DEPARTMENT OF FINANCE (DOF)
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS (DPWH)
DEPARTMENT OF INTERIOR AND LOCAL GOVERNMENT (DILG)
THE REPUBLIC OF THE PHILIPPINES

THE URGENT DEVELOPMENT STUDY ON THE PROJECT ON REHABILITATION AND RECOVERY FROM TYPHOON YOLANDA IN THE PHILIPPINES

FINAL REPORT (I)

APPENDIX

TECHNICAL SUPPORTING REPORT

JUNE 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.
PACIFIC CONSULTANTS CO., LTD.
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PASCO CORPORATION

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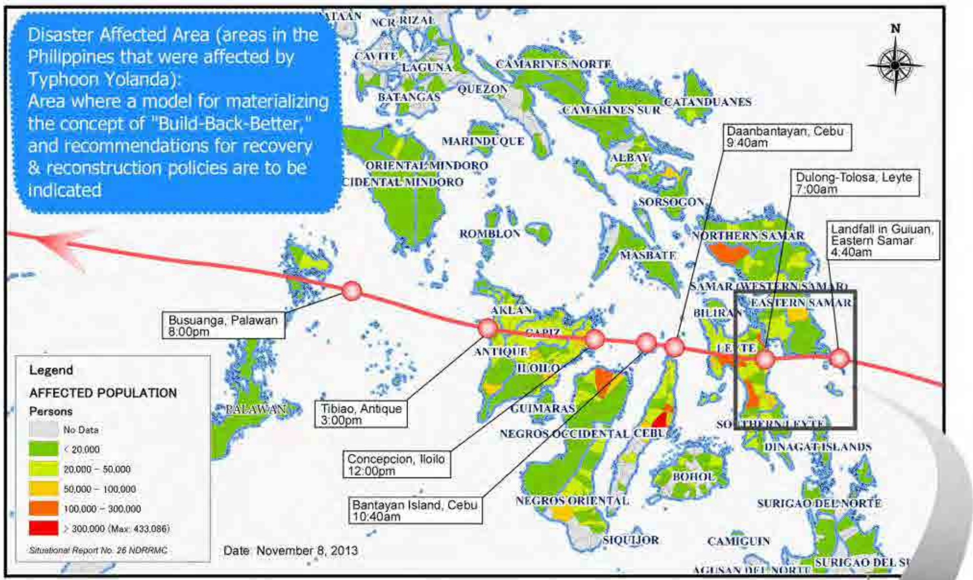
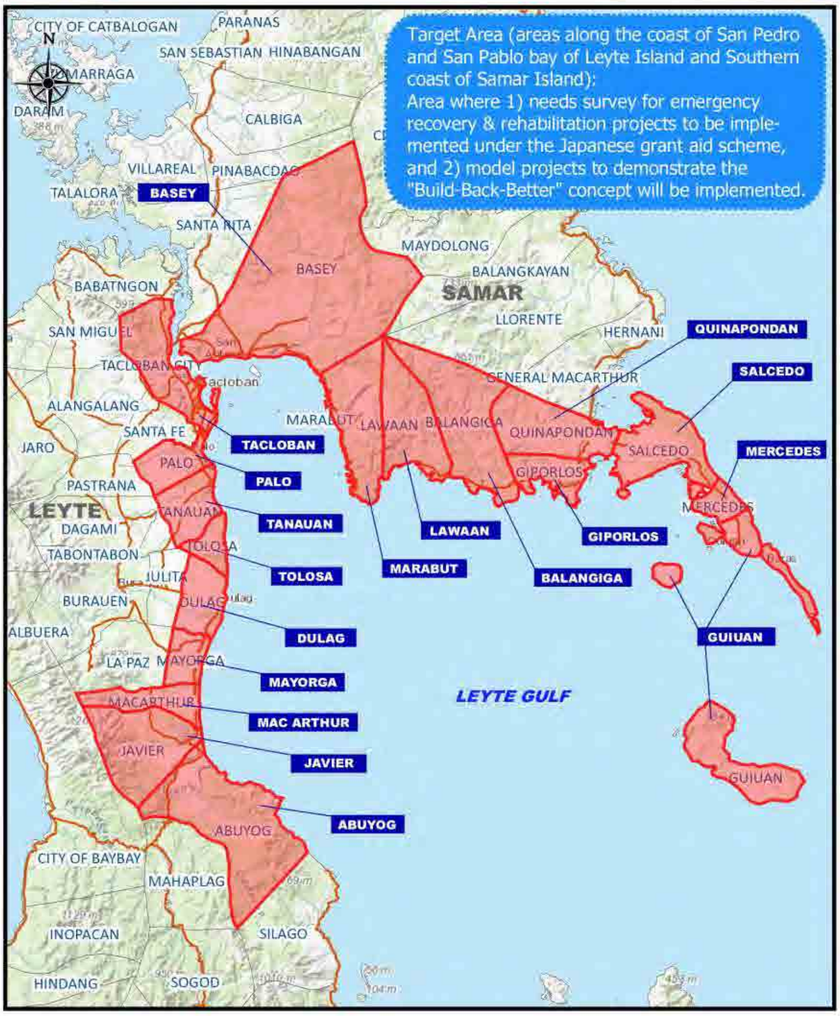
Composition of Final Report (I)

Summary		
Main Report	Volume 1	Recovery and Reconstruction Planning
	Volume 2	General Grant Aid Project
	Volume 3	Quick Impact Projects
Appendix	Technical Supporting Report	

US$ 1.00 = Phillipines Peso (PHP) 44.56 = Japanese Yen ¥ 123.96

(June, 2015)





Map of the Disaster Affected Area and Target Area

Republic of the Philippines

The Urgent Development Study on

The Project on Rehabilitation and Recovery from Typhoon Yolanda

Appendix

Technical Supporting Report

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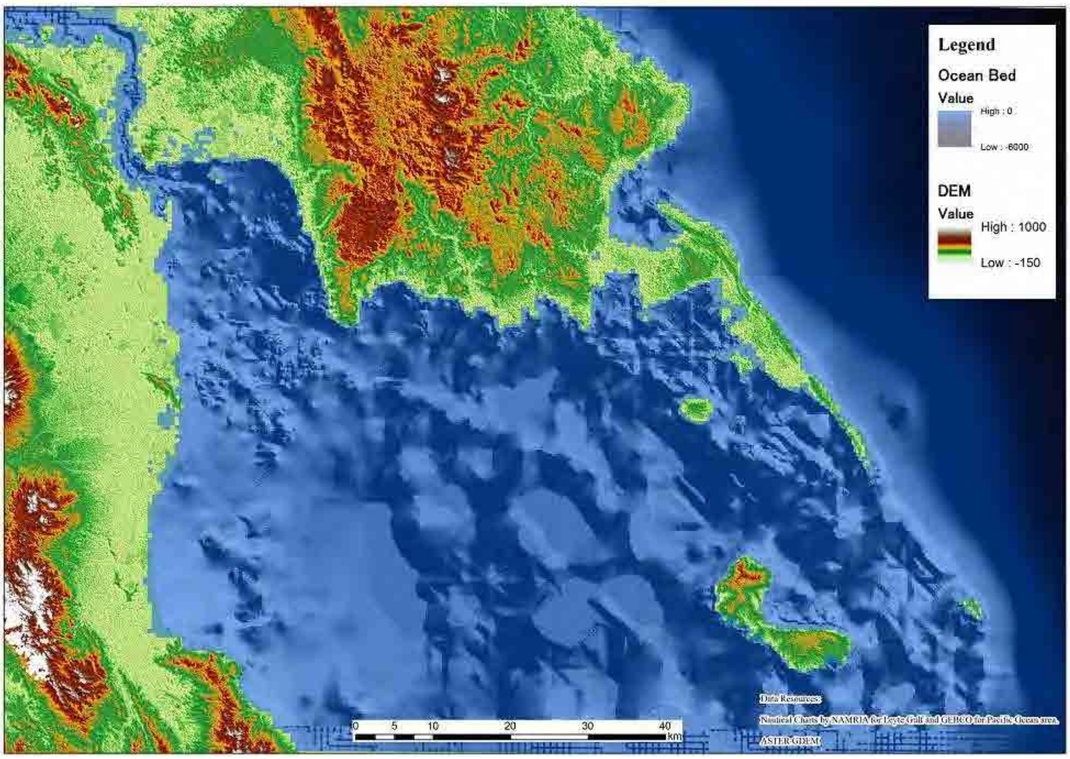
Chapter 1 Summary of Study Area

1.1 Natural Conditions

1.1.1 Geology and Topography

The Study Area covers the Leyte and Samar islands and their adjacent coastal area and sea. It is situated between 9 degrees 30 minutes to 11 degrees 30 minutes North Latitude and between 124 degrees 30 minutes to 126 degrees 30 minutes East Longitude.

Figure 1.1-1 shows the topographic relief of both the land surface and seabed in and around the Study Area. The depth of Leyte Gulf is shallow compared with the Pacific Ocean side. It is reportedly said that the islands of the archipelago are actually the peaks of mountains uplifted from the sea floor by the horizontal pressure exerted by the Indo-Australian Plate and the Asiatic Plate on the eastern boarders of the Philippine Plate during the Miocene Period. The series of small islands composed of "half-drowned mountains" form part of a long and wide cordillera extending from Indonesia to Japan while other peaks are of volcanic origin.



Source: JICA Project Team

Figure 1.1-1 Topographic Relief in and around the Project Area

The Philippines archipelago could be, as the basic conception, considered as wedges caught between two sets of oppositely dipping subduction zones. The Leyte and Samar islands are situated between the Sulu Negros Trench and the Philippines Trench. These trenches are interpreted as subduction zones where the ocean submarine floor under thrusts beneath the continental or island massif.

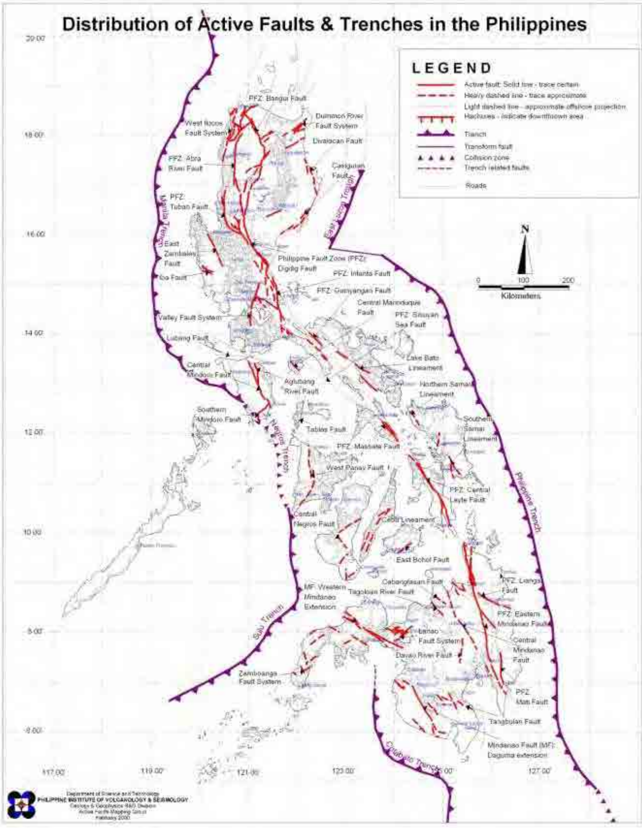
The alignment of these trenches, especially of the two major trenches, the Philippines Trench and the East Luzon Trench trending toward NNW to N, characterizes the Philippines archipelago as a zonal structure with several wide belts connecting island to island arch wise in the same trend as the trenches.

The archipelago consists essentially of two separable and distinct structural units, a mobile belt and a stable region. The mobile belt covers almost all the archipelago and is characterized by the concentration of earthquake epicenters, numerous active and inactive volcanos and deeply sheared zones forming narrow canyons, intermontane basins and straits. The stable region, the southwestern part of the archipelago which embraces mainly Palawan and Sulu Sea, is essentially aseismic and shows the virtual absence of Tertiary igneous activity.

The mobile belt is further subdivided into three structural belts (western, central and eastern structural belts) running parallel from northwest to southeast. The Project area is directly related with the central and eastern structural belts.

The central structural belt is composed of cordilleras, lowlands, troughs and offshore basins. It extends from Cagayan passing through central Luzon, Bondoc Peninsula, Shibuyan, Masbate, western and central Visayas and Leyte to Cotabato. The belt is characterized by thick sequences of Cretaceous to Tertiary sedimentary rocks intruded by Neagene diorite botholith. Quaternary volcanos, inactive or still active, heavily concentrate into this belt. Activity in the Philippine fault appears to have been continuous since the Paleogene.

The eastern structural belt constitutes a narrow belt limited on the east by the Philippine Trench and on the west by the western limits of Sierra Madre, Bicol range, Samar highland and Diwata range in eastern Mindanao. This belt is characterized by the presence of the post-Jurassic metamorphic rocks, numerous overthrust faults and heavy concentrations of earthquakes with shallow focus which signify dynamothermal activities along the ridge system fronting the Philippine Trench and the East Luzon Trench.



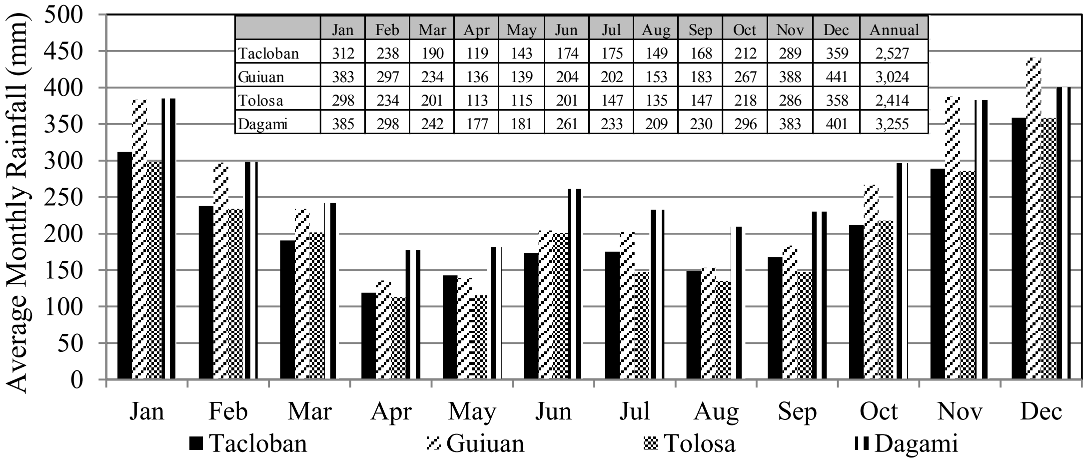
Source: PHIVOLCS

Figure 1.1-2 Distribution of Active Faults and Trenches of the Philippines

1.1.2 Meteorology

The climate of the Project Area is dominated by monsoons associated with the Inter Tropical Convergence Zone (ITCZ), where typhoons are born in the western Pacific Ocean.

The Project area is classified into "Type 2" and "Type 4" in the Philippines Climate Types, with unclear difference between dry and rainy seasons. Rainfall occurs throughout the year (as shown in Figure 1.1-3), and increases between November to February.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Tacloban	312	238	190	119	143	174	175	149	168	212	289	359	2,527
Guiuan	383	297	234	136	139	204	202	153	183	267	388	441	3,024
Tolosa	298	234	201	113	115	201	147	135	147	218	286	358	2,414
Dagami	385	298	242	177	181	261	233	209	230	296	383	401	3,255

Data Source: Daily and six hourly Rainfall observed by PAGASA, organized in The Project

Figure 1.1-3 Average Monthly Rainfall

1.1.3 Rivers and Coastal Area

(1) Rivers

The rivers in the Project area, whose main basin areas are 300 - 550km^2, are classified into medium and small size river basins. Figure 1.1-4 shows the main rivers in the Study Area. There are different river basin characteristics between the rivers located in Eastern Leyte and Southern Samar.

1) Eastern Leyte

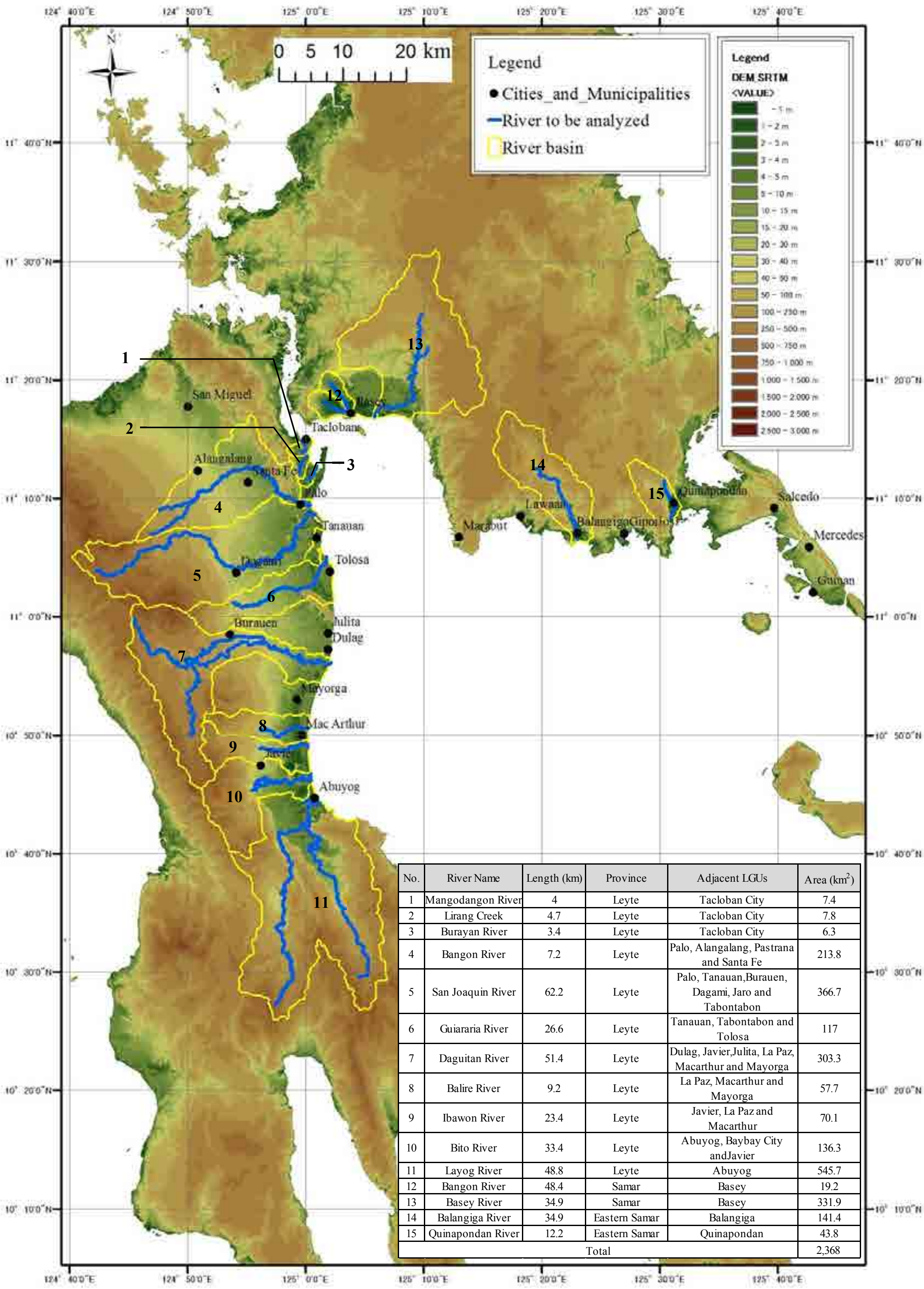
The rivers located in Eastern Leyte (e.g. Bangon, San Joaquin and Daguitan rivers), have three types of river characteristics based on topological conditions; a) alluvial area in the upper to middle reaches with steep slope, b) plain and irrigated areas in the middle to lower reaches with moderate slope and c) intermixed areas with lowlands, swampy and residential areas in the lower reaches, where the river channel is meandering.

