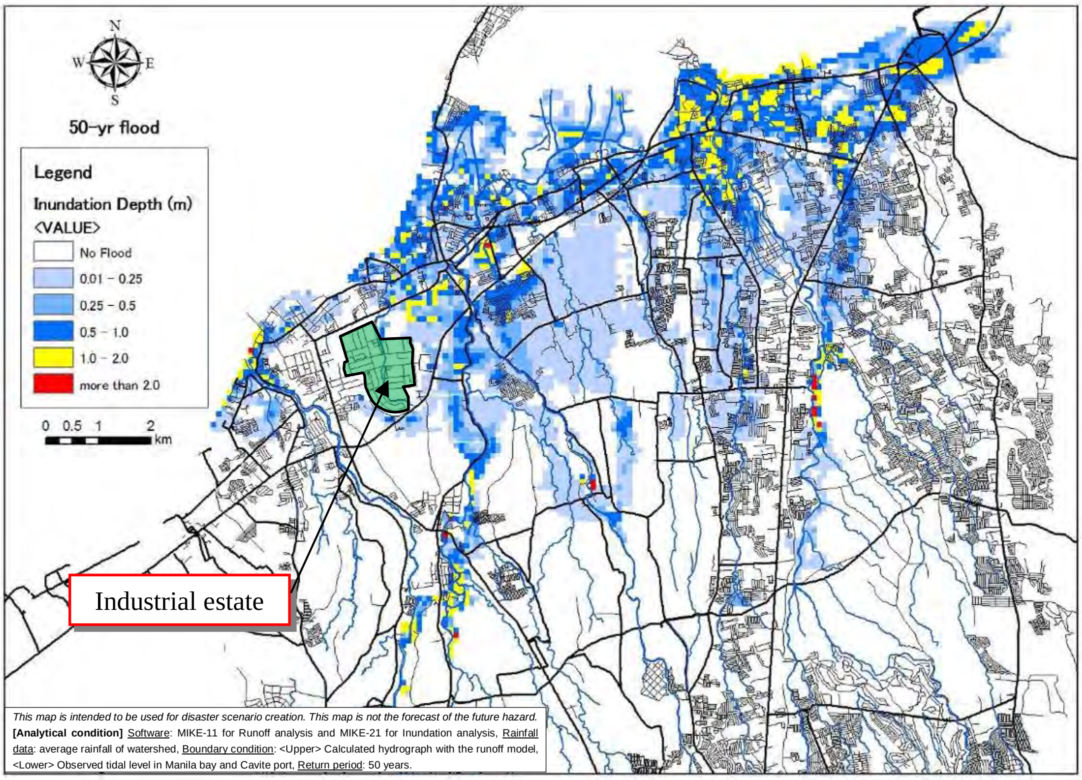


Figure A.3.2 Estimated Inundation Area/Depth (flood scale: 50-year)

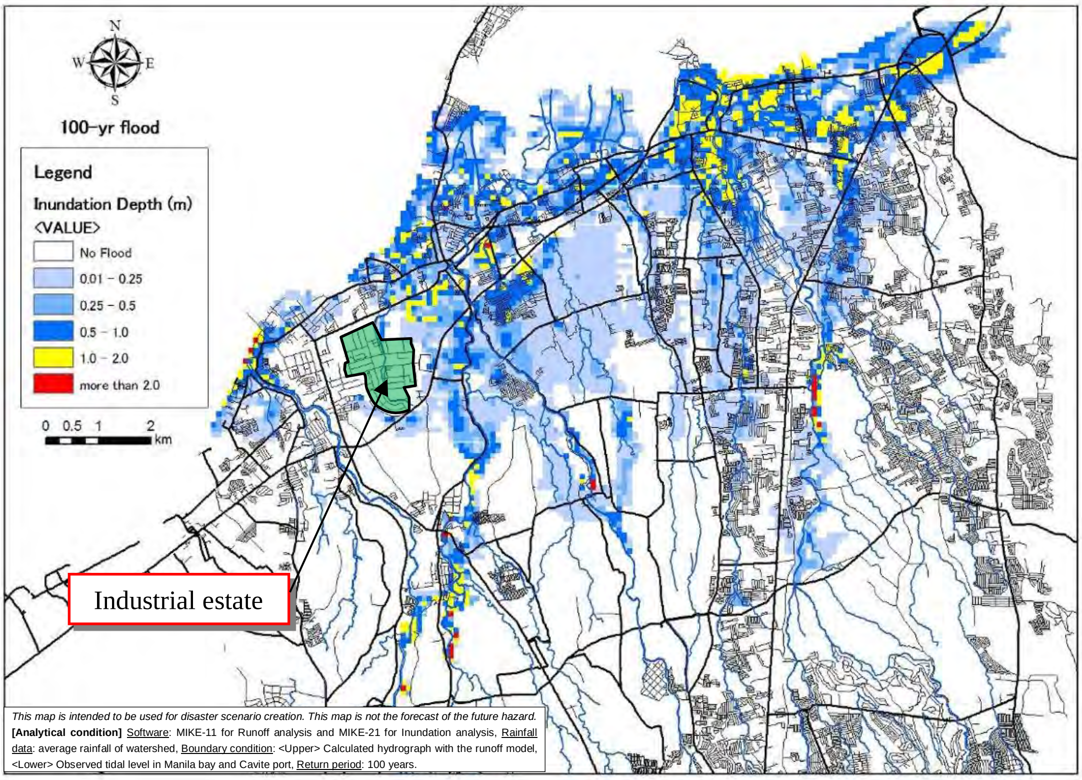


Figure A.3.3 Estimated Inundation Area/Depth (flood scale: 100-year)

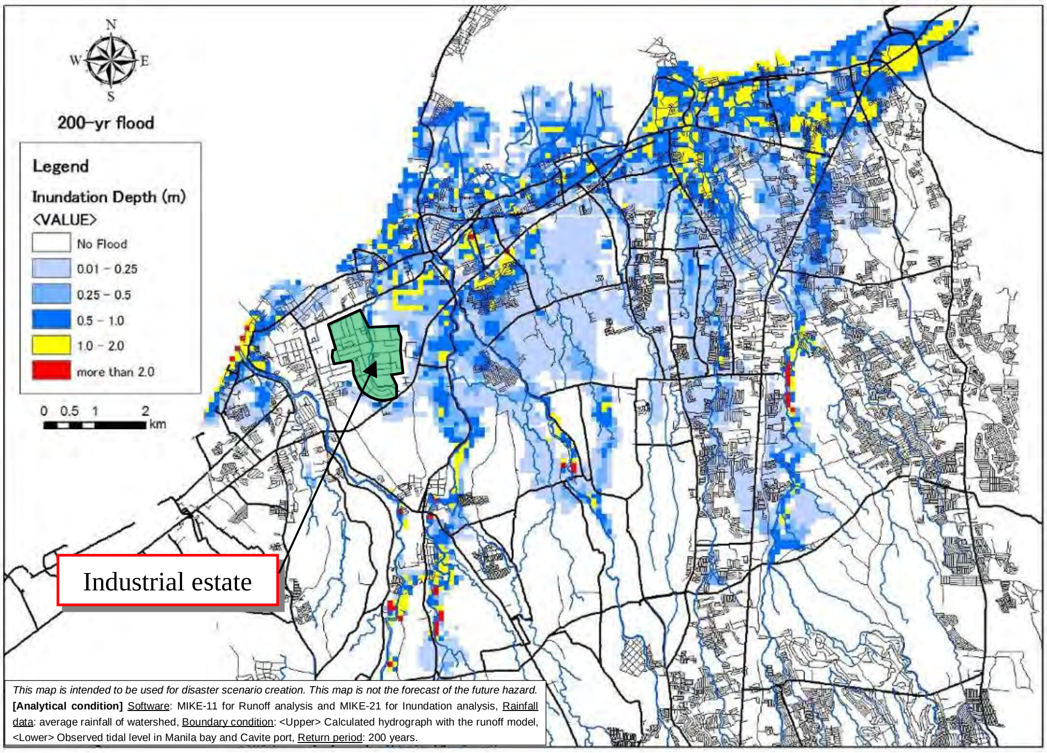


Figure A.3.4 Estimated Inundation Area/Depth (flood scale: 200-year)