In the Project area, flooding frequently occurs but not severe enough that people’s lives were lost. Flood occurred where the river slope changes between the upper to middle reaches (e.g. Dagami and Burauen), and at lower reaches due to the low discharge capacity of the river channel because of the meandering (e.g. Palo, Tanauan, Tolosa, Dulag, MacAthur and Abuyog). As for the lower reaches, rainfall inundation chronically occurs in the lowlands besides flooding. Also, it was testified that the most serious hazard is flooding at Abuyog.

2) Southern Samar

In the Southern Samar, the river basins have small plain areas located near the seashore, where residential areas are also located. Besides the rivers shown in Figure 1.1-4, a lot of small creeks flow down into Leyte Gulf.

Flood occurs where their plain areas are relatively large and residential areas are also in the plain areas. Flood and rainfall inundation in the lowlands were reported in the flood condition survey at Southern Samar. Especially for Quinapondan river where flood has been reported by LGU Staff, who insisted that river improvement is the first priority.



No.	River Name	Length (km)	Province	Adjacent LGUs	Area (km^2)
1	Mangodangon River	4	Leyte	Tacloban City	7.4
2	Lirang Creek	4.7	Leyte	Tacloban City	7.8
3	Burayan River	3.4	Leyte	Tacloban City	6.3
4	Bangon River	7.2	Leyte	Palo, Alangalang, Pastrana and Santa Fe	213.8
5	San Joaquin River	62.2	Leyte	Palo, Tanauan,Burauen, Dagami, Jaro and Tabontabon	366.7
6	Guiararia River	26.6	Leyte	Tanauan, Tabontabon and Tolosa	117
7	Daguitan River	51.4	Leyte	Dulag, Javier,Julita, La Paz, Macarthur and Mayorga	303.3
8	Balire River	9.2	Leyte	La Paz, Macarthur and Mayorga	57.7
9	Ibawon River	23.4	Leyte	Javier, La Paz and Macarthur	70.1
10	Bito River	33.4	Leyte	Abuyog, Baybay City andJavier	136.3
11	Layog River	48.8	Leyte	Abuyog	545.7
12	Bangon River	48.4	Samar	Basey	19.2
13	Basey River	34.9	Samar	Basey	331.9
14	Balangiga River	34.9	Eastern Samar	Balangiga	141.4
15	Quinapondan River	12.2	Eastern Samar	Quinapondan	43.8
Total					2,368

Source: JICA Project Team

Figure 1.1-4 Main River Systems in the Study Area

1.2 Social and Economic Conditions

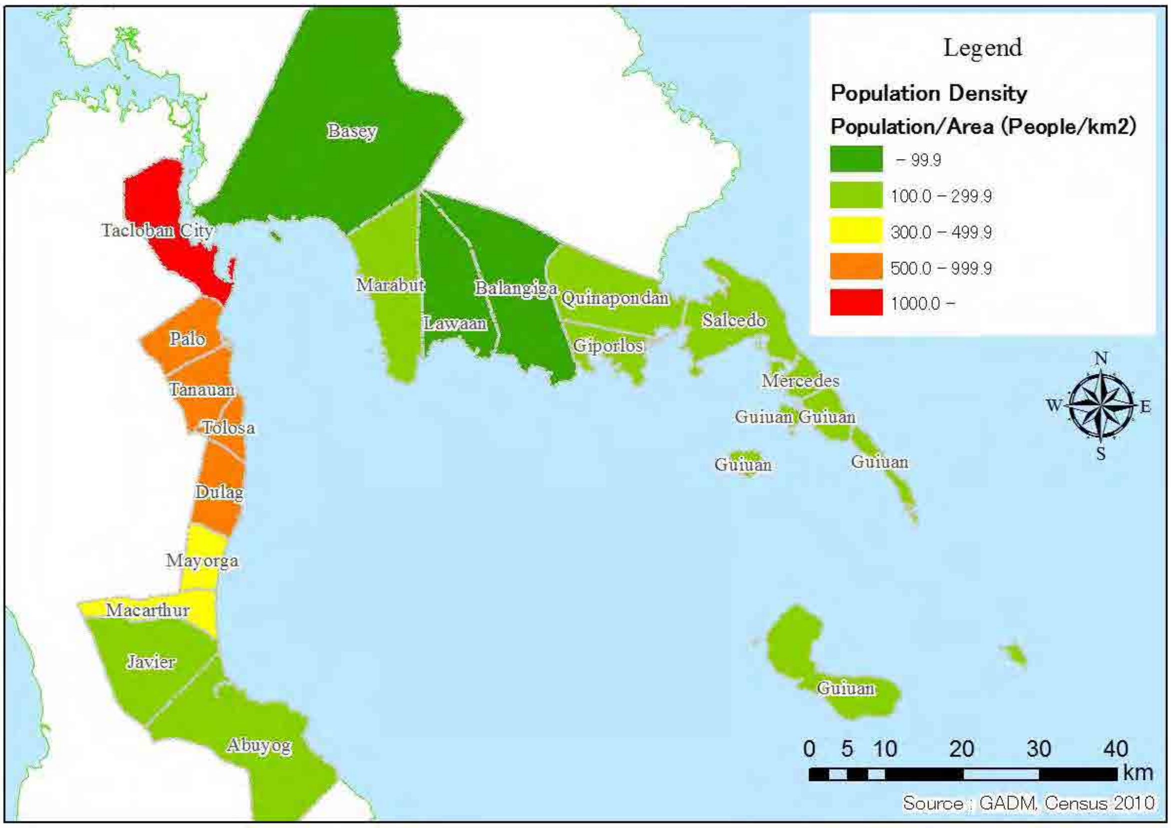
1.2.1 Population

Table 1.2-1 shows the census population and average annual growth rate of the project target 18 city/LGUs. Around 4.4% of the Philippines' population lives in Region VIII. And around 17% of the Region VII population inhabits the target 18 city/LGUs. In general, the growth rate of the region is much lower than that of the rest of the Philippines; however, the growth rate of Tacloban and Palo are remarkably larger than the national average growth rate.

Table 1.2-1 Population of Target City and LGUs

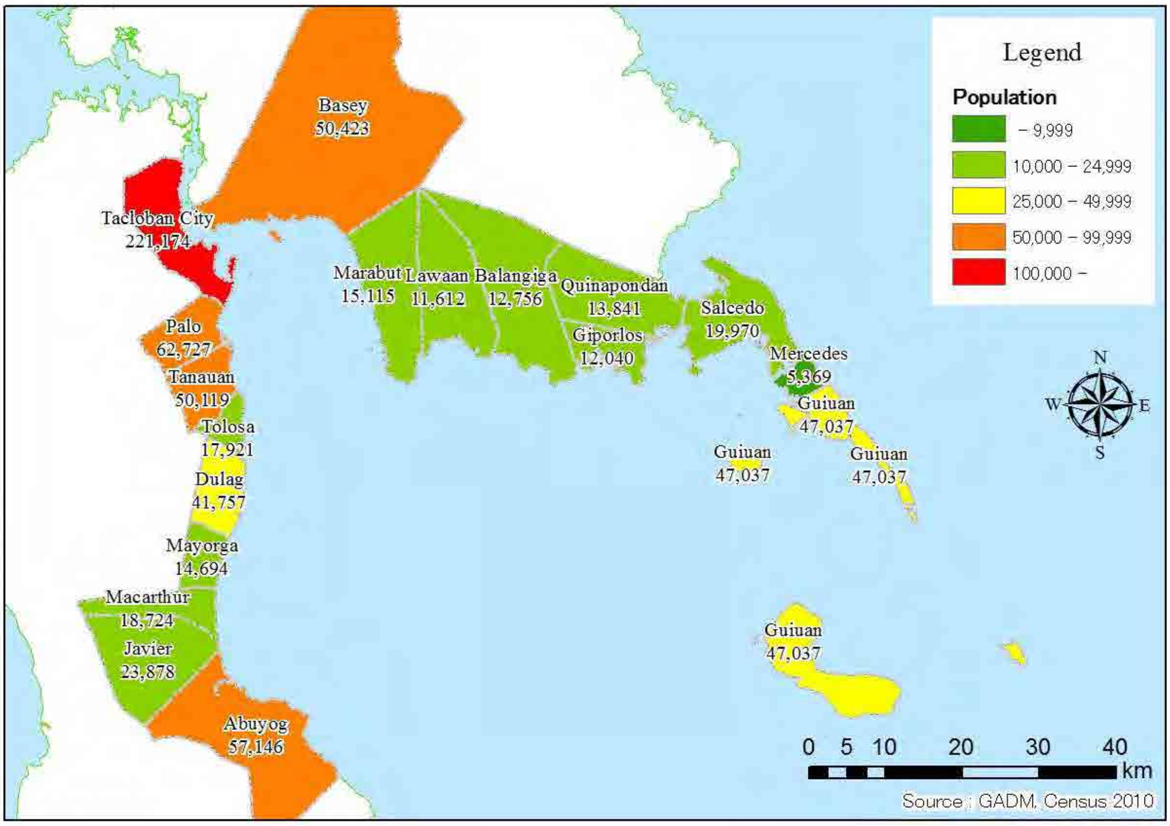
Areas		Land Area	Census Population (000)			Average Annual Growth Rate (%)	
		Km^2	1990	2000	2010	1990-00	2000-10
Philippines		299,404	60,703.2	76,506.9	92,337.8	2.34	1.90
Region VIII (E. Visayas)		21,431	3,054.5	3,610.3	4,101.3	1.68	1.28
1. Province of Leyte		5,713	1,367.8	1,592.2	1,789.1	1.53	1.17
Project Target City/LGUs	1. Tacloban	202	136.9	178.6	221.2	2.69	2.16
	2. Palo	80	38.1	48.0	62.7	2.33	2.72
	3. Tanauan	68	38.0	45.1	50.1	1.71	1.07
	4. Tolosa	22	13.3	14.5	17.9	0.90	2.11
	5. Dulag	110	33.0	38.9	41.8	1.65	0.71
	6. Mayorga	47	10.5	12.7	14.7	1.85	1.51
	7. Macarthur	72	13.2	16.8	18.7	2.50	1.06
	8. Javier	153	18.7	22.9	23.9	2.05	0.44
	9. Abuyog	383	47.3	53.8	57.1	1.31	0.60
	Total	1,137	349.0	431.3	508.1	2.14	1.65
2. Province of Samar		5,591	533.7	641.1	733.4	1.85	1.35
Project Target LGUs	1. Basey	533	39.1	43.8	50.4	1.13	1.42
	2. Marabut	143	10.5	12.3	15.1	1.58	2.05
	Total	676	49.6	56.1	65.5	1.23	1.56
3. Province of Eastern Samar		4,641	329.3	375.8	428.9	1.33	1.33
Project Target LGUs	1. Lawaan	174	7.8	9.8	11.6	2.38	1.65
	2. Balangiga	196	9.6	10.7	12.8	1.09	1.81
	3. Giporlos	106	11.0	10.2	12.0	-0.74	1.65
	4. Quinapondan	84	11.0	11.7	13.8	0.65	1.68
	5. Salcedo	114	16.6	17.0	20.0	0.22	1.64
	6. Mercedes	24	4.5	4.9	5.4	0.76	1.01
	7. Guiuan	175	33.8	38.7	47.0	1.35	1.97
	Total	873	94.3	103.0	122.6	0.89	1.76

Source: NSO



Source: JICA Project Team

Figure 1.2-1 Population Density of LGUs (person / km²)



Source: JICA Project Team

Figure 1.2-2 Population of LGUs

1.2.2 Economy

(1) GRDP

Table 1.2-2 shows the GDP of the Philippines and the GRDP of Region VIII over the period of 3 years from 2010 up until 2012. The economy scale of Region VIII was around 2.5% in the national economy. The primary sector features in the economy of Region VIII. The economic growth of Region VIII was rather lower than the national growth over the same period: especially in 2012 due to the manufacturing sector's slowdown when the Regional economy recorded negative growth. The per capita GRDP of the Region was 60% of the per capita GDP in 2012.

Table 1.2-2 National GDP and GRDP of Region VIII

Items	Particulars		2010	2011	2012
GDP & GRDP at current price	Philippines	PHP billion	9,003.5	9,706.3	10,564.9
	Region VIII		226.4	240.7	228.2
	Share of Region VIII		2.5%	2.5%	2.2%
Growth 1)	Philippines		7.6%	3.6%	6.8%
	Region VIII		3.0%	2.1%	-6.2%
By Sector	Philippines	Primary	11.6%	11.5%	11.1%
		Secondary	32.6%	32.0%	32.0%
		Tertiary	55.8%	56.5%	56.9%
	Region VIII	Primary	22.5%	21.9%	22.6%
		Secondary	44.0%	43.8%	38.0%
		Tertiary	33.5%	34.3%	39.4%
	Share of Region VIII to Philippines	Primary	5.1%	4.9%	4.7%
		Secondary	3.6%	3.6%	2.7%
		Tertiary	1.6%	1.6%	1.6%
Per Capita	Philippines	PHP	55,082	57,873	54,236
	Region VIII		36,694	37,006	34,305

Note: 1) Growth: annual growth rate on the basis of constant year 2000 prices
Source: NSCB

(2) Regional Economy

1) Region VIII

The economy of Region VIII is characterized by the primary sector such as agriculture, livestock and fishery industries. As shown in Table 1.2-2, the primary sector's share of the GRDP reached 22.6% in 2012, which is double of that of its share of the national GDP.

According to the NSCB, rice (palay) and coconut are the leading commodities among all with 41.2% contribution to the agricultural production of the region (see Table 1.2-3), particularly the province of Leyte contributes a large part of the same productions (See Table 1.2-4).

Table 1.2-3 Five Largest Agricultural Products in the Region VIII (year 2011)

Production	Share of total Agricultural Production of the Region VIII	Rank of the Region in the National Production
1. Rice (Palay)	21.9%	**7th**
2. Coconut	19.3%	**2nd**
3. Hog	15.4%	9th
4. Chicken	6.6%	9th
5. Banana	2.9%	6th
Total	66.1%	-

Source: Country Stat, NSCB

Table 1.2-4 Production and Cultivated Area of Rice and Coconut

Area	2005 1)	2006	Cultivated Area	
	Metric Tons	Metric Tons	Hectares	Share
< Rice (Palay)>				
Region VIII	788,857	830,808	233,221	100%
Leyte	458,641	479,264	104,869	45%
Samar	68,212	71,673	40,072	17%
Eastern Samar	34,722	39,529	15,632	7%
< Coconut >				
Region VIII	1,690,953	1,764,645	371,642	100%
Leyte	702,461	726,891	150,103	40%
Samar	284,422	301,195	45,629	12%
Eastern Samar	268,651	275,652	46,225	12%

Note: 1) Production year of coconuts is 2002.
Source: "The Disaster Risk Reduction and Climate Change Adaption Enhanced Provincial Development and Physical Framework Plan", Province of Eastern Samar

2) Provinces

Table 1.2-5 shows the total of household head income by business sector. It clearly reveals that the primary sector is also the principal income earner in the 3 provinces of Leyte, Samar and Eastern Samar.

Table 1.2-5 Total Household Head Income by Business Sector (Year 2000)

Province	Agri./ Fish	Mining/ Quarry	Manufacturing	Construction	Services	WS/RS 1)	T/C/S 2)	N/D 3)	Total
Region VIII	27%	0.3%	5%	4%	22%	11%	5%	26%	100%
Leyte	20%	0%	6%	5%	24%	11%	5%	29%	100%
Samar	38%	1%	3%	2%	16%	13%	4%	22%	100%
Eastern Samar	36%	1%	3%	2%	17%	11%	6%	23%	100%

Note: 1) WS/RS = wholesale and retail, 2) T/C/S = transport, communication and storage, 3) N/D = not defined
Source: Family Income and Expenditures 2000, NSCB

However, with regard to the secondary sector, the share of generated income is quite low; because the establishments are small in numbers and are mostly small light industries. The manufacturing establishments are concentrated in the municipality of Isabel, located in the southwest of the Leyte Province.

1.2.3 Employment

The employment status of the Philippines and Region VIII is presented in Table 1.2-6. The table indicates that the employment rate was quite high for both the nation and the Region. In general, the rural areas have indicated higher employment rates than the urban areas in the Philippines.

Table 1.2-6 Employment Status

Items	Area	2005	2012
Population of 15 years old and over (in thousands)	Philippines	54,388	62,985
	Region VIII	2,528	2,942
Labor Force (in thousands)	Philippines	35,189	40,436
	Region VIII	1,717	1,868
Employment Rate	Philippines	92.2%	93.0%
	Region VIII	95.8%	94.8%
Unemployment Rate	Philippines	7.8%	7.0%
	Region VIII	4.2%	5.2%

Source: NSO

1.2.4 Family Income

Table 1.2-7 shows the annual family income of the Philippines and Region VIII. It reveals that the income of Region VIII was 70% of that of the Philippines in 2012.

Table 1.2-7 Average Annual Family Income

Area	2009		2012	
	Peso	% of the Philippines	Peso	% of the Philippines
Philippines	206,000	100%	235,000	100%
Region VIII	161,000	78%	166,000	70%
Leyte	178,000	86%	-	-
Samar	135,000	66%	-	-
Eastern Samar	130,000	63%	-	-

Source: NSO

1.2.5 Poverty

The poverty line of the Philippines and Region VIII was 18,935 and 18,076 (annual income in peso/capita) in 2012 respectively. Table 1.2-8 presents the poverty indices among families in the Philippines and Region VIII. The indices of Region VIII and these 3 provinces are relatively bigger than that of the Philippines. Particularly the Samar Province represents remarkably high indices in every year.

Table 1.2-8 Poverty Indices among Families

	2006	2009	2012
Philippines	21.0%	20.5%	19.7%
Region VIII	30.7%	26.0%	25.7%
Leyte	32.2%	29.8%	31.4%
Samar	41.3%	49.2%	55.4%
Eastern Samar	32.3%	34.9%	43.5v

Source: NSCB,

1.2.6 Industry

(1) Agriculture

According to the Bureau of Agricultural Statistics, Eastern Visayas contributed 2.56 percent to the country's Gross Domestic Product. Gross Regional Domestic Product increased by 1.76 percent. The Agriculture, Fishery and Forestry Sector accounted for 20.49 percent of the regional economy. Agriculture contributed significantly to the region's economy, rice and coconut were the leading commodities with 41.20 percent contribution to agricultural production of Eastern Visayas for the year 2011. And hog and chicken together shared 22.05 percent and placed the region in the 9th rank.

Table 1.2-9 Top agricultural commodities, Eastern Visayas, 2011

Commodity	Share to total agric. output of the Region (%)	Production growth rate (%)
Rice	21.86	2.06
Coconut	19.34	0.05
Hog	15.41	2.72
Chicken	6.64	3.70
Banana	2.87	0.41

Source: Bureau of Agricultural Statistics

Before Typhoon Yolanda struck, Eastern Visayas was the 7th largest rice producer and the 3rd largest coconut producer in the country, with 37,780 ha of rice fields and 46 million coconut palm trees growing on over 420,000 ha.

This Coconut farm lands occupies 58 percent of agricultural land area in Eastern Visayas and almost 1.7 million people are dependent on the industry. And intercrops under coconut palm trees were also important, ranking the area as the 2nd largest producer of abaca, 7th for banana and 1st for sweet potato. These crops traditionally protect farmers' income from the highly fluctuating copra prices, which are generally low. Despite the importance of these crops, the region remains vulnerable to disasters and at 37.2% the region has the 3rd highest poverty incidence in the country.