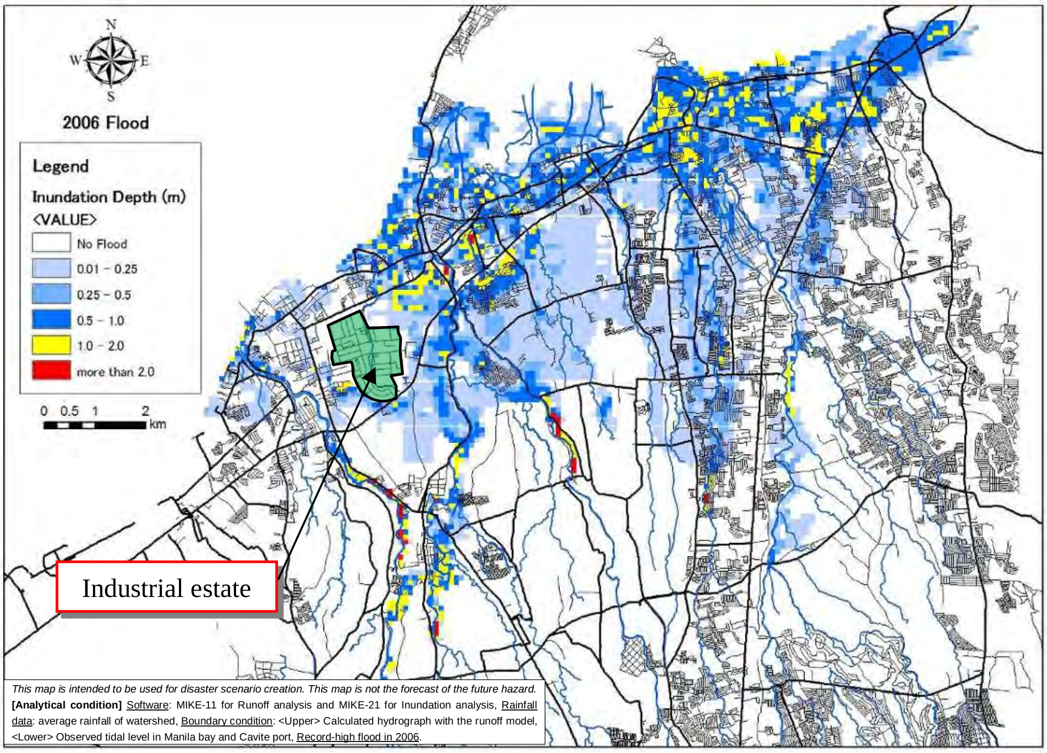
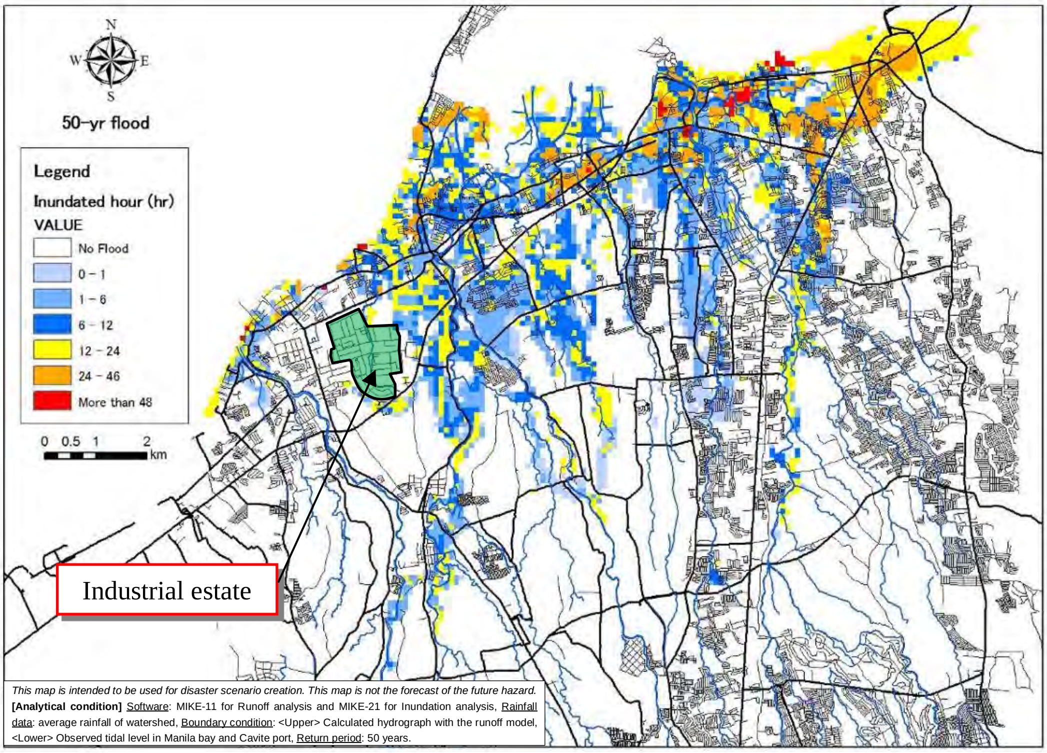
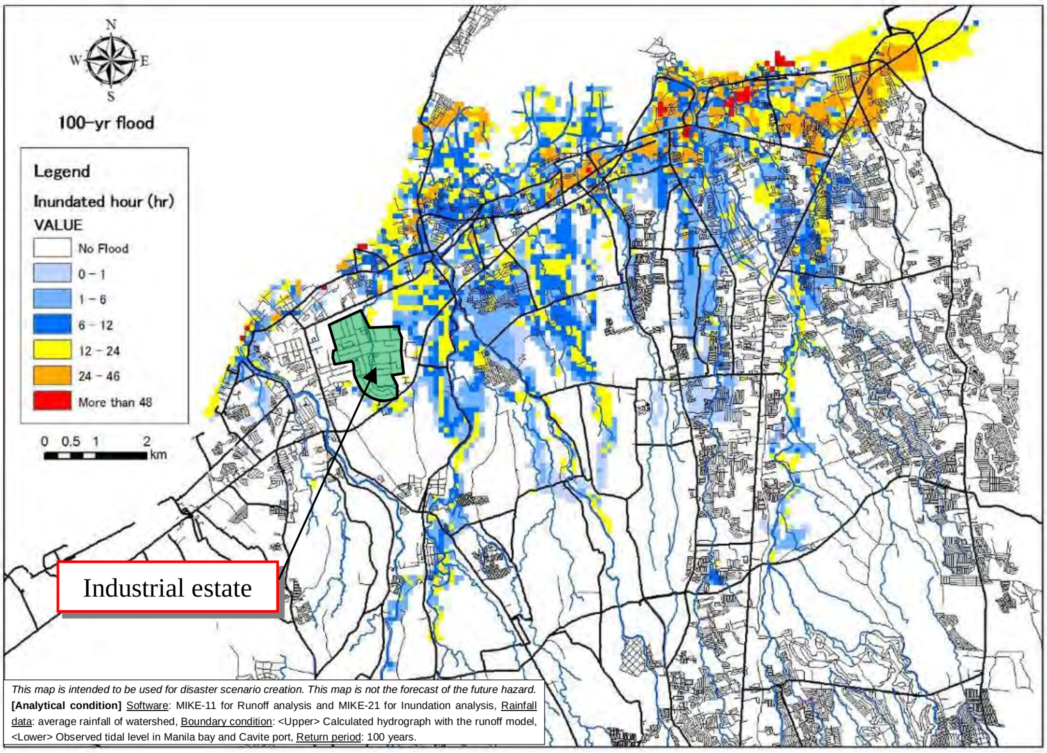