Livestock production is also an important farming activity in rural areas in Eastern Visayas. Livestock rearing is an integrated activity of the economic structure at farm and village level and it largely contributes to food security, rural income and to the efficient use of the local natural resources by use of local biomass for feed and nutrient recycling through animal manure.

(2) Fisheries

In 2011, total volume of fish production in Eastern Visayas (Region 8) reached 209,778 metric tons (MT) or 4.2% of the country's fish production. At the provincial level, Leyte achieved the highest fish production among all provinces with 68,574 MT, followed by Eastern Samar with 53,739 MT, and Samar with 47,947 MT (National Statistical Coordination Board, 2012).

Table 1.2-10 Fish production by type and province in 2011 (in metric tons)

	Province						
	Leyte	**Biliran**	**S. Leyte**	**Samar**	**N. Samar**	**E. Samar**	**Total**
No. of coastal barangays	379	94	253	405	200	253	1587
No. of registered fisherfolk	18,582	3,167	10,004	16,774	4,344	16,774	60,284
Municipal fisheries prod'n	14,533	3,215	8,120	31,104	15,815	25,425	98,212
Commercial fisheries prod'n	28,657	3,266	4,664	6,384	2,734	15,524	61,229
Aquaculture prod'n	25,384	22	315	10,459	1,367	12,790	50,337

Source: National Statistical Coordination Board (2012)
List of LGUs with Fisherfolk Registry as of November 28, 2013

Fisheries are classified into three sectors. The municipal fisheries (using bancas of 3 tons or less) produced 98,212 MT, while the commercial fisheries (using larger boats of more than 3 tons) and the aquaculture sectors were 61,229 MT and 50,337 MT, respectively. Aquaculture has expanded by almost three times in the last ten years (2002-2011). Aquaculture production in fresh-, brackish- and marine waters include those from fish ponds, fish cages and fish pens. Production of municipal and commercial fisheries slowed down as a result of a decline in fisheries resources (described below).

To date, the following species are being cultured in Region 8: milkfish (bangus), tilapia (tilapia), tiger prawn (sugpo), mud crab (alimango), grouper (lapu-lapu), siganid (samaral), catfish (hito), oyster (talaba), mussel (tahong) and seaweed (guso). Production contributed by seaweed (primarily Eucheuma) and milkfish was 63% and 24%, respectively. The bulk of seaweed was absorbed by the local processors and export traders (National Statistical Coordination Board, 2012). Fresh milkfish is destined to local markets as post-harvest processing techniques are not widely used in Region 8. High value products like grouper and mud crab are brought to city markets like Manila and Cebu (Granali, pers. comm.).

Milkfish sold at Tacloban market

Grouper buying station in Guiuan

The number of municipal fishing bancas in Region 8 was 58,068 in 2000. Of this total number, 28% were motorized, while the remaining 72% were non-motorized (Philippine Fisheries Profile, 2011). Gill net, hook and line, and fish corrals are the most frequently used gear in municipal fisheries. The main target species are threadfin bream (bisugo), frigate tuna (tulingan), indo-pacific mackerel (hasa-hasa) and indian sardines (tamban) (Leyte Fisheries Profile).

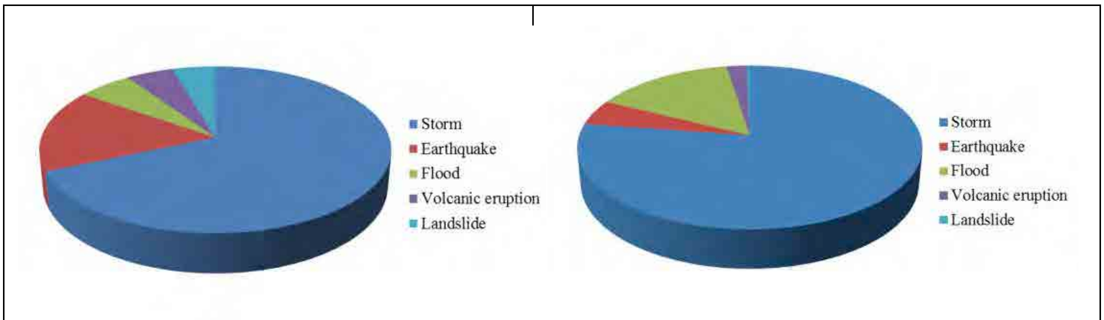
For commercial fisheries, the number of vessels was 350 in 2007 (Philippine Fisheries Profile, 2011). Fishing gear being used are trawlers, danish seine, ring net and bag net. Fish species being landed are yellowfin tuna (tambakol), skipjack (gulysan), spanish mackerel (tangigue) and indian sardines (tamban) (Leyte Fisheries Profile).

An agency attached to the Department of Agriculture (DA), the Bureau of Fisheries and Aquatic Resources (BFAR) Regional Office 8 functions as a technical arm involved in the conduct of research, formulation of policies and designing of fisheries programs and projects at the regional level. The Philippine Fisheries Development Authority (PFDA) implements the government program for the establishment and improvement of regional and municipal fish ports/landings, ice plants and cold storage and other post-harvest and marketing support facilities (CNFIDP, 2005).

1.3 Past Disasters

1.3.1 General

The Philippines, like Japan, lies along the Pacific Ring of Fire, having high seismicity and frequent volcanic activity. The Philippines is a disaster prone country, which suffered not only earthquake and volcanic eruption but also storms, and floods as well as landslides. The lives lost and economic loss of the Philippines from 1900 to 2013 are shown in Figure 1.3-1. Storms caused the most damage in terms of both life and economic loss, while earthquakes come second for life loss and third for economic loss.



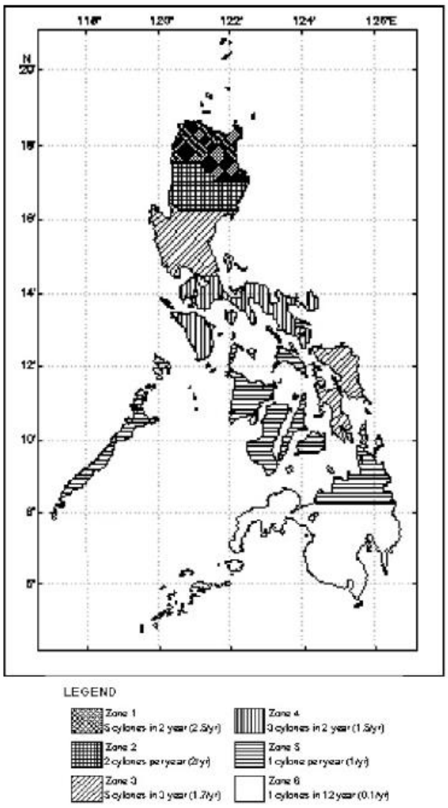
(a) Life Loss **(b) Economic Loss**

Source: EM-DAT, CRED

Figure 1.3-1 Life and Economic Loss by Natural Disasters during 1900 to 2013

1.3.2 Typhoon

The Philippines are regularly hit by a typhoon, but its frequency varies from region to region. PAGASA has classified the archipelago into 6 zones based on the frequency of typhoon passage, as shown in Figure 1.3-2. The project area falls into zone 3, the 3rd frequently-hit zone with 5 typhoos in 3 years, which means that the region is hit by 1.7 typhoons per year. This map shows that the northernmost part of the archipelago has the highest frequency with 2.5 typhoons per year, whereas the southern part of Mindanao only receives 1 typhoon in 12 years.



Source: PAGASA

Figure 1.3-2 Frequency of typhoon passage in the Philippines

Landfall of typhoon in the Philippines usually takes place from June to December as shown in Figure 1.3-3, where STY is an abbreviation for super-typhoons, TY for typhoons, TS for tropical storms and TD for tropical depression. The landfall latitude tends to shift northward during the summer and then it descends to the south from October to June, as Figure 1.3-4 shows. The project area is located at around 11 degrees north latitude, which explains the track of Yolanda that made a landfall on November.

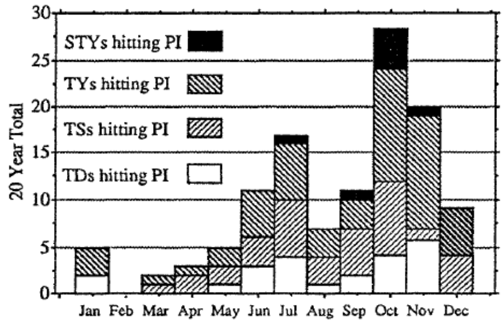


Figure B.3: TCs Hitting the PI during the 20 Years 1970–1989 (adapted from Shoemaker (1991)).

Source: Joint Typhoon Warning Center: Characteristics of Tropical Cyclones Affecting the Philippines Islands (Shoemaker 1991)

Figure 1.3-3 Number of tropical cyclones hitting the Philippines from 1970-1989

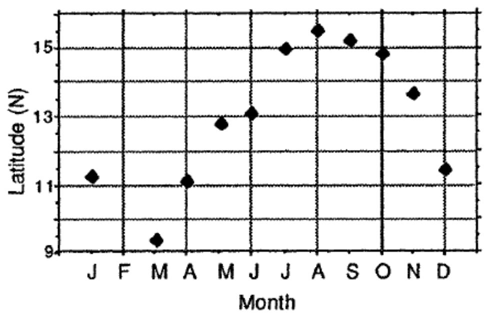


Figure B.5: Monthly Climatology of Landfall Latitude of TCs hitting PI (adapted from Shoemaker (1991)).

Source: Joint Typhoon Warning Center: Characteristics of Tropical Cyclones Affecting the Philippines Islands (Shoemaker 1991)

Figure 1.3-4 Landfall latitude of tropical cyclones in the Philippines

Table 1.3-1 shows destructive typhoons that hit the Philippines between 1947 to 2012. Undang in 1984 and Amy in 1951 are the two noticeable typhoons that hit the project area, one of which will be discussed later in the next chapter. Although it is not included in Table 1.3-1, Typhoon that hit the region in 1897 caused extensive damage.

Table 1.3-1 Destructive typhoons hitting the Philippines between 1947 to 2012

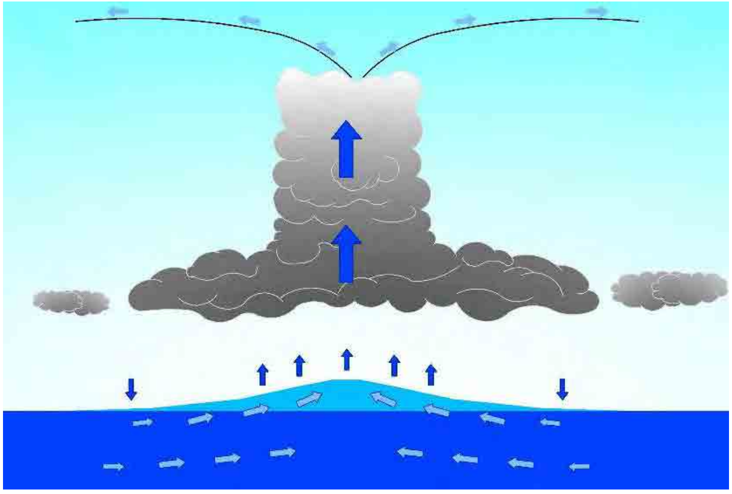
Date	Name	Gustiness	Region Affected	Death
Sep30-Oct11, 2009	Pepeng	250 kph	Cagayan Valley, Cordillera Administrative, Ilocos	492
Sep24-Sep27, 2009	Ondoy	165 kph	Calabarzon, Central Luzon	464
Jun18-Jun23, 2008	Frank	205 kph	Eastern Visayas, Western Visayas	938
Nov26-Dec1, 2006	Reming	250 kph	Bicol, Calabarzon	754
Oct15-Oct24, 1998	Loleng	250 kph	Bicol, Central Luzon, Ilocos	303
Oct30- Nov4, 1995	Rosing	260 kph	Bicol, Calabarzon	936
Sep30-Oct7,1993	Kadiang	130 kph	Calabarzon, Cagayan, Cordillera Administrative, Ilocos	576
Nov10-Nov14,1990	Ruping	220 kph	Eastern Visayas, Central Visayas, Western Visayas	748
Nov23-Nov27,1987	Sisang	240 kph	Bicol, Central Luzon	979
Nov3-Nov6,1984	**Undang**	**230 kph**	**Eastern Visayas, Bicol**	**895**
Aug31-Sep4,1984	Nitang	220 kph	Caraga, Central Visayas, Western Visayas	1363
Oct11-Oct15,1970	Sening	275 kph	Bicol, Calabarzon	768
Dec6-Dec19,1951	**Amy**	**240 kph**	**Eastern Visayas, Central Visayas, Western Visayas**	**991**

Source: Typhoon2000.com

1.3.3 Storm surge

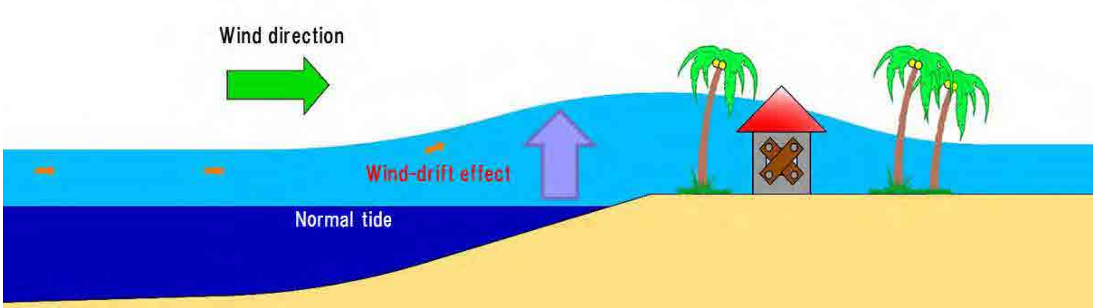
Storm Surge is mainly caused by change of the atmospheric pressure and wind with the weather disturbance. These factor trigger normal line stress and tangent line stress each on the sea surface, and brings the flow of the seawater and a slant on the sea surface.

When a strong wind caused by a typhoon blows from the offing towards the shore, seawater is up onto the shore, thus the sea surface will rise abnormally.



Source: http://www.mlit.go.jp/river/pamphlet_jirei/kaigan/kaigandukuri/takashio/1mecha/01-2.htm

Figure 1.3-5 Suction of the sea surface by the atmospheric pressure depression



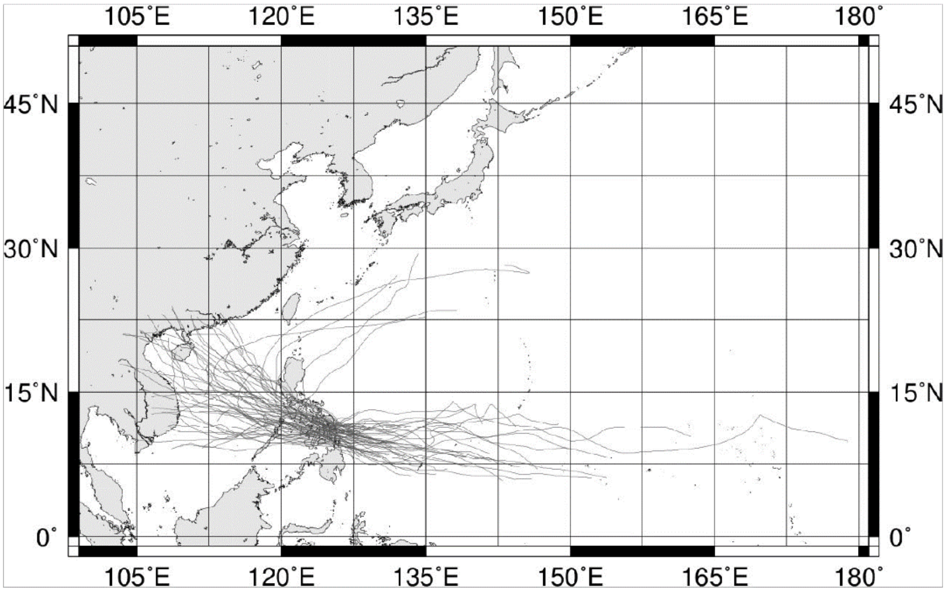
Source: http://www.mlit.go.jp/river/pamphlet_jirei/kaigan/kaigandukuri/takashio/1mecha/01-0.htm

Figure 1.3-6 Wind setup

Storm surge is generated by not only the suction of the sea and wind setup but also the wave setup near the coastline. But, in the trial calculation for typhoon YOLANDA, the influence that wave setup gave to the storm surge was very small except on the Pacific coastline.

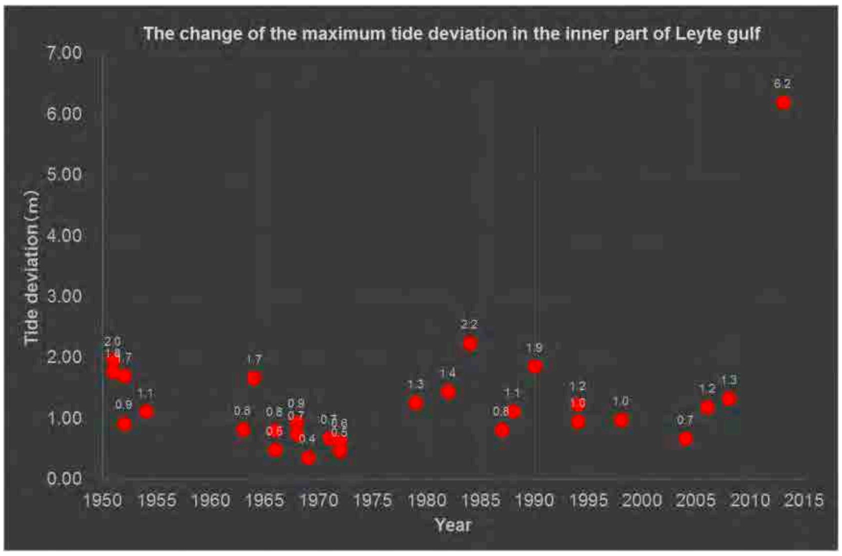
(1) Storm surge caused by Undang(1984) and Amy(1951)

Undang in 1984 and Amy in 1951 were the two major typhoons that caused relativy high storm surge in the project area after 1947. Undang is the one many residents recall of when asked about the past storm surge and Amy is the one that is said to have damaged the San Jose airfield by its storm surge. Although accurate observational tidal data for both typhoons is not available, storm surge analysis conducted for past typhoons that passed Leyte Gulf reveals that these two typhoons caused the highest storm surge before Yolanda, as shown in Figure 1.3-8. The storm surge caused by Undang is simulated to have reached 2.2m and that of Amy to have reached 2.0m above mean sea level. Method of storm surge analysis is explained later in this report.