Figure A.3.5 Estimated Inundation Area/Depth (record-high flood, 2006yr)



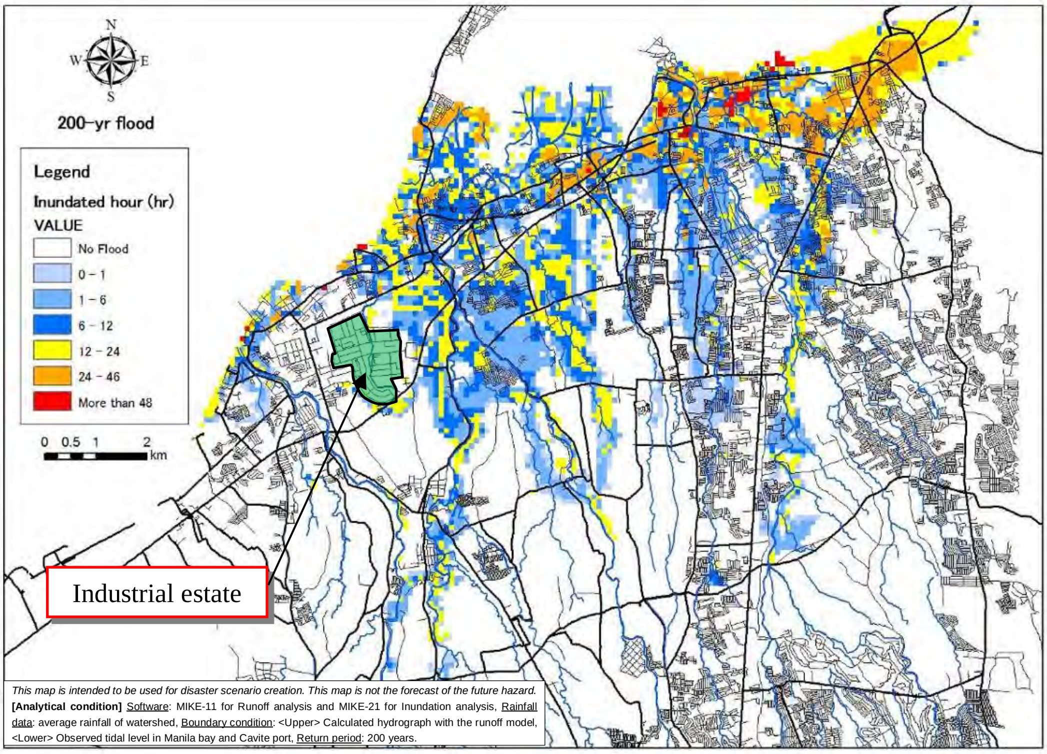
*Inundation depth less than 5cm is not displayed

Figure A.3.6 Estimated Inundation Period (flood scale: 50-year)



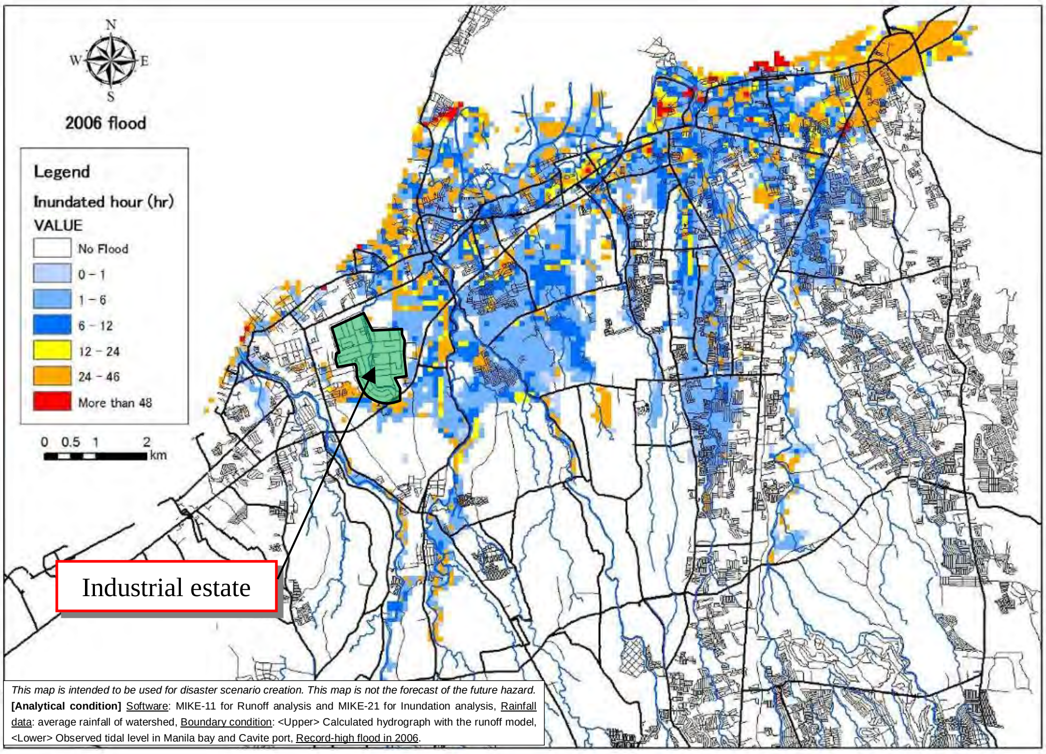
*Inundation depth less than 5cm is not displayed