Source: http://agora.ex.nii.ac.jp/digital-typhoon/

Figure 1.3-7 Typhoon tracks passing through Leyte Gulf (1951～)



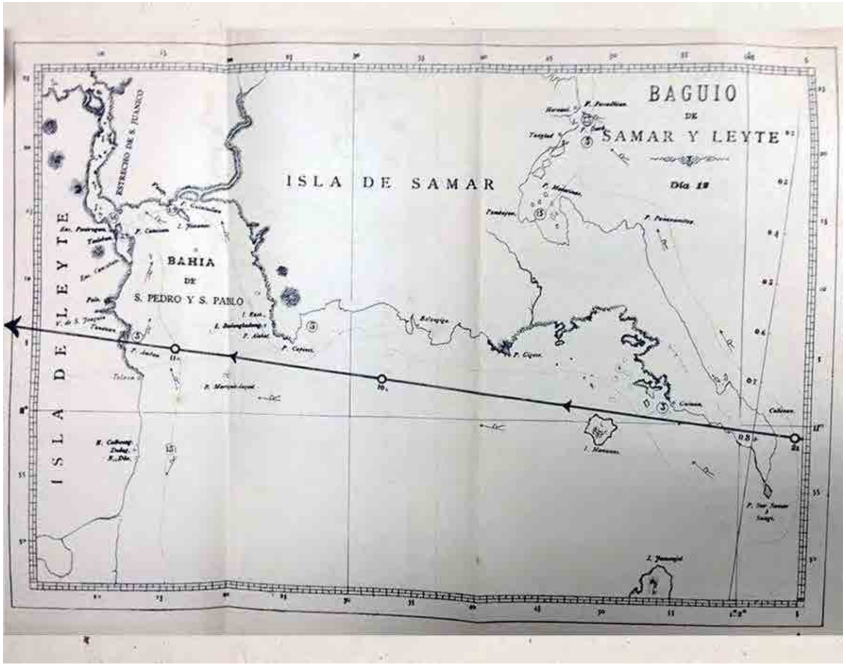
Source: JICA Study Team

Figure 1.3-8 Maximum Tide Deviation in the inner part of Leyte Gulf

(2) Storm surge caused by theTyphoon of October 1897

After the Yolanda disaster, several media covered the Typhoon of October 1897 as comparable to Yolanda, not only for its course and the height of storm surge but also for the extent of the damage caused. The Typhoon of October 1897 was recorded circumstantially in Spanish document "El Baguio de Samar y Leyte, 12-13 de Octubre 1897(published by Fr. Jose Algue, S.J. of the Observatorio de Manila)" which gives us detailed information about this event that took place more than 100 years ago.

The track of the typhoon is quite similar to that of Yolanda as shown in Figure 1.3-9. The height of storm surge is said to have reached 5 meters in Tanauan, around 3.9 meters in the Tacloban peninsula (wherer the airport is located now) , 4.9 meters at Basey and 5 meters in Eastern Samar. Approximately 500 residents lost their lives in Basey, 200 deaths in Tacloban, 94 deaths in Guiuan, 44 deaths in Salcedo and 11 deaths in V.S. Joaquin, although the cause of deaths is not clarified.

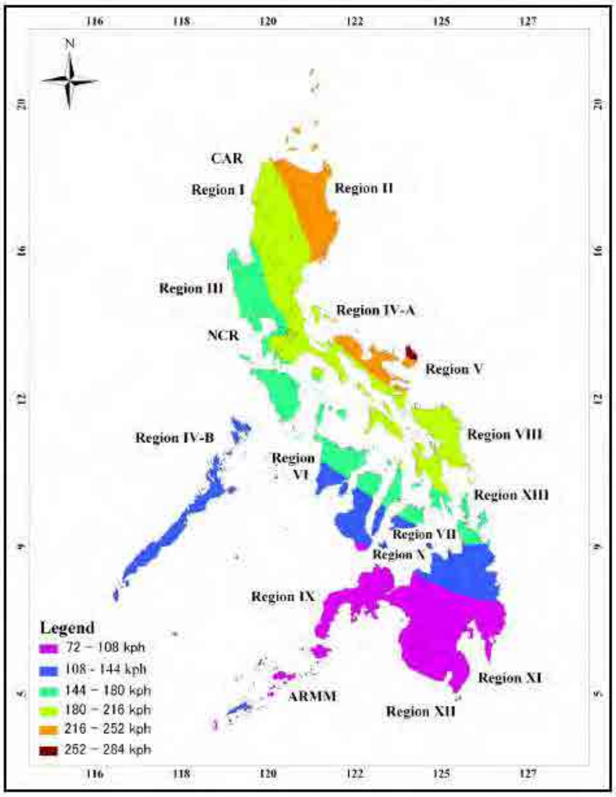


Source: El Baguio de Samar y Leyte, 12-13 de Octubre 1897

Figure 1.3-9 Track of the Typhoon of October 1897

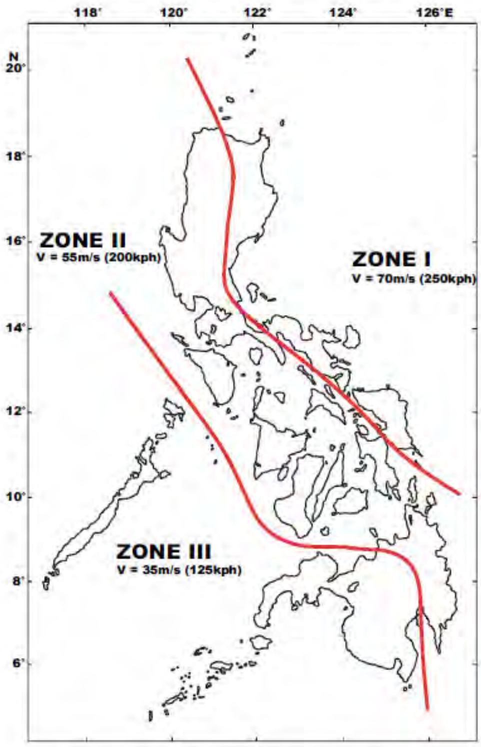
1.3.4 Strong wind

Strong wind is generally brought by the passage of typhoon. Area susceptible to strong wind is therefore where a typhoon passes by at its best, which concludes to Figure 1.3-10. It shows the expected 50 year wind-speeds (gustiness) in the archipelago based on 50 years of observational data for about 40 PAGASA stations. The project area falls into an area where the expected wind speed is 180 to 216 kph, which is 50 to 60 m/s. Figure 1.3-11 from the National Structural Code of the Philippines (NSCP) 2001 also shows gustiness with a 50-year return period, based on 35 years of observational data for 50 PAGASA stations. In this map, the project area is divided in 2 zones, Samar Island in zone I with a gustiness of 70 m/s and Leyte Island in zone II with a gustiness of 55 m/s.



Source: Garciano et al (2005) "Development of a Regional Map of Extreme Wind Speeds in the Philippines."

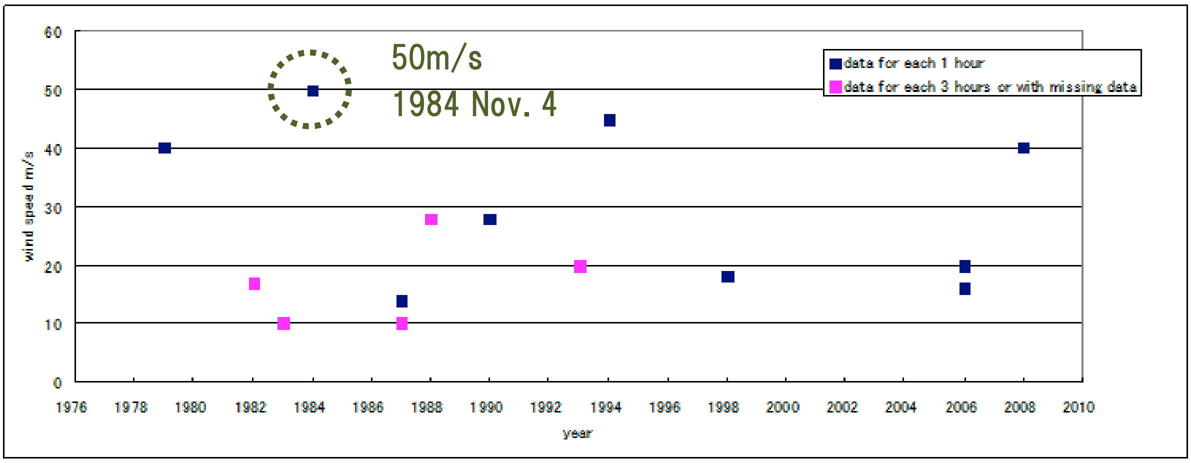
Figure 1.3-10 Expected 50 year wind-speeds in the Philippines



Source: NSCP-2001

Figure 1.3-11 Wind speed map for NSCP-2001

Among past typhoons, Undang(1984) was the one that brought the strongest wind in the past 30 years prior to Yolanda as shown in Figure 1.3-12 which shows the observed wind speed at Guiuan PAGASA station. Note that this figure shows 10-minute sustained wind speed. Maximum gustiness was observed at Tacloban with 230 kph (64 m/s).



Source: PAGASA

Figure 1.3-12 Wind speed observed at Guiuan during major typhoons from 1976 to 2010

Typhoon of October 1897 cited in 161.3.3 brought not only high storm surge but also strong wind and some pictures of the damage caused are compiled in "El Baguio de Samar y Leyte, 12-13 de Octubre 1897(published by Fr. Jose Algue, S.J. of the Observatorio de Manila)."

Source: El Baguio de Samar y Leyte, 12-13 de Octubre 1897

Figure 1.3-13 Damaged house at Dulag (Typhoon of October 1897)

Source: El Baguio de Samar y Leyte, 12-13 de Octubre 1897

Figure 1.3-14 Damaged trees at Basey (Typhoon of October 1897)

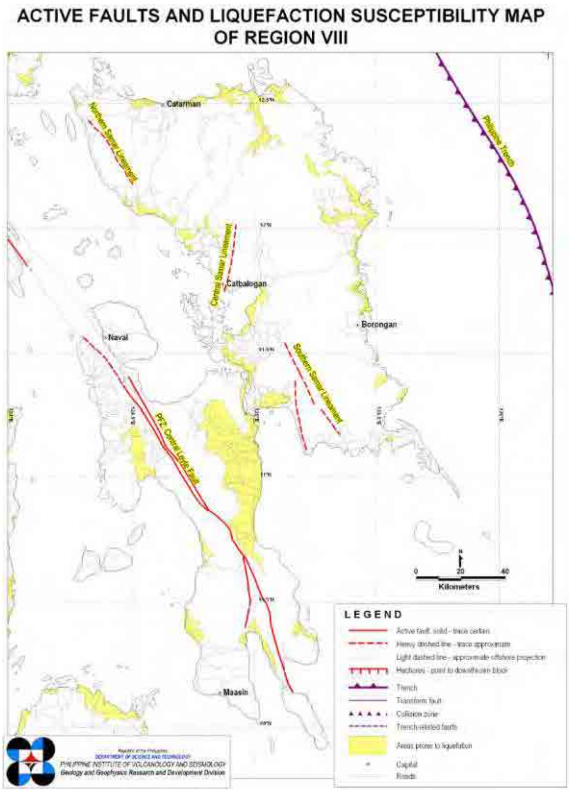
1.3.5 Earthquakes

The plate tectonics in the Philippines are complex with the Philippine Plate in the east and the Eurasian Plate in the west and several micro-plates between the two convergent plate margins. The Distribution of Earthquakes in Central Visayas

active faults in the Philippines are shown in Figure 1.3-16 and the active faults in Region VIII (the project area and vicinity) are shown in Figure 1.3-15. A major tectonic feature of the Philippines is the 1,200km long Philippine fault zone (PFZ) that transects the whole Philippine archipelago from northwestern Luzon to southeastern Mindanao. This arc-parallel, left-lateral strike slip fault is divided into several segments and has been the source of several past large earthquakes. The Philippine fault zone passes through Leyte Island from north to south. The distance from the fault to the east cost of Leyte is about 10 to 50 km. There are two active faults in southern Samar. Eastern Samar is facing the Philippine Trench and could be affected by large earthquakes in the trench zone. All of these faults characterize the project area facing a high seismic hazard.

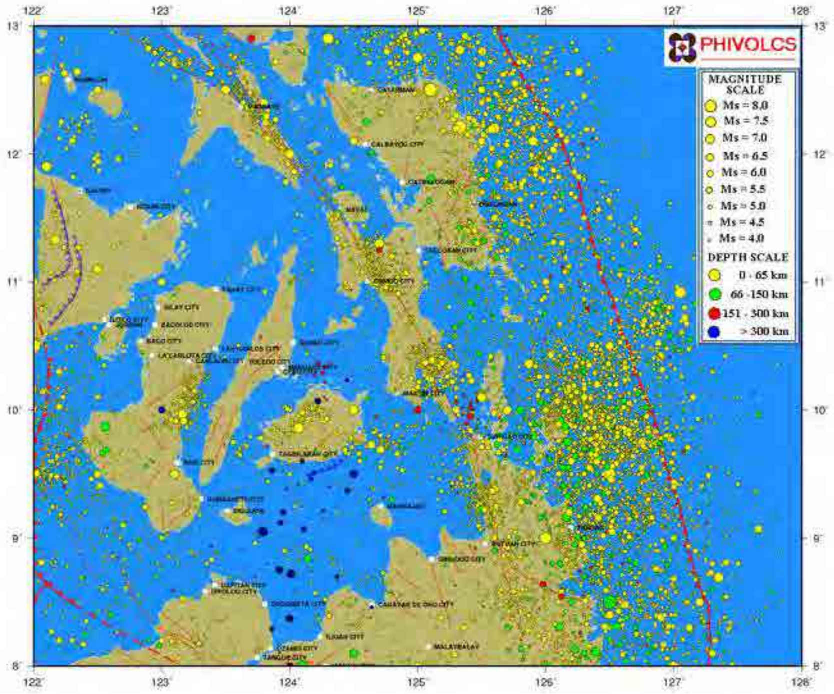
There have been a number of earthquakes in history around the project area. Earthquakes with magnitude larger than 3 that occurred in Central Visayas during 1900 to 2013 are shown in Figure 1.3-16, from which it can be observed that the earthquakes are mainly distributed along the Philippine fault zone and Philippine Trench. The destructive earthquakes after 1900 are listed in Table 1.3-2. There are 28 quakes, which caused damage, in a period of about 110 years. There was an earthquake that occurred on 31 August 2012 in Guiuan (Eastern Samar), which caused 1 death and affected about 28,879 people. For the earthquakes around the project area before 1900, there are two on the list of the National Geophysical Data Center archives of the National Oceanic and

Atmospheric Administration (NOAA), USA. One of them was in 1743 in Leyte and another was 1890 in Leyte and Samar.



Source: PHIVOLCS

Figure 1.3-15 Distribution of Active Faults of Region VIII



Source: PHIVOLCS

Figure 1.3-16 Distribution of Earthquakes in Central Visayas

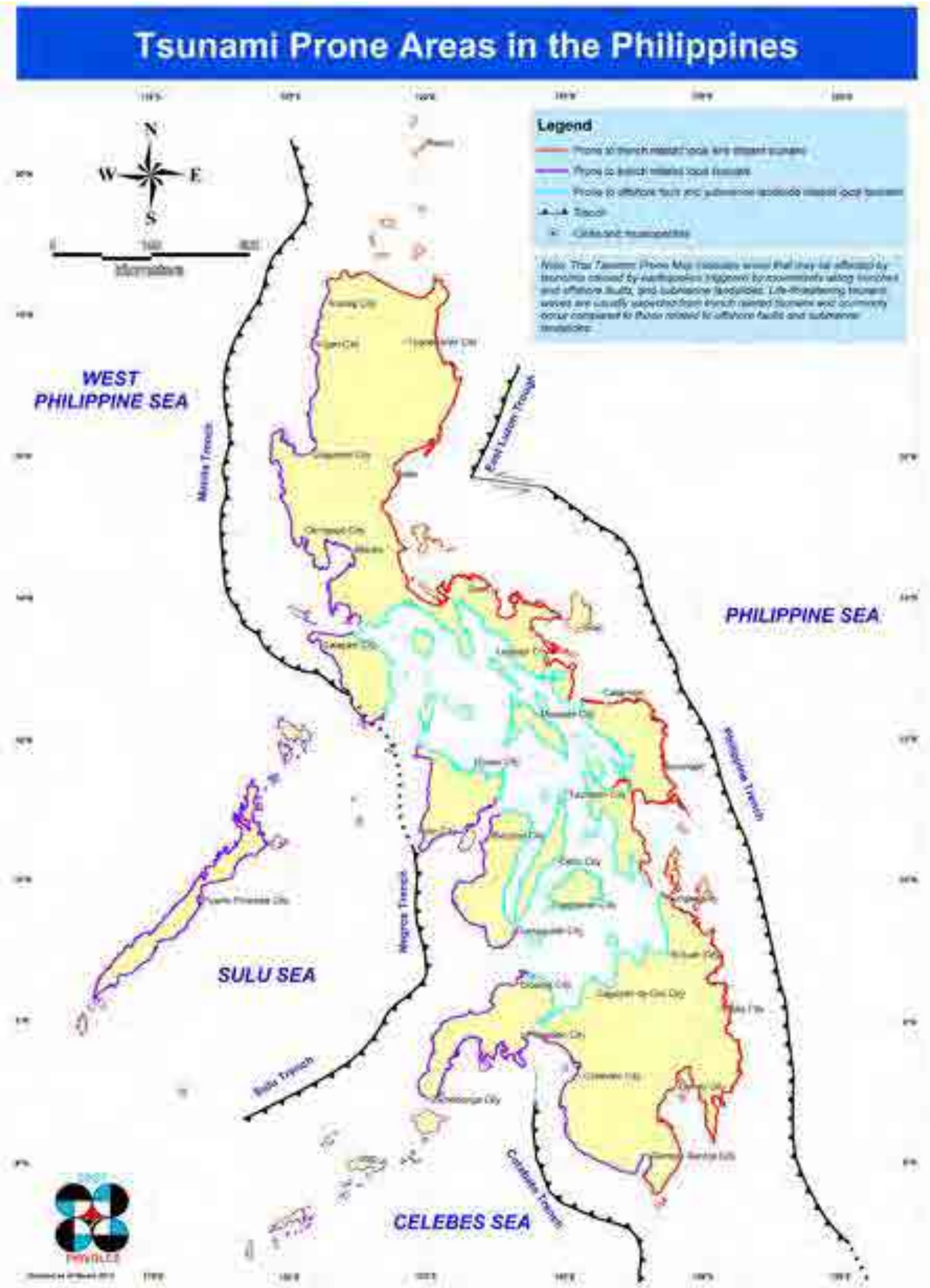
Table 1.3-2 Destructive Earthquakes in the Philippines after 1900

Date	Location	Killed	Total Affected	Damage (US$ Mil)
15/10/2013	Bohol	200		50
31/08/2012	Guiuan (Eastern Samar)	1	28,879	3
04/09/2012	Valencia, Maramag		4,001	
06/02/2012	Tayasan	113	320,277	9
07/11/2011	Valencia		28	
18/09/2009	Pablacion, Norala, Panay		392	0
06/03/2002	General Santo city	15	73,451	2
12/12/1999	Luzon (Manila Region)	6	190	2
21/04/1995	near Dolores (Samar Isl.)			
13/05/1994	Oro area (Mindanao)		218	
15/11/1994	Mindoro, Luzon	81	270,866	4
16/07/1990	Cabanatuan, Baguio	2,412	1,597,553	370
14/06/1990	Cualasi area (Near Panay)	4	15	
08/02/1990	Bohol, Cebu	1	34,504	1
18/03/1985	Mindanao	2	175	
18/08/1983	Ilocos Norte	19	1,901	2
11/01/1982	Catanduanes (Luzon Isl.)			
19/03/1977	Cagayan (N.E. Luzon)	1	60,030	0
16/08/1976	Gulf of Moro, Sulu	6,000	181,348	134
17/03/1973	Luzon, Tablas Is.	14	64	0
07/04/1970	Luzon	14	200	
02/08/1968	Luzon Is., Manila	271	261	5
00/08/1967	Manilla	200		
22/05/1960	Nationwide	32		
01/04/1955	Mindanao, Lanao	400	2,000	
02/07/1954	Luzon, Sorsogon, Bacon	13	101	
25/01/1948	Panay, Iloilo city	27		
15/08/1918	Mindanao, South Cotabato	100		

Source: EM-DAT, CRED

1.3.6 Tsunami

The tsunami prone areas in the Philippines are shown in Figure 1.3-17, from which it is observed that the project area is subjected to the risk of trench related local and distant tsunami.



Source: PHIVOLCS

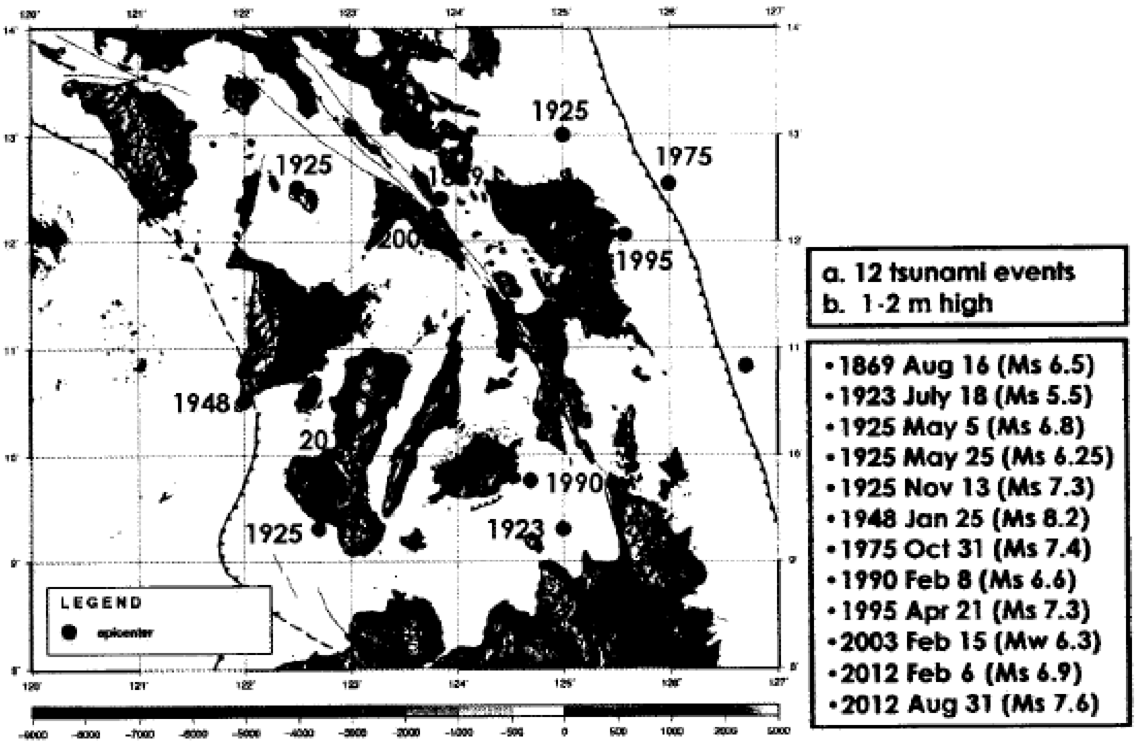
Figure 1.3-17 Tsunami Prone Areas in the Philippines

PHIVOLCS has just published a book titled Philippine Tsunamis and Seiches (1589-2012). According to the book, there were 12 earthquakes which were confirmed to have caused the tsunamis in the Visayan region. The earthquakes are shown in Figure 1.3-18. The maximum tsunami height was 1 - 2 meters. There were 4 tsunamis in Samar area, which are shown as follows.

Table 1.3-3 List of Tsunami

Date	Ms	Epicenter	Tsunami height
1925 Nov 13	7.3	NE part of Samar Island	2m
1975 Oct 31	7.4	Offshore east of Samar Island	2m
1995 April 21	7.3	Offshore east of Samar Island	2m
2012 Aug 31	7.6	Guiuan	

Source: PHIVOLCS

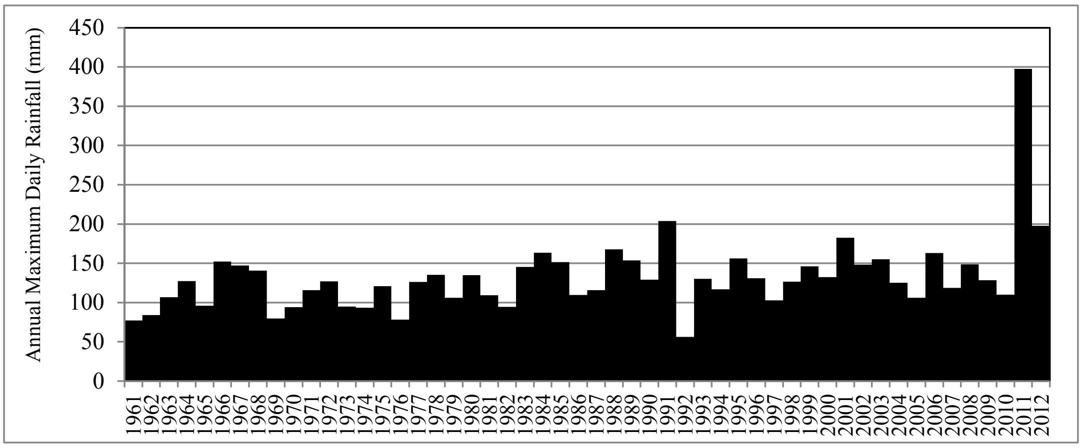


Source: PHIVOLCS

Figure 1.3-18 Historical Tsunamis in the Visayan Region

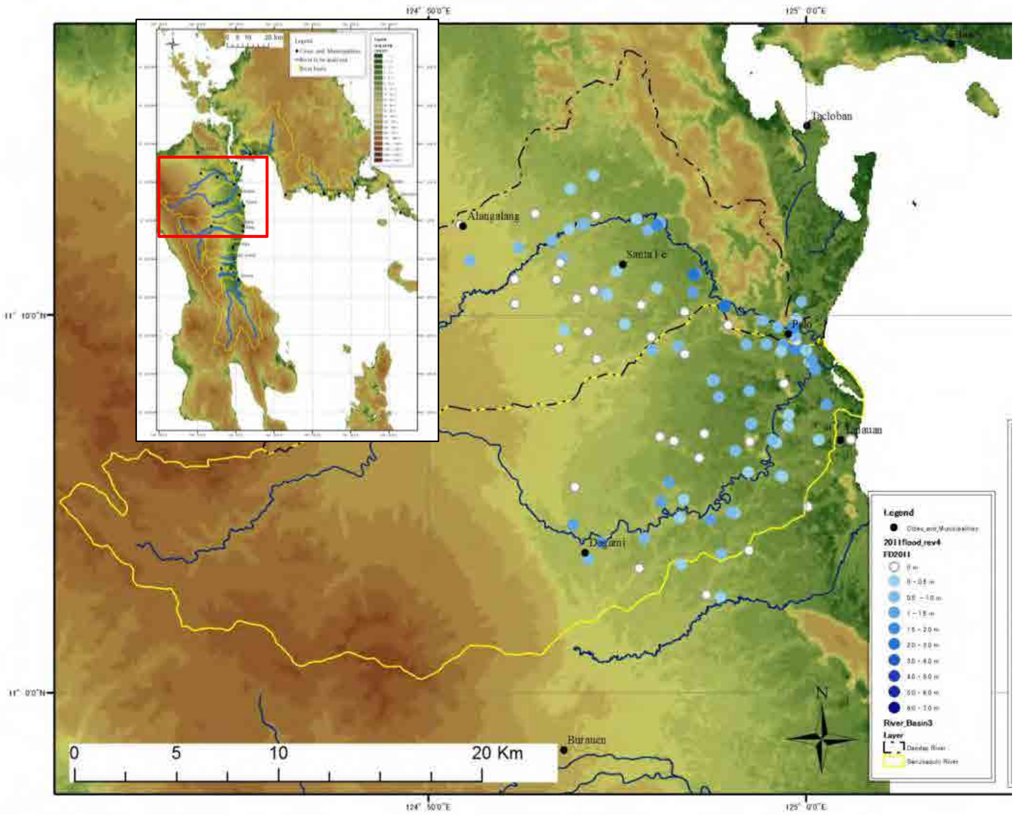
1.3.7 Flood

The biggest rainfall event in Tacloban is a continuous rainfall recorded on March 16, 2011, with daily rainfall of 397mm (as shown in Figure 1.3-19). Its return period is beyond 400 years. According to LGUs Staff of Palo and Tanauan, it was the most serious flood that has ever occurred. On the other hand, the amounts of typhoon-induced rainfall are not as significant as that of continuous rainfall. These return periods are within 5 years.



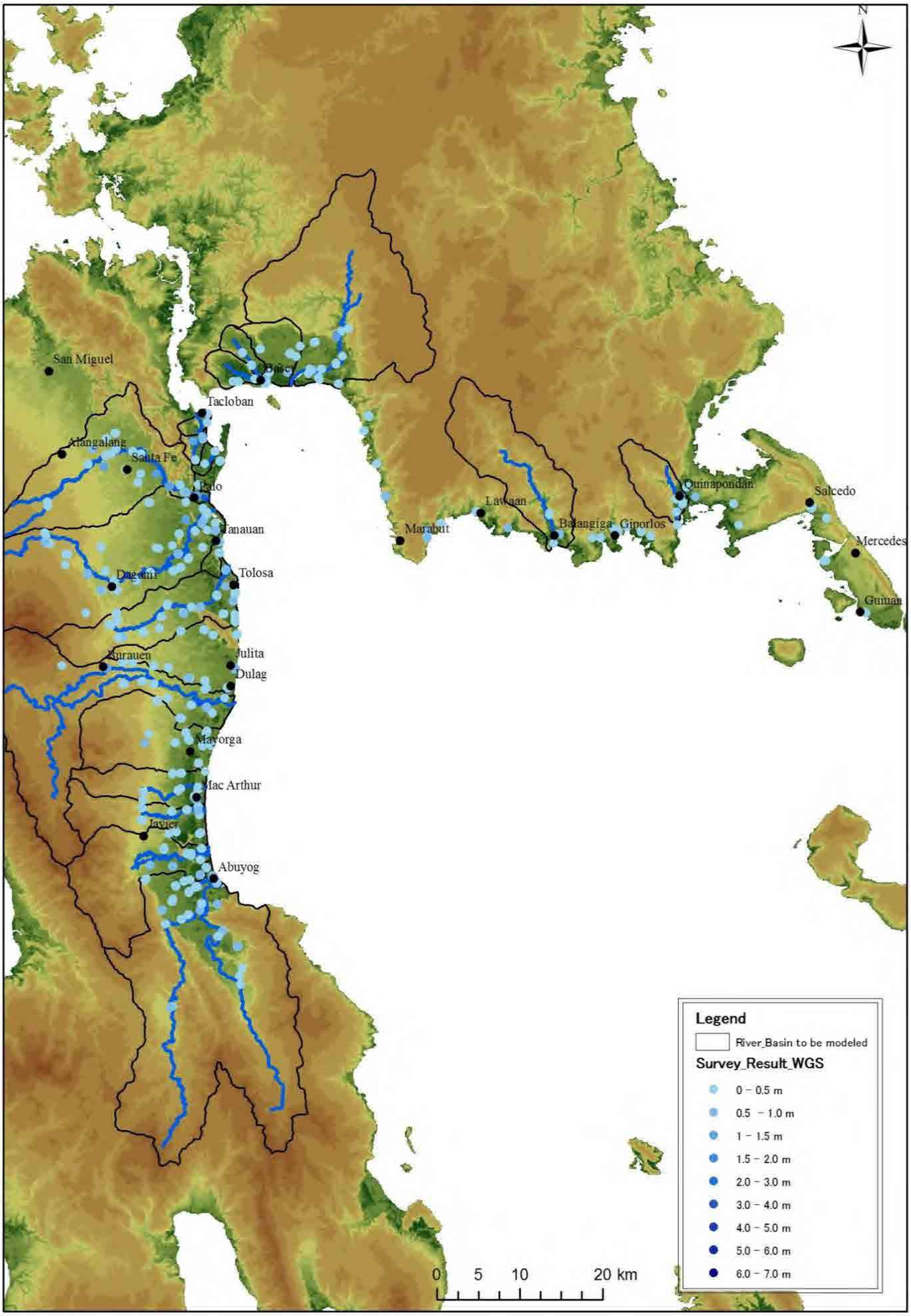
Source: Daily and six hourly Rainfall observed by PAGASA, organized in The Project

Figure 1.3-19 Annual Maximum Daily Rainfall in Tacloban



Source: JICA Project Team

Figure 1.3-20 Flood Depth during March 16, 2011 Flood



Source: JICA Project Team

Figure 1.3-21 Flood Depth during Annual Flood

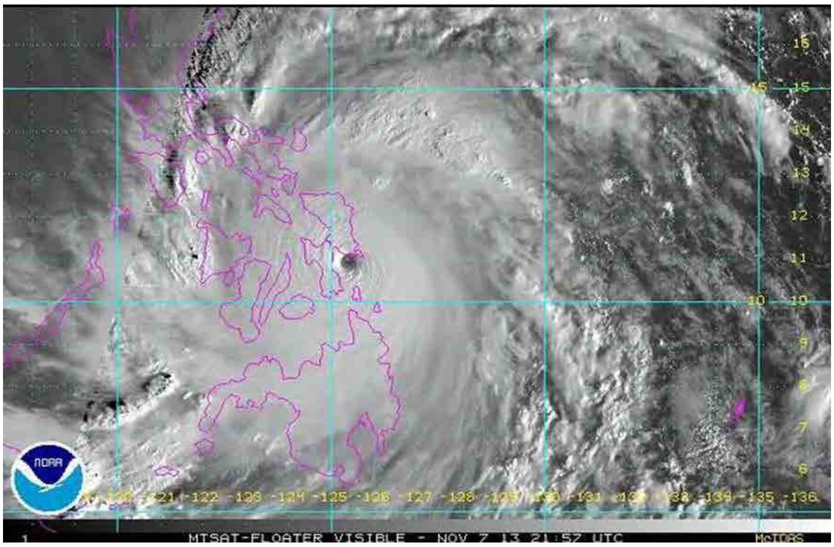
Chapter 2 Assessment of Damage by Typhoon Yolanda

2.1 Typhoon Yolanda

2.1.1 Outline Information

In the early morning of Friday, November 8, 2013, Typhoon Haiyan (known in the Philippines as Yolanda), one of the strongest typhoons to strike land on record, slammed into the central Visayas region. Over a 16 hour period, the super typhoon or cyclone, with a force equivalent to a Category 5 hurricane and clouds that covered two-thirds of the country, directly swept through six provinces and affected over 10 % of the population of the Philippines.

Typhoon Yolanda's estimated wind speeds were 195 mph at its peak with wind gusts of up to 235 mph. Several hundred thousand people reportedly had fled their homes in advance of Yolanda's arrival. Many of those displaced were moved to evacuation centers.



Source: NOAA (from PAGASA Presentation file)

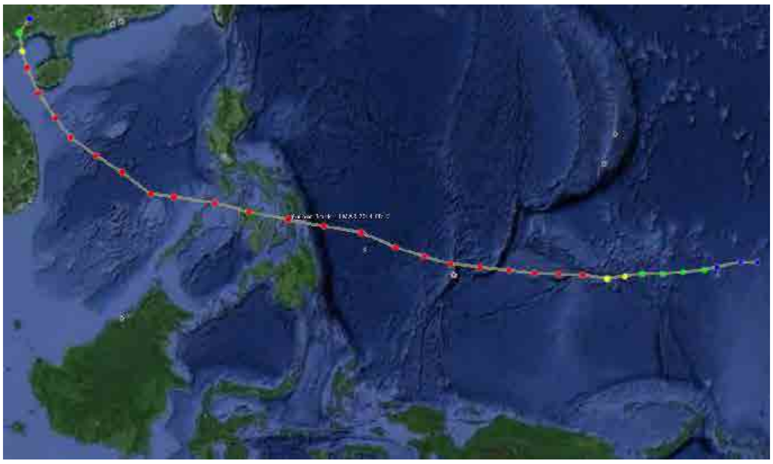
Figure 2.1-1 Typhoon Yolanda and its Eye

2.1.2 Typhoon Track and its Development

Typhoon Yolanda entered the Philippine Area of Responsibility (PAR) on November 6, 2013 and made first landfall in the following areas:

- Guiuan, Easter Samar.
- Tolosa, Leyte.

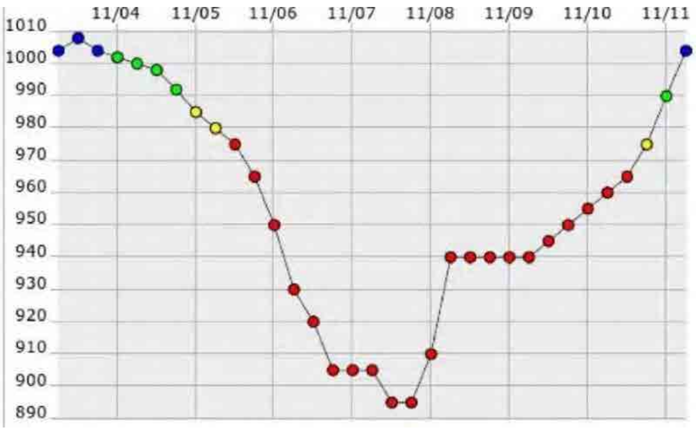
After the landfalls of the above, the Yolanda went to Busuanga, Palawan and exited PAR on November 9, 2013. The tracking path of Yolanda is shown in Figure 2.1-2.



Source: http://agora.ex.nii.ac.jp/digital-typhoon/

Figure 2.1-2 Tracking Path of Typhoon Yolanda

Figure 2.1-3 shows the change of the central atmospheric pressure of Yolanda during Nov.4 to Nov.11, 2013, which indicates the development of the typhoon. According to this chart, the lowest pressure of 895 hPa was recorded on November 7, 2013.



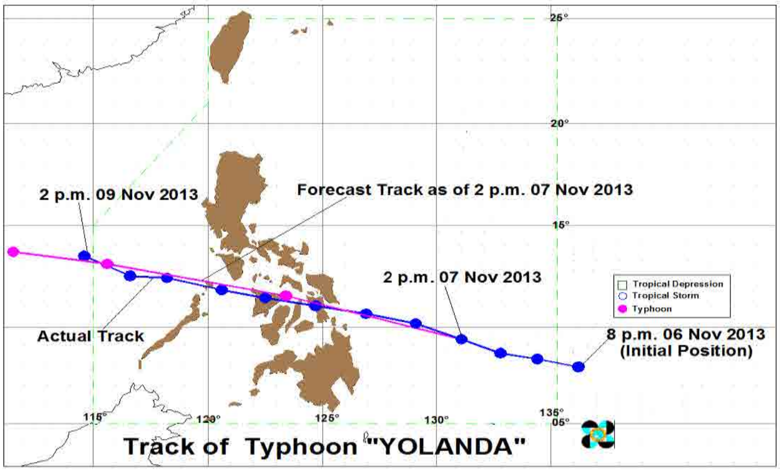
Source: http://agora.ex.nii.ac.jp/digital-typhoon/

Figure 2.1-3 Change of the Central Atmospheric Pressure of Yolanda during Nov.4 to Nov.11, 2013

2.1.3 Typhoon Forecast and Response

(1) Forecast of Typhoon Track

Actual movement of Typhoon Yolanda was predicted accurately by PAGASA. Figure 2.1-4 shows the comparison between the forecast track and the actual track. At 2 pm of Nov. 7, 2013, PAGASA forecast the track and where the typhoon would exit PAR. The predicted typhoon track was almost the same as the actual track.