Figure A.3.7 Estimated Inundation Period (flood scale: 100-year)



Inundation depth less than 5cm is not displayed

Figure A.3.8 Estimated Inundation Period (flood scale: 200-year)



Inundation depth less than 5cm is not displayed

Figure A.3.9 Estimated Inundation Period (record-high flood, 2006)

For reference, inundation area caused by increase of water level of the Laguna Lake shall be examined. Probable water level of Laguna Lake is shown as following table. Maximum high water level in decade was 13.85m (DPWH Datum[3]) caused by typhoon Ondoy in 2009, which is evaluated to be equal to flood scale of 50-year return period. Record-high water level was 14.08m, in 1972.

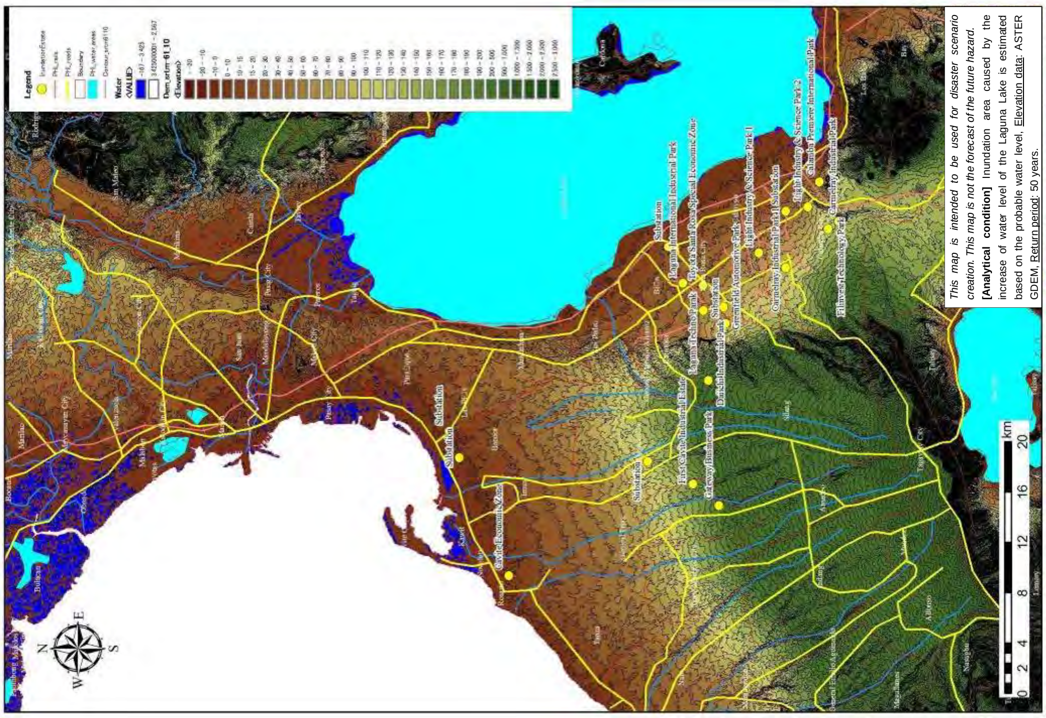
Estimated inundation each flood scale (50-year, 100-year and 200-year) is shown in next page. In southern west of the lake, approx. ten industrial estates are located but all industrial estates were constructed in high-land and never inundated by water level rise of the lake.