Source: PAGASA

Figure 2.1-4 Predicted and Actual Tracks of Typhoon Yolanda

PAGASA issued the following warnings:

- Issued 2 Advisories (at 11AM each day Nov. 6-7, 2013)
- Issued initial Bulletin (Nov. 7, 11 pm) even though it was still outside PAR
- Issued 12 Severe Weather Bulletins
- disseminated through OCD-NDRRMC
- conducted press conferences, and social networking, including SMS, twitter and Facebook

(2) Forecast of Storm Surge

According to the GIZ Report[1], at least 2 agencies are known of having issued computer simulations of storm surge caused by Yolanda for Leyte before the storm made landfall. They were the Joint Research Center (JRC) of the European Union and Project NOAH.

Table 2.1-1 shows the predicted storm surge height by the above agencies before the landfall of Typhoon Yolanda. The PAGASA predicted height of 7 m in Tacloban was near the actual height. It can be said that such high storm surge for Tacloban was anticipated on Nov. 7, 2013, before the landfall of the typhoon.

Table 2.1-1 Predicted Storm Surge Height

Organization	Date and Time	Prediction
JRC	20:00 Nov.6	2.6 m for Tolosa-Tacloban area
Project NOAH	(Before landfall)	4.5 m for Tacloban
PAGASA	12:00 Nov.7 18:00 Nov.7	7 m for Tacloban 7 m for Tacloban

Source: GIZ

2.2 Damage caused by Yolanda

At 18:00h Nov.7, 2013, NDRRMC issued Situation Report No.4 for Yolanda. It included information for Easter Samar, Samar, and Leyte, the Public Storm Warning Signal was Signal

1 GIZ(2014), Assessment of Early Warning Efforts in Leyte for Typhoon Haiyan/Yolanda, pp.41, March 2014

No.4, for a storm whose level is winds of more than 185 kph and is expected to arrive in 12 hours or more. There is a possibility that the PAGASA prediction was not recognized in the site as a clear message.Damage caused by Yolanda

2.2.1 Macroeconomic Impact

According to RAY[2] on 16 December, 2013, macroeconomic damage of typhoon Yolanda is estimated to be PHP 101.79 billion, which is equal to 0.9 percent of Gross Domestic Product (GDP). Among the regions, Region VIII, Eastern Visayas, recorded the highest amount of damage and losses, estimated at around PhP 48.79 billion, which equivalent to 17.4 percent of GRDP in 2013.

2.2.2 Human Damage

The causalities included **6,300 individuals** dead as of April 17, 2014 in the whole country. The injured and still missing are 28,689 and 1,061 persons, respectively, according to NDRRMC Update dated on April 17, 2014.

The total affected families are 3,424,593 (16,078,181 individuals) in Regions IV-A, IV-B, V, VI, VII, VIII, X, XI and CARAGA, of which 890,895 families (4,095,280 individuals) were reportedly displaced. Out of the displaced, 20,924 families or 101,527 individuals are in 381 evacuation centers and outside evacuation centers are 869,971 families or 3,993,753 individuals.

At the Provincial level, the numbers of deaths, the injured and the missing individuals are shown in Table 2.2-1. Most of the human damage was generated in Region VIII, which is the Project area.

Table 2.2-1 Causalities in the Country

Region	Province	Deaths	Injured	Missing
Region IV-A		3	4	-
Region IV-B		19	61	24
Region V		6	21	-
Region VI		294	2,068	27
Region VII		74	348	5
Region VIII		5,895	26,186	1,005
	Eastern Samar	*267*	*8,018*	*20*
	Leyte	*5,402*	*15,672*	*931*
	Samar	*225*	*2,378*	*54*
	Biliran	*8*	*118*	-
Region IX		1	1	-
Region XIII		1	-	-
TOTAL		6,300	28,689	1,061

Source: NDRRMC April 03, 2014

The number of deaths are quite concentrated in Leyte Province, in which the 5,402 deaths in Leyte

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is 91 % of the total deaths in Region VIII. The number of missing shows a similar tendency because the deaths and the missing are assumed to be correlated.

The number of the injured is also concentrated in Leyte Province, which are 15,672 individuals while the number of injured in Eastern Samar reached 8,018 individuals. The increase of the injured in Eastern Samar is the result of the strong wind hazard.

Table 2.2-2 shows a summary of personal damage and mortality rate in the study area. The number of deaths due to the typhoon is 5,253 in the study area, while the highest mortality rate is 4 percent in Tanauan. Tacloban and Palo also show high mortality rates of 1.4 percent and 2.2 present, respectively.

Table 2.2-2 Summary of Mortality Rate in the Study Area (18 LGUs)

No.	Name of Municipality	Population	Casualties				Mortality Rate
			Dead	Injured	Missing	Total	
Leyte Province							
1	Tacloban	221,174	2,394		594	2,988	**1.40%**
2	Palo	62,727	1,089	5,887	292	7,268	**2.20%**
3	Tanauan	50,119	1,252		754	2,006	**4.00%**
4	Tolosa	17,921	32			32	0.20%
5	Dulag	41,757	26	1,240	3	1,269	0.10%
6	Mayorga	14,694	4	141		145	0.00%
7	Macarthur	18,724	10	255		265	0.10%
8	Javier	23,878	5	63		68	0.00%
9	Abuyog	57,146	33	13		46	0.10%
	Sub-total	508,140	4,845	7,599	1,643	14,087	1.30%
Samar Province							
10	Basey	50,423	193	320	25	538	0.40%
11	Marabut	15,115	30	2,058		2,088	0.20%
	Sub-total	65,538	223	2,378	25	2,626	0.40%
East Samar Province							
12	Lawaan	11,612	11	238		249	0.10%
13	Balangiga	12,756	14	328		342	0.10%
14	Giporlos	12,040	14	2,004		2,018	0.10%
15	Quinapondan	13,841	10	190		200	0.10%
16	Salcedo	19,970	29	782		811	0.10%
17	Mercedes	5,369	1	469		470	0.00%
18	Guiuan	47,037	106	3,626	16	3,748	0.30%
	Sub-total	122,625	185	7,637	16	7,838	0.20%
	Total	696,303	5,253	17,614	1,684	24,551	1.00%

Source: LGUs

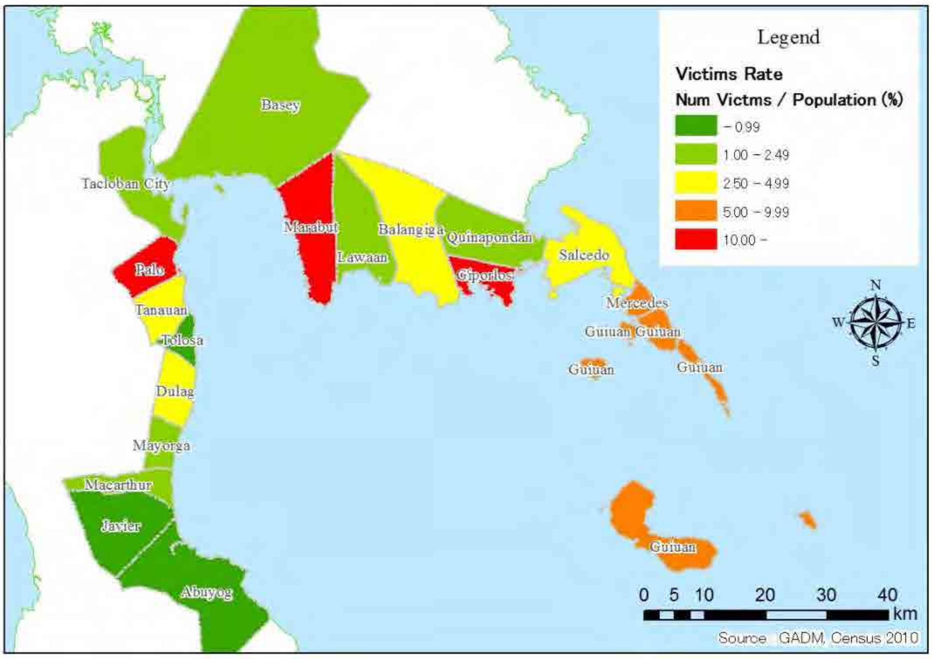
GIZ reported their analysis on the reason for the deaths in Palo, Tacloban and Tanauan as shown in Table 2.2-3. GIZ concluded that the main killer was strong waves from the storm surge (drowning, collapsing buildings and other structures, as well as floating debris) and to a much lesser extent river floods, flash floods or landslides, and powerful winds (collapsing buildings and other structures/trees, as well as flying debris).

Table 2.2-3 GIZ analysis on Causalities in Leyte

LGU	Deaths due to storm	Deaths due to storm surge	Total dead
Palo	56	1,033	1,089
Tacloban	199	2,297	2,496
Tanauan	45	1,207	1,252

Source: GIZ

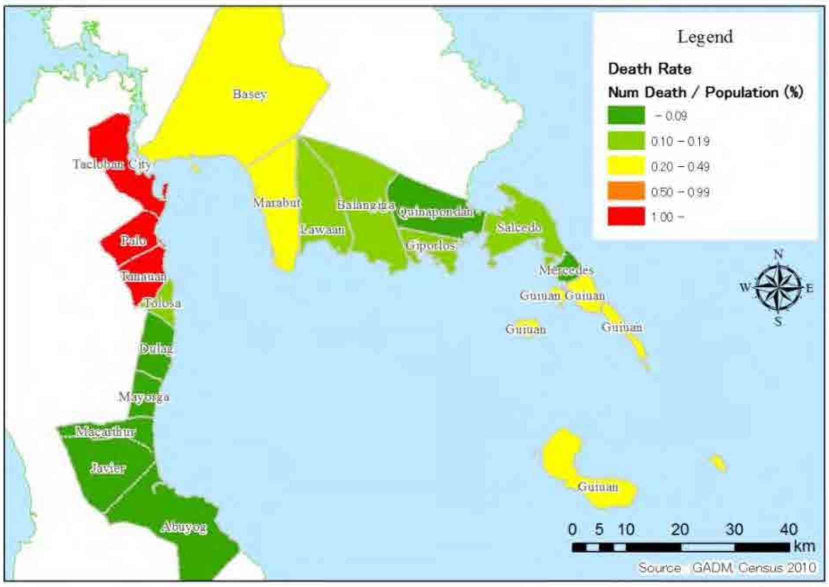
At the LGU level, the ratios of total affected individuals (the causalities, the injured and the missing) to the total population are shown in Figure 2.2-1. Higher ratios are indicated in Palo (Leyte), Marabut (Samar) and Giporlos (Eastern Samar).



Source: JICA Project Team

Figure 2.2-1 Ratios of total affected individuals (the causalities, the injured and the missing) to the total population

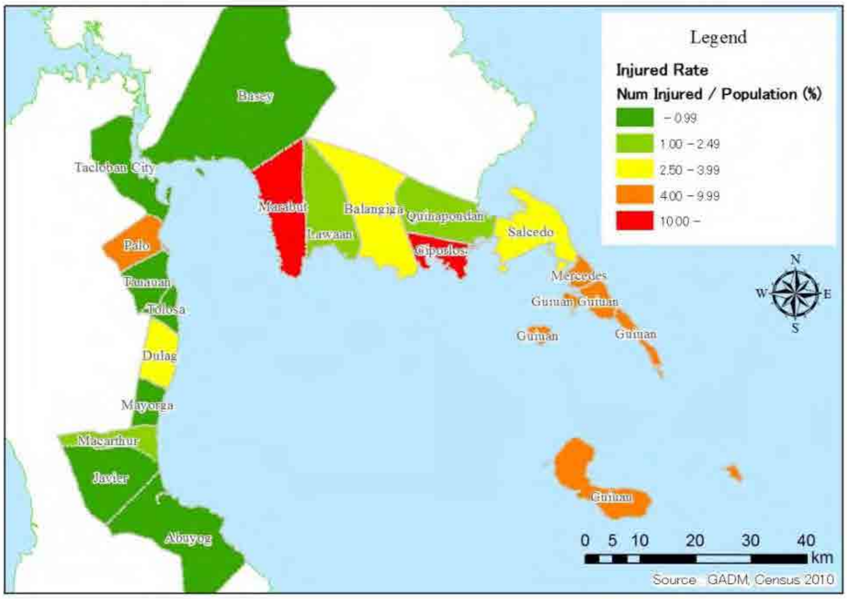
Figure 2.2-2 shows the ratio of the victims to the total population by LGU. Higher ratios are shown in Tanauan, Palo, and Tacloban where the effect of the storm surge was extremely high.



Source: JICA Project Team

Figure 2.2-2 Ratio of victims to the total population by LGU

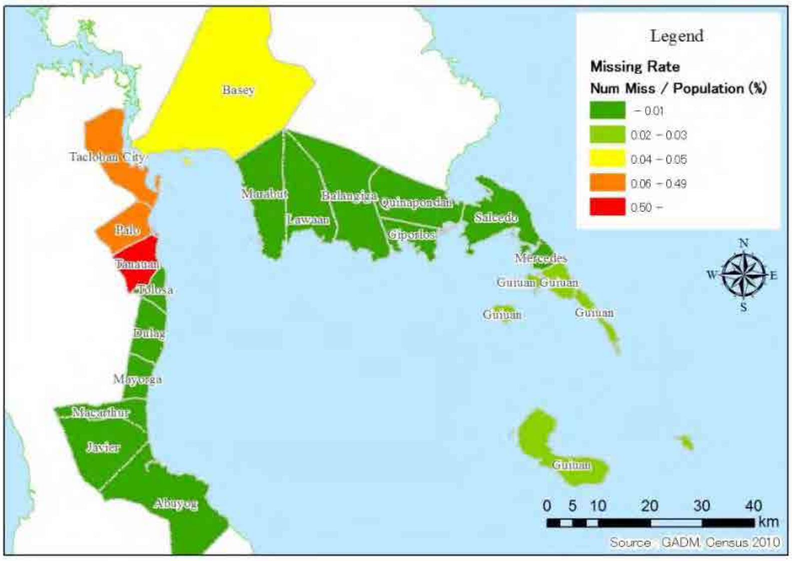
Figure 2.2-3 shows the ratio of the injured to the total population by LGU. Higher ratios are shown in LGUs along the Leyte Gulf coastal area in Eastern Samar and Samar. It is understood the effect of strong wind was significant.



Source: JICA Project Team

Figure 2.2-3 Ratio of the injured to the total population by LGU

Figure 2.2-4 shows the ratio of the missing to the total population by LGU. Higher ratios are shown in Tanauan, Palo, and Tacloban where the effect of storm surge was extremely high.



Source: JICA Project Team

Figure 2.2-4 Ratio of the missing to the total population by LGU

2.2.3 Physical Damage

(1) Houses

A total of 1,084,762 houses (partially: 595,149 / totally: 489,613) were damaged during the onslaught of typhoon Yolanda.

(2) Infrastructure

Table 2.2-4 shows the cost of damage for infrastructure and agriculture in Regions IV-A, IV-B, V, VI, VII, VIII, X, XI and CARAGA (NDRRMC SitRep No.108). The cost of damage for infrastructure and agriculture are PhP 19.5 billion and PhP 20.2 billion, respectively.

Table 2.2-4 Cost of Damage by Typhoon Yolanda in the Country

Damage to Infrastructure	Cost of damage in PhP
-Roads/Bridges and other structures	15,746,727,686
-Flood Control	230,393,000
-Health facilities	1,272,434,800
-Schools	2,309,823,650
Sub-Total(=A)	19,559,379,136
Damage to Agriculture	Cost of damage in PhP
-Crops (rice, corn, others)	9,491,493,471
-Livestock	2,890,306,123
-Fisheries	5,996,896,091
-Irrigation facilities	231,000,000
-other agricultural infrastructures	1,652,423,030
Sub-Total(=B)	20,262,118,716
Grand Total(=A+B)	39,821,497,852

Source: NDRRMC April 03, 2014

Another report from NDRRMC dated April 17, 2014 shows the total damage by the typhoon Yolanda reached PhP 89.5 billion which includes infrastructure, productive, social and cross-sectorial sectors (Table 2.2-5).

Table 2.2-5 Cost of Damage by Sector in the Country

Sector	Cost of damage in PhP
-Infrastructure	9,584,596,305
-Productive	21,833,622,975
-Social	55,110,825,740
-Cross-Sectoral	3,069,023,613
Total	89,598,068,635

Source: NDRRMC April 03, 2014

2.2.4 Impact to Local Government Units (LGUs)

(1) Damages of the Municipal Halls in the Study Area

Damages of the municipal halls in the study are shown in Table 2.2-6.

Table 2.2-6 Summary of Damages of the Municipal Halls in the Study Area (18 LGUs)

No.	Prov.	Municipality	Pop.	Fatalities +missing	Fatality Rate	Damage of Municip-ality Hall	No. of Staff at LGU	No. of Fatalities	No. of staff at DRRMO	No. of staff at PDO
1	Leyte	Tacloban	221,174	2,988	1.35%	B	586	6	1	13
2		Palo	62,727	1,381	2.20%	B	322	7	4	-
3		Tanauan	50,119	2,006	4.00%	C	126	1	3	6
4		Tolosa	17,921	32	0.18%	B	61	1	-	2
5		Dulag	41,757	29	0.07%	C	75	2	-	3
6		Mayorga	14,694	4	0.03%	C	61	0	-	1
7		Macarthur	18,724	10	0.05%	B	14	0	-	2
8		Javier	23,878	5	0.02%	C	65	0	-	3
9		Abuyog	57,146	33	0.06%	C	197	0	-	7
		Sub-total	508,140	6,488	1.28%					
10	Samar	Basey	50,423	218	0.43%	B	124	1	-	7
11		Marabut	15,115	30	0.20%	A	53	0	-	3
		Sub-total	65,538	248	0.38%					
12	East Samar	Lawaan	11,612	11	0.09%	B	47	0	-	1
13		Balangiga	12,756	14	0.11%	C	57	0	-	2
14		Giporlos	12,040	14	0.12%	C	59	0	-	2
15		Quinapondan	13,841	10	0.07%	C	55	0	1	3
16		Salcedo	19,970	29	0.15%	B	86	0	-	10
17		Mercedes	5,369	1	0.02%	C	141	0	-	1
18		Guiuan	47,037	122	0.26%	B	122	0	-	3
		Sub-total	122,625	201	0.16%					
		Total	696,303	6,937	1.00%					

Source: JICA Study Team, NDRRMC

Note1: Classification of Damage; A: Completely Destroyed, B: Half/ Partially Damaged, C: Minor damaged

Note2: DRRMO: Disaster Risk Reduction Management Office, PDO: Planning and Development Office

(2) Impacts on Local Government Administration by Typhoon Yolanda

Fragile administrative aspects on local government administrations towards natural disasters were exposed by Super Typhoon Yolanda. Since 1970s the Government of Philippines has prepared DRRM against natural disasters established at OCD, although, in total nine regions with 16 million populations centered in Region VIII, Eastern Visaya, were severely affected. This clause explains identified impacts on local government administration based on interviews and existing available information.

1) Insufficient administration conducted due to severely damaged premises
   - The most municipalities were well prepared for Yolanda from a few days before, however it disclosed various kind of weakness on administrative management against disaster preparedness.
   - Administrative buildings such as city/municipality halls, barangay halls, civic centers, etc., at affected LGUs were severely damaged by unprecedented typhoon Yolanda. Only one municipality building, Marabut, in the study area was completely destroyed while other municipality buildings except a few municipalities located in inland location or far from the center were partially damaged. However extremely strong wind blew roofs and windows of municipality buildings, then the administrative function had been suspended, and DRRM Operations center was out of order at some municipalities, or DRRM had not been prepared. Thus it is exposed the buildings were not complied with certain architectural standard namely National Building Code.
   - Civil servants were also affected their houses and it was unable to go to their office immediately.
   - Partially damaged municipality halls had been utilized as a disaster operation center and medical facilities temporarily; it became the center of rescue for a while.
   - The priority was given to emergency requirements and matters that LGUs had to take care, so regular public services such social welfare, medical and education were discontinues temporarily.