Table A.3.2 Probable Water Level of the Laguna Lake

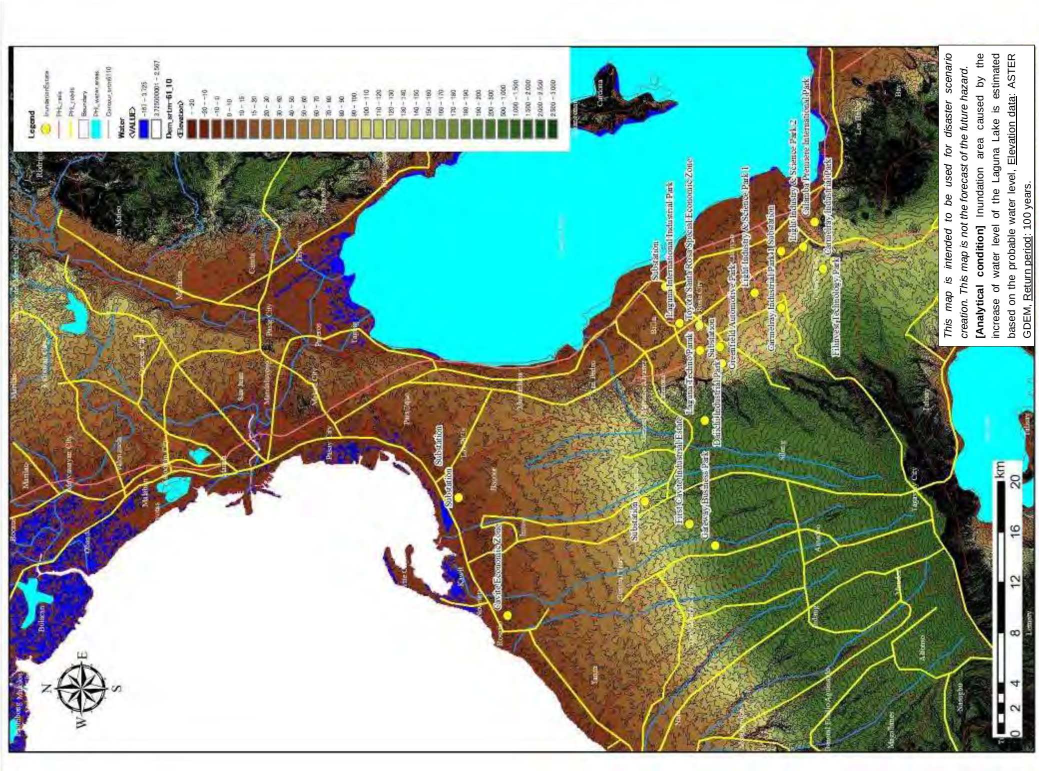
Return Period (year)	Annual Maximum Lake Water Level	
	DPWH Datum (m)	MSL (m)
2	12.3	1.825
3	12.5	2.025
4	12.8	2.325
10	13.2	2.725
20	13.5	3.025
30	13.7	3.225
50	13.9	3.425
80	14.1	3.625
100	14.2	3.725
150	14.4	3.925
200	14.6	4.125
400	14.9	4.425

Reference: Master Plan for Flood Management in Metro Manila and Surrounding Area, World Bank

[3] DPHW Datum is defined by Department of Public Works and Highways, DPWH. If DPWH Datum is converted to mean sea level (MSL), it is necessary to subtract 10.475m from water level in DPWH Datum.