2) Temporarily discontinuing delivery of utility services and insufficient telecommunication capacity at LGUs' offices
   - Utilities such as water supply, electricity, telecommunication, etc., were interrupted temporarily. Especially overhead distribution system of electricity and telecommunication were suspended, while water supply, which is underground distribution system, had a less damage. (These utilities are operated by regional companies.)
   - Many of LGUs has prepared backup generators but there were limited.
   - Official communications were mainly relied on individual's cellular phone of LGUs and governmental offices. The number of Telecommunication line is limited for those offices.

3) Degraded security conditions
   - Police stations of PNP were also severely damaged as well as municipal buildings, and security conditions "law and order" had been degraded right after Yolanda for a while, plunderer incidents were reported. One of the reasons why was that it was reportedly not supply food properly.
   - It is reported that absence of security service and lack of police visibility after Yolanda brought restlessness to communities for a while, and lack of reliable communication led restlessness to communities as well.

4) Paper based official documents were soaked or washed out
   - Paper based official and administrative documents such as tax declaration documents, cadastral maps, accounting sheets, planning data and information, police records, court records, etc., were washed out or soaked by inundation caused by storm surge along the coastal areas or strong wind with rain.
   - Digital data including above mentioned documents, records, data and information was also gone with the PCs or was soaked.
   - Inappropriate management of official documents was exposed by Yolanda and backup system of those official documents shall properly be managed towards disasters at LGUs.

5) Decreasing revenue of LGUs is projected
   - It is said that approximately 40% of business entities in Tacloban have been ceased since the typhoon Yolanda, and it is projected that local revenue is expected to decrease. The reason varies that heavily damage of business premises and plunderer incidents were reported. (concrete information shall be added)
   - Recession of economic activities caused by Yolanda brought loss of personal productivity with limited working hours and displacement of personnel. The factor includes loss of equipment, destruction of facilities, lack of utilities, etc.

6) Lack of capacity for financing and implementing recovery and reconstruction activities
   - Early recovery and rehabilitation is demanding, however, insufficient capacity of resources is not able to prepare required documents and plans in proper timing with necessary information.
   - In addition, it is predicted that disbursement of the funded project will not be disburse smoothly with inappropriate project management with insufficient resources.
   - It is reported that monthly report of LDRRM Fund has not submitted timely to OCD and DILG.
   - Lack of transparency had been seen that allegations in handling of relief goods and donations in Barangay level.

7) Exposing the gap on Local Government Code and DRRM

- In fact, many of municipalities in the subject area have established Municipal Disaster Risk Reduction Management Office (MDRRMO) temporarily and planning staff holds a post concurrently at some municipalities.
- There was a gap between DRRM requirement and local legislation that assigning staff for DRRM Office, three administrative staff, in accordance with RA 10121 "Philippine Disaster Risk Reduction and Management Act of 2010" is mandatory. However, there is discrepancy on allocation from General Fund of LGU to LDRRMO/B.
- In response, April 4 2014, after Yolanda, Joint Memorandum Circular No.2014-1 "Implementing guideline for the establishment local DRRM Offices (LDRRMOs) or Barangay DRRM Committees (BDRRMCs) in Local Government Units (LGUs)" was issued in order for secure financial source from General Fund of LGS.
- Another aspect in planning at LGU level, local legislation has to approve the consolidation of DRRM into CLUP.
- Member of MDRRMC shall include members who have academic and science and technology background.
- These gaps would be revised at the after five years reviews of RA 10121 enacted, so called sunset review, which is year 2015.

2.2.5 Agriculture

(1) Damage caused by Yolanda

1) Targeted Area and Agriculture before Yolanda

Eastern Visayas is an agricultural region. More than half of its population directly and indirectly earn livelihood from agriculture. 20.5 % of its economy is derived from the sector.

Before Typhoon Yolanda struck, Eastern Visayas was the 8th largest rice producing region (5.5 % of national production, 2012) and the 3rd largest coconut producer (11.2%, 2012) in the country, with 285,000 ha of rice field and 46 million bearing coconut trees growing on 420,000 ha.

This Coconut farm land occupies 58 percent of agricultural land area in Eastern Visayas and almost 1.7 million people depend on the industry. And intercrops under coconut palm trees were also important, ranking 2nd largest producer for abaca (28.0 %, 2012), 5th for banana (6.72 %, 2012) and 1st for sweet potato (24.4 %). These crops traditionally protect farmers' income from the highly fluctuating copra prices, which are generally low.

Livestock production is also an important farming activity in rural areas in the Eastern Visayas. Livestock rearing is an integrated activity of the economic structure at farm and village level and it largely contributes to food security, rural income and to the efficient use of the local natural resources by use of local biomass for feeds and nutrient recycling through animal manure.

In 2012, the region recorded a 3.4 % decrease in agricultural output. The crops subsector shared 54.5 % in agricultural production. It grew by 0.2 %. Output decreases were noted in the livestock, poultry and fisheries subsectors.

The situation on production of major crops in the region in 2012 is shown the table below. Two major crops in the region are coconut and rice.

Table 2.2-7 Cultivated Area, Volume of Production and Value by Crop (2012)

Crop	Eastern Samar		Leyte		Samar		Eastern Visayas			Pjilippines		
	Area (ha)	Production (ton)	Area (ha)	Production (ton)	Area (ha)	Production (ton)	Area (ha)	Production (ton)	Value ('000 peso)	Area (ha)	Production (ton)	Value ('000 peso)
Temporary Crop												
Rice	21,054	59,413	133,090	521,115	54,698	140,529	285,394	994,972	7,969,710	4,689,960	18,032,422	151,111,760
Corn	250	593	40,328	55,392	6,656	9,133	61,699	87,333	571,140	2,593,825	7,377,076	49,033,280
Water melon	8	39.7	50	300.4	34	244.0	110	775.5	--	6,240	105,040.9	--
Squash	77	187.5	146	805.2	98	257.9	393	2,210.2	--	12,868	222,584.1	--
Sweet potato	2,274	7,296.8	4,872	62,068.7	3,647	7,254.2	24,655	123,349.9	726,530	100,736	516,365.5	2,406,330
Cassava	2,173	15,471.7	7,022	37,366.1	4,440	9,808.0	21,441	81,918.1	326,860	217,978	2,223,144.3	7,958,810
Gabi	30	214.2	1,378	7,048.2	473	4,771.3	4,566	22,113.3	--	16,352	111,481.9	--
Ubi	24	44.7	133	621.7	30	12.5	241	947.4	--	2,622	15,799.3	--
Ginger	10	37.3	181	1,556.9	40	190.9	284	2,206.4	--	4,004	27,630.9	--
Bitterv Squash	12	34.8	170	726.1	38	130.0	297	1,196.4	--	10,893	87,059.2	--
Kangkong	10	24.7	168	6,900.1	62	1,995.0	366	9,732.4	--	6,963	77,408.1	--
Mongo	12	11.7	372	232.7	22	7.4	436	270.6	5,850	44,324	32,364.5	735,450
Peanut	49	20.6	479	257.7	216	187.0	849	579.1	13,980	26,108	29,133.9	515,780
String bean	16	10.5	296	1,408.5	25	78.8	392	1,911.4	--	14,200	117,243.1	--
Abaca	2,875	401.0	13,020	6,606.7	2,128	1,382.4	37,780	19,190.9	446,550	138,523	68,510.5	1,279,080
Banana	1,434	5,708.4	6,328	51,456.2	4,965	116,236.8	30,542	280,439.1	1,046,040	454,179	9,225,998.0	39,118,240
Pinapple	32	592.7	178	1,990.7	275	4,236.5	583	7,456.6	57,960	58,442	2,397,627.6	16,207,980
Permanent Crop												
Coconut	62,357	274,851.9	167,973	676,021.1	50,510	292,607.4	419,540	1,771,459.4	6,979,550	3,573,806	15,862,385.8	32,517,880
Cacao	35	23.1	56	16.3	15	2.3	334	114.4	--	9,338	4,831.1	--
Mango	86	80.2	251	450.1	34	44.5	910	882.7	13,940	188,617	768,234.5	13,974,290
Papaya	98	924.3	93	876.7	32	538.3	474	3,109.4	--	8,564	164,820.5	--

Source: DA

The cropping calendar in the region is indicated in the following figure.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rice, irrigated	------------	------------	------------	□□							○…	…--…×----
					○…	……×--	------------	------------	------------	□□		
Rice, rainfed/upland			○---	------------	------------	------------	------------	------------	□□			
Corn					○------	--------	□□					
						○------	--------	□□				
							○------	--------	□□			
Coconut	------------	------------	□□□	------------	------------	□□□	------------	------------	□□□	------------	------------	□□□
Banana	all season, maturity: 8-9 months after transplanting											
Pineapple	------------	------------	--□□□	□□□□	□□□□	□□□--	------------	------------	------------	------------	------------	------------
Mango	------------	------------	------------	--□□□	□□□□	□□□□	□□□--	------------	------------	------------	------------	------------
Jackfruits	------------	------------	------------	------------	--□□□	□□□--	------------	------------	------------	------------	------------	------------
Rambutan	------------	------------	------------	------------	------------	----□□□	□□□□	□□□□	□□□--	------------	------------	------------
Durian	------------	------------	------------	------------	------------	------------	------------	--□□□	□□□□	□□□□	□□□--	------------
Mungbean		○○	○○--------	------□	□□□							
					○○	○○--------	--------□	□□□				
									○○	○○--------	------□	□□□
Bitter squash	all season, maturity: 60-75 days after sowing											
Kangkong	all season, maturity: 30-50 days after sowing											
Gabi	all season, maturity: 6-12 months after transplanting											
Sweet potato	all season, maturity: 90-120days after transplanting											
Ginger	□□□□	□□□□	□□□□	××	××--------	------------	------------	------------	------------	------------	------------	------------
	○	sowing	･･･	nursery	×	transplanting	□	harvest				

Source: DA

Figure 2.2-5 Cropping Calendar in Eastern Visayas

2) The coconut related industry in Eastern Visayas

a) Status of the industry

Hectarage planted to coconut

Eastern Visayas has a total of 420,000 ha of coconut lands. Of this area, the largest portion (40.01%) is in Leyte. The second and third largest portions, meantime, are in Northern Samar and Eastern Samar.

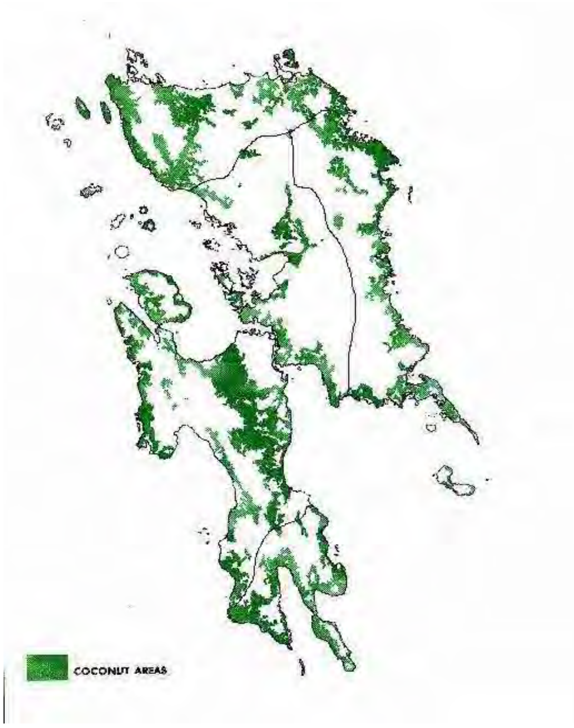


Figure 2.2-6 Coconut Plantation in Eastern Visayas

Before Typhoon Yolanda, a tota1 of 46.3 million of palm trees in the region were bearing trees. However, Northern Samar had the highest percentage of bearing trees. Of the 46.3 million bearing trees in the region, 13.0% were senile.

Tenure status in coconut lands

A total of 260,292 ha or 64.1 % of the coconut lands in the region are owned while the rest are tenanted of leased. Of the provinces in the region, Southern Leyte and Eastern Samar have the largest coconut lands that are owner-operated.

Table 2.2-8 Tenure of Coconut Farmlands (2002)

(upper: in ha, lower: % shared)

Province	Tenure of Parcels					Total Physical Area of Farm
	Fully Owned / Ownerlike Possession	Tenanted	Leased	Rent Free	Others	
(((Coconut)))						
Region VIII (Eastern Visayas)	**260,292 (64.1%)**	**121,909 (30.0%)**	**9,360 (2.3%)**	**9,063 (2.2%)**	**5,238 (1.3%)**	**405,862 (100.0%)**
Eastern Samar	47,679 (68.0%)	18,004 (25.7%)	1,791 (2.6%)	1,980 (2.8%)	624 (0.9%)	70,078 (100.0%)
Leyte	75,426 (59.8%)	43,921 (34.8%)	3,041 (2.4%)	2,396 (1.9%)	1,359 (1.1%)	126,143 (100.0%)
Samar	30,323 (66.1%)	11,321 (24.7%)	1,734 (3.8%)	2,043 (4.5%)	473 (1.0%)	45,894 (100.0%)

Source: DA

Production

Region VIII produced a total of 2 billion coconut nuts in 2009. At a conversion rate of 4.5 nuts to a kilogram of copra, Region VIII's production in 2009 tota]ed 444,000 MT of copra.

Copra is processed in crude coconut oil. From the processing of the copra, copra meal is produced. The meal is used as ingredients in animal feeds. The crude coconut oil is processed into oleochemicals, which are used in the food and cosmetics industries. Aside from those of copra and copra-based products, there are other uses for other parts of the coconut, namely, coconut shell, husk, water and white meat. Most coconut shells are burned as charcoal and used as fuel. They are also used to make various handicrafts. Recently however, they have been used to make granulated charcoal, which is then turned into activated carbon. Activated carbon is used to purify water, air and food; recover solvents; and make various pharmaceutical products. Moreover, most coconut oil mills in the region have started to use coconut shell as a source of fuel. It is estimated that Region VIII produced a total of 360,000 MT of coconut shells in 2009, with 5,555 nuts needed to produce a metric ton of shells.

Meanwhile, coconut husk which has usually been used either as scrub for household use or dried and used as fuel, is now being used to produce coconut coir. Coconut coir is used as material for upholstery padding, floor mats, mattresses and handicraft, and as a soil erosion control tool. At a conversion rate of 12,500 nuts per 1 MT, Region 8 could have produced 160 MT of coir in 2009 if it converted all the nuts it produced into coir However, it is estimated by PCA Region 8 that half of the nuts produced in the region are used to dry copra. The potential coir production for the region is therefore 80 MT a year.

Aside from copra, coconut meat is also used for other products. Currently the more popular of these other uses are Virgin Coconut Oil and coco methyl ester or coco biodiesel. Virgin Coconut Oil is known as being good for the health if drank. Coco methyl ester, on the other hand, is used either as diesel fuel or diesel fuel enhancer. Finally coconut water has been used to make vinegar and wines. A new product from it is coco sap brown sugar.

Trade

Trade in copra in Eastern Visayas changed dramatically in recent years. In 2002, PCA 8 estimated that 63% of all copra produced in the region was exported out of the region but used in the country, 24% was used for local products, and 13% was processed and then exported out of the country. In 2007, 80% of all copra produced in the region was processed for exports outside the country. Sixteen percent (16%) was processed and used for the local market, and only 4% was sold outside the region but still within the Philippines.

Table 2.2-9 Tenure of Coconut Farmlands (2002)

Destination of Copra	2002	2007	
Outside the Region	63%	4%	⇓
Inside the Region	24%	16%	↓
Outside the Country	13%	80%	⇑
Total	100%	100%	

In 2010, the region exported 176,260 MT of coconut products outside the country. Nearly half (45.3%) of these exports was crude coconut oil while a fourth (25.8%) was copra cakes. The rest of the exports were cochin oil, low color oil, and Refined, Bleached, and Deodorized (RBD) oil, From these exports, the region earned a total of US$ 180 million, almost twice what it earned the previous year.

Stakeholder

- Farmers

Coconut farmer –landowners in Eastern Visayas in 2009 numbered 368,524. Of these farmers, 33.3% were in Leyte while 21.7% were in Eastern Samar. With coconut lands totaling 649,030 ha, these farmers have farms averaging 1.76 ha in size. Meanwhile, there were 1,395,431 tenants and workers.

It was estimated that copra production in 2006 from a hectare in a year was 0.86 MT. An average farming family, farming an average of 1.76 ha of land therefore produces 1.51 MT of copra a year. Copra is produced four times a year in the region, usually in the months of March, June, September and December.

Based on the average production of 1.51 MT and the average farm gate price of copra in the first half of 2010, an average coconut farming family running an owner-operated farm would earn for this year a gross income of Php 59,787 a year or Php 4,982 a month, However, the cost of running the farm averaged Php 24,429 in 2006. The net income of a coconut farming family would therefore be Php 35,358 for this year or Php 2,947 a month.

This level of income is less than a third (28.9%) of the average income of a family in the region in 2006, It is also less than half (44.0%) of the average family expenditure in the region in the same year.

The situation is much worse for tenants. It is the common practice in the region that tenants receive 50% of the harvest of the farm they operate.

This subsistence level living has made most coconut farmers constantly dependent on the credit line extended to them by traders in exchange for the assurance that their future harvest would be sold to the creditor. This' dependence on the trader for his credit needs only one of the factors why the coconut farmer has no other option except to accept whatever price the trader says his produce is worth. One other factor is the farmer's lack of access to the knowledge, skill, or technology to contest the assessment of the trader of the quality of his copra. Another is his lack of access to market information to enable him to bargain better with the trader or to have the choice of trading with someone else. Still1 another factor is his lack of savings that would enable him to wait for better prices. The other factors include the absence of other traders in the area and the farmer's lack of access to transportation facilities and the production volume to enable him to look for more advantageous markets.

- Traders

There are two to three layers of copra traders in Region VIII, who act mainly as consolidators and transporters of copra before these are sold to the oil mills. From the farm gate, copra is sold to village or barangay traders who, in turn, sell them to municipal traders who then sell them to lead traders. It is the lead traders who sell directly to the oil mills.

A majority of traders in Region VIII work independently of any network and sell to any other traders or to mills that offers the best deal. There are, however, traders who operate within a network. In these networks, the lead traders provide funds to the municipal trader who, in turn, distributes the funds to municipal traders who then lends capital to barangay or village traders working within the network. The funds enable these traders to provide credit to farmers, and also to buy copra from the farmers.

The trading system for raw coconut shell and charcoal is more complex than that for copra. There are at least four routes that could be taken in selling coconut shell, depending on who are the ultimate users, and these routes intersect with one another. These users are the oil millers who use coconut shell as substitute for bunker fuel, the households who use charcoal as household fuel and buy it at the town plaza, the charcoal processing p]ants, and the activated carbon plants.

- The Processors

Before Typhoon Yolanda struck, there were eight oil mills operating in Eastern Visayas. The capacity of these oil mills had registered with the Philippine Coconut Authority (PCA) totals 380,300 MT a year. And there were four activated carbon manufacturing plants in Region VIII, with a total capacity of 15 MT per day.

(2) Damage in Agriculture

Typhoon Yolanda caused devastation of great proportions to Eastern Visayas. About 80% of the area was destroyed. Crops were dislodged, trees uprooted, and mortality to poultry and livestock was very high. The damage to agricultural crops, especially coconut, has affected the regional economy. Fruit trees suffered stress such that it will take 4–5 years for them to recover and regain their pre–disaster productivity level. This aggravated the yield loss, investment loss, opportunity cost, clearing operation, etc. that farmers have to cope with while waiting for conditions to normalize.

The typhoon flattened millions of coconut trees, and the country’s third largest coconut-producing region was one of the areas most affected. In this region alone about 34 million coconut palm trees were damaged or destroyed and more than a million coconut farmers impacted. The devastation created drastic effects along the entire value chain, affecting people who were engaged both directly and indirectly – from farm owners, tenant farmers, workers, to traders and processors.