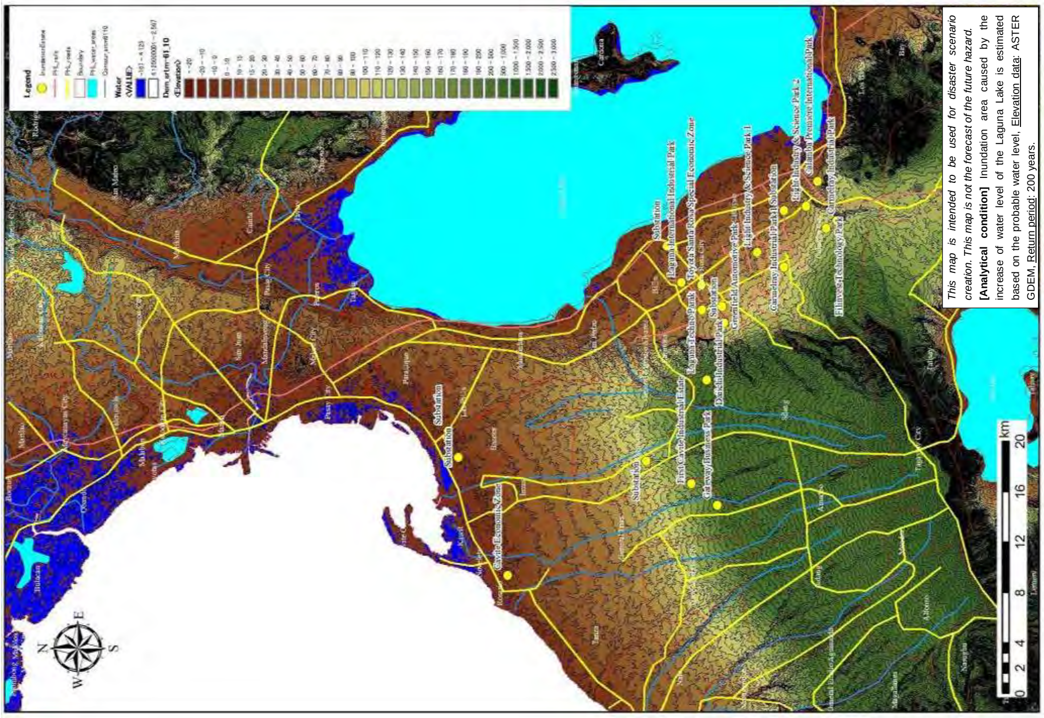


flood scale: 50-year (13.9m)

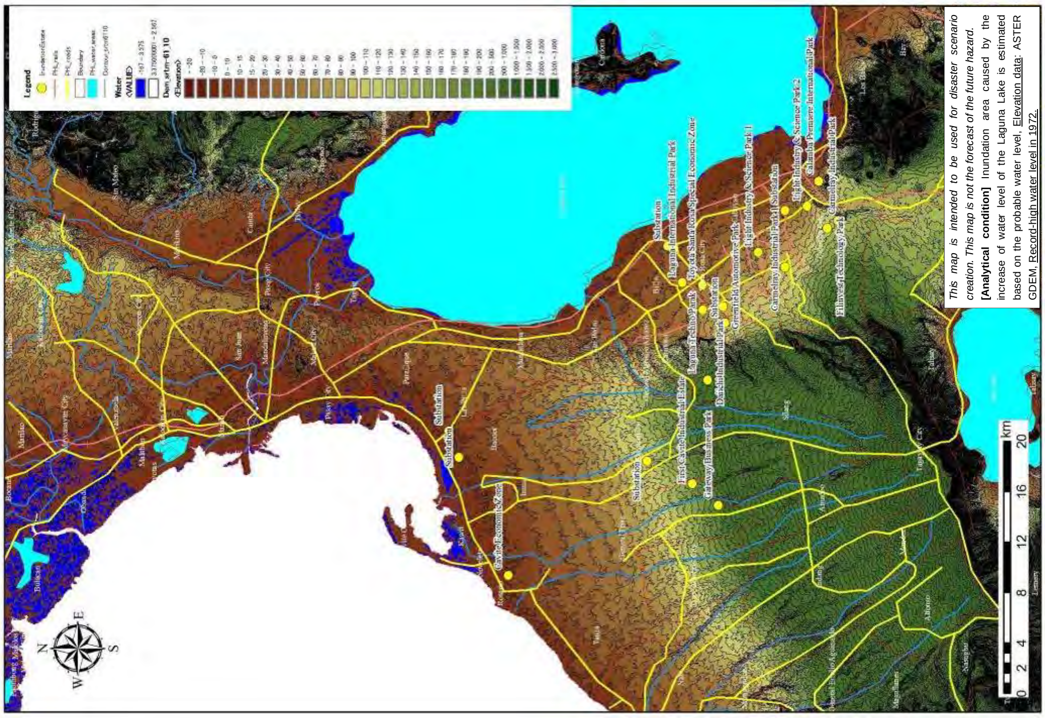


flood scale: 100-year (14.2m)

Figure A.3.10 Inundation Map around the Laguna Lake (1/2)



flood scale: 200-year (14.6m)



Record-high water level in 1972

Figure A.3.11 Inundation Map around the Laguna Lake (2/2)

A.3.4 Evaluation of the Results

The analysis of flooding in Cavite considers plenty of precise conditions because the data and software, which are used in the existing precise study project, are made use of. The surveyed cross section of river and channel and surveyed elevation data are used. The precise high precision analysis method is adopted. This analysis is higher than outline level and over-spec for disaster scenario. The flooding simulation specialist was occupied for six months during the existing study. This may be far beyond the proper input for disaster scenario formulation.