The damage data in agriculture in Region VIII, which is studied by DA, is shown on the next page (except the data of coconut).

Table 2.2-10 Crop damage in Eastern Visayas (except coconut)

Province	No. of Farmers Affected	Area Affected (ha)	Production Loss	
			Volume (Mt)	Value (Pesos)
REGIONAL TOTALS	***1,287,479***	***1,011,677***	***1,315,423.85***	***18,859,879,924.66***
Rice	28,497	30,284	34,570.33	227,026,707.91
Corn	5,722	3,875	5,352.74	96,918,430.00
Vegetables	51,001	2,221	4,461.50	125,998,397.75
Fruit Trees	2,390	1,407	2,837.10	22,374,375.00
Root Crops	4,037	3,712	18,998.64	82,923,725.00
Banana	16,993	17,652	42,032.90	317,444,186.00
Organic	-	-	-	6,559,000.00
Livestock (head)	12,406	648,940	1,201,121.27	206,431,860.00
Fisheries	1,339		-	101,330,000.00
Infrastructure	-	-	-	834,780,435.00
PCA (Coconut)	1,160,336	295,192	-	16,604,449,183.00
FIDA (Abaca)	4,759	8,364	6,049.38	233,643,625.00
LEYTE	***712,621.88***	***799,660***	***576,131.41***	***13,639,552,418.00***
Rice	17,596	18,434	22,419.76	141,169,875.00
Corn	4,246	2,981	4,083.45	74,858,000.00
Vegetables	27,720	1,155	1,153.70	81,655,000.00
Fruit trees	1,170	786	1,449.14	11,796,675.00
Root Crops	2,178	1,826	4,756.28	63,582,900.00
Banana	8,163	7,394	15,195.50	154,967,340.00
Organic				3,130,000.00
Livestock (head)	1,564	590,246	523,358.27	110,458,700.00
Fisheries	689			101,330,000.00
Infrastructure				629,524,005.00
FIDA (Abaca)	2,478	4,953	3,715.32	105,766,000.00
SAMAR	***162,592.56***	***70,124***	***82,168.98***	***742,158,229.91***
Rice	3,987	3,445	2,716.01	24,600,432.91
Corn	938	571	713.40	14,268,000.00
Vegetables	11,767.56	490	2,314.14	14,562,669.00
Fruit Trees	-	-	-	-
Root Crops	-	-	-	-
Banana	1,598.00	2,072	4,143.56	41,435,600.00
Organic				1,009,000.00
Livestock (head)	6879	35,824	72,080.00	6,368,900.00
Fisheries	-			-
Infrastructure				40,846,405.00
FIDA (Abaca)	136	269	201.87	10,093,500.00
EASTERN SAMAR	***304,303.66***	***87,884***	***466,982.12***	***3,518,414,420.75***
Rice	3,296	4,332	4,432.10	32,454,000.00
Corn	199	110	261.10	2,724,430.00
Vegetables	7,661.52	319	638.46	20,473,668.75
Fruit Trees	812.14	406	812.56	6,094,200.00
Root Crops	1,619.00	1,691	13,561.56	16,913,200.00
Banana	1,335.00	1,451	2,936.34	29,019,400.00
Organic				2,420,000.00

Livestock (head)	3,813	22,464	444,340.00	89,022,860.00
Fisheries	20			-
Infrastructure				22,824,850.00
FIDA (Abaca)				

Source: NDRRMC April 03, 2014 prepared by DA 8 command center

Philippines is the second largest coconut producer, following Indonesia and being followed by India, and produced 26.6% of world production in 2013. According to the Philippines Coconut Authority, Region VIII had 46 million coconut trees planted and was the third largest coconut producer before the hit of Yolanda. Yolanda left 15 million coconut palm trees damaged beyond recovery and another 20 million trees severely damaged, resulting in total losses of 396 million US dollars equivalent to 17.7 million Pesos. And almost 1.7 million people depended on the coconut industry including copra traders and wage earners in the various coconut value chains in the region, which resulted in economic losses multiplied by many-fold.

The coconut trees damaged by Typhoon Yolanda in the region were announced by PCA as follows:

Table 2.2-11 Coconut damage by Province Targeted

Province	Before Yolanda			Affected by Yolanda		
				Number of Damaged Trees		
	Area Planted (ha)	No. of Farmers	No. of Trees	Damaged, Recoverable	Damaged, Deadly	Total
Region VIII, total	**925,651**	**780,412**	**74,607,354**	**19,711,813 (26.4%)**	**13,891,173 (18.6%)**	**33,602,986 (45.0%)**
Eastern Samr	302,591	142,138	13,192,227	3,244,157 (24.6%)	3,057,358 (23.2%)	6,301,515 (47.8%)
Leyte	217,436	406,500	27,506,848	9,588,207 (34.9%)	10,172,724 (37.0%)	19,760,931 (71.8%)
Samar	120,078	69,556	11,667,709	2,819,805 (24.2%)	276,556 (2.4%)	3,096,361 (26.5%)

Source: Coconut damage report prepared by PCA

Leyte had the largest number of damaged coconut trees among targeted three provinces. However, the municipalities targeted by the Study Team are only coastal ones. The damages varied with the distance from the pass of Typhoon Yolanda and geographical conditions as follows;.

Table 2.2-12 Coconut damage by LGU Targeted

Municipality	Before Yolanda			Affected by Yolanda					
				Number of Damaged Trees					
	Area Planted (ha)	No. of Farmers	No. of Trees	Damaged, Recoverable		Damaged, Deadly		Total	
Region VIII, total	925,651	780,412	74,607,354	19,711,813	(26.4%)	13,891,173	(18.6%)	33,602,986	(45.0%)
Eastern Samar Province, total	302,591	142,138	13,192,227	3,244,157	(24.6%)	3,057,358	(23.2%)	6,301,515	(47.8%)
Balangiga	6,636	9,080	822,864	100,215	(12.2%)	567,885	(69.0%)	668,100	(81.2%)
Giporlos	7,310	2,175	906,439	101,340	(11.2%)	574,260	(63.4%)	675,600	(74.5%)
Guiuan	5,610	32,949	1,385,453	94,360	(6.8%)	754,880	(54.5%)	849,240	(61.3%)
Lawa-an	3,338	8,398	413,911	39,620	(9.6%)	356,580	(86.1%)	396,200	(95.7%)
Mercedes	2,218	4,137	201,997	60,640	(30.0%)	90,960	(45.0%)	151,600	(75.1%)
Quinapondan	5,475	9,962	655,724	50,650	(7.7%)	455,800	(69.5%)	506,450	(77.2%)
Salcedo	3,483	3,610	419,325	151,968	(36.2%)	164,632	(39.3%)	316,600	(75.5%)
Leyte Province, total	217,436	406,500	27,506,848	9,588,207	(34.9%)	10,172,724	(37.0%)	19,760,931	(71.8%)
Tacloban	2,654	10,729	267,156	49,352	(18.5%)	156,281	(58.5%)	205,633	(77.0%)
Abuyog	12,533	26,548	1,355,936	646,066	(47.6%)	656,370	(48.4%)	1,302,436	(96.1%)
Dulag	4,874	7,993	522,032	98,566	(18.9%)	413,466	(79.2%)	512,032	(98.1%)
Javier	6,615	16,124	699,563	423,331	(60.5%)	232,733	(33.3%)	656,065	(93.8%)
MacArthur	2,959	5,486	419,421	98,222	(23.4%)	311,159	(74.2%)	409,381	(97.6%)
Mayorga	1,990	10,518	236,665	50,379	(21.3%)	183,032	(77.3%)	233,411	(98.6%)
Palo	2,178	19,815	227,088	21,167	(9.3%)	195,921	(86.3%)	217,088	(95.6%)
Tanauan	2,116	17,844	233,532	32,413	(13.9%)	191,119	(81.8%)	223,532	(95.7%)
Tolosa	1,341	6,340	156,162	21,919	(14.0%)	129,243	(82.8%)	151,162	(96.8%)
Samar Province, total	120,078	69,556	11,667,709	2,819,805	(24.2%)	276,556	(2.4%)	3,096,361	(26.5%)
Bassey	15,234	4,252	1,521,513	1,499,400	(98.5%)	15,200	(1.0%)	1,514,601	(99.5%)
Marabut	2,886	1,935	293,416	21,850	(7.4%)	254,750	(86.8%)	276,600	(94.3%)

Source: Coconut damage report prepared by PCA

2.2.6 Fishery

BFAR reported that 49,090 fisher folks, consisting of those involved in capture fisheries, aquaculture and post-harvest, were affected by Typhoon Yolanda in Region VIII. The most severely damaged provinces are Leyte and Eastern Samar. It was estimated that, in Leyte, 10,264 bancas and 24 commercial fishing boats were lost or destroyed by the storm surge, while 1,723 fish cages were washed out in Eastern Samar. Fisher folk in Biliran, Southern Leyte and Samar have also lost fishing capacity due to damaged or lost fishing boats, fishing gear and aquaculture infrastructures (Food Security Cluster, 2014).

Table 2.2-13 Fisher folk affected by Typhoon Yolanda

	Leyte	Biliran	S. Leyte	Samar	E. Samar	Regional total
Capture fisheries	10,648	391	0	1,654	8,369	21,062
Aquaculture	4,659	72	61	4,796	17,670	27,260
Post-harvest	656	10	0	20	132	818
Total	15,913	473	61	6,472	26,171	49,090

Souce: Food Security Cluster Net (accessed 2014-04-24)

The estimated total cost of damage to the fishery sector in Region VIII is about P1.66 billion, according to a Typhoon Yolanda Damage Report (BFAR, 2014). Of the five provinces in the region, Eastern Samar was most affected with an estimated cost of PhP 648 million, followed by Leyte, Samar, Biliran and Southern Leyte.

BFAR facilities were also badly hit by very strong winds, which blew off the roofs and the heavy rain coming through soaked everything inside. The damage could cost PhP 244 million. Yolanda-hit BFAR facilities are BFAR Regional Office, Guiuan Marine Fisheries Development Center, Regional Freshwater Aquaculture Production Center, Southern Leyte Provincial Fishery Office, Laoang Mariculture Park, Leyte West Fisherfolk Center, Carigara Fisherfolk Center, etc.

Damaged fish cages
(Brgy. Cambayan, Basey, Samar)

Hatcheries of Guiuan Marine Fisheries Development Center

Chapter 3 Recovery and Reconstruction Efforts

3.1 The Government Response

The efforts by the central government, local governments, etc. are explained chronologically in line with executive orders as follows.

3.1.1 Central Government

(1) Early Warning on Typhoon Yolanda by President

The Statement of President Aquino on typhoon Yolanda[1] was made publicly on November 7 2013 in order to remind the people of the need for their preparedness and it included a projection of the magnitude which was stronger than the previous strong typhoon, Pablo, (internationally designation is Bopha) that hit Mindanao on November 2-9 2012, and his statement included its projected course and time, and expected disasters. It was forecast that typhoon Yolanda would have extremely low pressure and a "Public Warning Storm Signal #4[2] was disseminated over some areas in accordance with advice by experts from DOST, PAGASA and the Mines and Geosciences Bureau based on the latest information as well as its projected effects on the country.

(2) Declaring a State of National Calamity

A proclamation declaring a National Calamity (Proclamation No.682, s.2013)[3] was issued on 11 November 2013 by President Benigno S. Aquino III based on the recommendation of the National Disaster Risk Reduction and Management Council (NDRRMC) stipulated in Sec.16 of RA No.10121 "Philippines Disaster Risk Reduction and Management Act of 2010". The proclamation covered the area affected by Typhoon Yolanda (internationally Haiyan), including Samar, Leyte, Negros, Cebu, Bohol, Capiz, Aklan, Antique, Iloilo and Palawan. The State of National Calamity shall remain in force and effect until lifted by the President.

Accordingly the government provided about PhP2.6 billion worth of relief assistance to nine affected regions. A total 35,417 personnel, 1,351 vehicles, 118 sea craft, 163 aircraft and 28,361 other assets from national, local, and foreign agencies, responders, and volunteer organizations deployed to various area to support relief and medical operations[4].

(3) Assigning National Relief Coordinators

On November 14, 2013, Memorandum Order No. 60, s.2013[5] titled "Designating Coordinators for Relief and Recovery Efforts in Connection with the Calamity Arising from Typhoon Yolanda" was published by the Office of the President. This Order designated the officials to coordinate the

1 http://www.gov.ph/2013/11/07/english-statement-of-president-aquino-on-typhoon-yolanda-november-7-2013/
2 http://www.pagasa.dost.gov.ph/learning-tools/public-storm-warning-signal
3 http://www.gov.ph/2013/11/11/proclamation-no-682-s-2013/
4 NEDA(2013), Reconstruction Assistance on Yolanda,pp.3.
5 http://www.gov.ph/2013/11/14/memorandum-order-no-60-s-2013/

preparation and distribution of the relief packages needed in the affected areas of Typhoon Yolanda. The officials designated for this purpose are:

- Secretary Cesar V. Purisima of the Department of Finance is designated as the overall coordinator for the preparation of all relief packs/goods prior to their distribution to affected localities.
- Director General Emmanuel Joel J. Villanueva of the Technical Education and Skills Development Authority is likewise designated as co-coordinator to assist the former in the said activities.
- Secretary Joseph Emilio A. Abaya of the Department of Transportation and Communications is designated as coordinator for all transportation and other logistical needs in connection with the distribution of relief packs/goods.

(4) Directing All Agencies and State Owned Corporations

15 November 2013, Memorandum Circular No.57, s. 2013 "Directing all department and secretaries and heads of agencies, bureaus, or officers of the government, including government-owned and controlled corporations, and authorizing and encouraging local government units, to mobilize their respective officials and employees in the relief and rehabilitation efforts in response to the calamity arising from typhoon Yolanda" was issued.

This order explains that civil servants shall provide services for humanitarian needs in line with the Implementing Rules and Regulations of Republic Act No.6713, or the Code of Conduct and Ethical Standards for Public Officials and Employees so that all government heads including LGUs' are authorized and encouraged to mobilize their assistance in relief and rehabilitation efforts.

(5) Directing Health and Sanitation Operation by DOH

18 November 2013, Memorandum Order No.61, s. 2013[6] "Directing the Department of Health to temporarily assume direct supervision and control over health and sanitation operations of local government units affected by typhoon Yolanda" was issued.

This order stated that the Department Health is temporally enabled to direct supervision and control over sanitation when LGU's service and facilities in affected areas that are not available or are in inadequate condition. This is designated in the Section 17 (f) of Republic Act No.7160, the Local Government Code of 1991, and Section 105 of Republic Act No.7160, and Presidential Decree No.856 "Code on Sanitation of the Philippines".

(6) Providing Timely Information and GIS for Relief and Rehabilitation Efforts

On 19 November 2013, Memorandum Circular No.58, s. 2013[7] "Directing all concerned heads of departments and agencies/offices, and encouraging concerned local government units to provide

6 http://www.gov.ph/2013/11/18/memorandum-order-no-61-s-2013/
7 http://www.gov.ph/2013/11/19/memorandum-circular-no-58-s-2013/

timely information to be used by the geographical information system relating to the relief and rehabilitation efforts in response to the calamity arising from typhoon Yolanda" was issued.

In response to the urgent needs of relief and recovery, this circular pursuant to Proclamation No.682 s.2013, a State of national Calamity, shall consolidate and pass on information regarding affected areas to the GIS personnel established at the National Disaster Risk Reduction and Management Council (NDRRMC) in coordination with the Department of Science and technology (DOST).

(7) Moratorium on Loan Payments

On 26 November 2013, Memorandum Circular No.59, s. 2013[8] "Directing all government financial institutions to grant a moratorium on loan payments of, and extend interest-free loans to, individuals and entities directly affected by the calamity arising typhoon Yolanda" was issued.

Interest free loans by government financing institutions (GFIs) are granted pursuant to Section 17 (d) of RA No.10121 'Philippines Disaster Risk Reduction and Management Act of 2010", and a six-month moratorium on the payment of outstanding loans of individuals and entities directly affected by typhoon Yolanda is mandated.

(8) Presidential Assistance for Rehabilitation and Recovery (PARR)

On 6 December, 2013, Memorandum Order No.62, s. 2013[9] "Providing for the function of the Presidential Assistance for Rehabilitation and Recovery" was issued. This order is a key decision in the post-disaster stage and the order designates to exercise oversight over the relevant government agencies with respect to the implementation of the plans and programs on recovery and rehabilitation activities. And President Benigno Aquino offered the position of Secretary of PARR to former Senator Panfilo Lacson and a business executive and professor Danilo A. Antonio was also accepted as the undersecretary of the Office of PARR at the Office of the President.

It is described that "Act as over-all manager and coordinator of rehabilitation, recovery, and reconstruction efforts of government departments, agencies, and instrumentalities in the affected areas, to the extent allowed by law", and

"Coordinate with the National Disaster Risk Reduction and Management Council (NDRRMC) and its member agencies and consult with the concerned local government units (LGUs) in the formulation of plans and programs for the rehabilitation, recovery and development of the affected areas ("the plans and programs"), including an over-all strategic vision and integrated short-term, medium-term and long-term programs, which shall be submitted to the President for approval."

OCD is responsible for "Post-disaster Needs Assessment". It seems that the Office of the PARR and OCD are overlapped, however, PARR is an overall coordination body in disaster recovery and

8 http://www.gov.ph/2013/11/26/memorandum-circular-no-59-s-2013/
9 http://www.gov.ph/2013/12/06/memorandum-order-no-62-s-2013/

reconstruction.

(9) The President's briefing on Yolanda Reconstruction Assistance Plan by NEDA

On 18 December 2013, President Aquino held a briefing for the Philippines development partners on Reconstruction for Yolanda (RAY)[10], which was prepared by the National Economic Development Authority (NEDA)[11], co-organized by the Department of Foreign Affairs (DFA) and the Department of Finance (DOF). The President expressed his commitment to "Build Back Better", a principle of building more resilient communities in areas devastated by Typhoon Yolanda.

Accordingly, the Secretary of Foreign Affairs, Secretary of Finance, Secretary of Budget and Management, Secretary of Social Welfare and Development, Secretary of Public Works and Highways, Secretary of Socioeconomic Planning and Secretary of PARR held a briefing for the Philippine Development Partners on Reconstruction Assistance for Yolanda (RAY)[12] to around 75 development partners; countries, multilateral organizations and international agencies .

3.1.2 Funding Arrangements for Disaster preparedness and Recovery and Rehabilitation

The government has set up the funding system for post-disaster rehabilitation and recovery activities, which are the National Disaster Risk Reduction and Management Fund (NDRRM Fund), formerly known as the Calamity Fund appropriated under the Annual General Appropriations Act RA No.10155 Section XXXVII-Calamity Fund, and the Local Disaster Risk Reduction and Management Fund (LDRRM Fund), also formerly known as Local calamity Fund, at the local government level.

(1) National Disaster Risk Reduction and Management Fund (NDRRM Fund)

In Section 22 of RA No. 10121 "Philippine Disaster Risk Reduction and Management Act of 2010"[13], it is stipulated that the NDRRM Fund shall be used for disaster risk reduction or mitigation, prevention and preparedness activities, and it can also be utilized for relief, recovery, reconstruction and other work or services in connection with natural or human induced calamities which may occur during the fiscal year or those that occurred in the past two years from the budget year.

Thirty percent (30%) of the NDRRM Fund shall be allocated to the Quick Response Fund (QRF) or a stand-by fund for relief and recovery programs in order that the situation and living conditions of people in communities or areas stricken by disasters, calamities, epidemics, or complex emergencies, may be normalized as quickly as possible.

[10] http://www.gov.ph/2013/12/18/speech-of-president-aquino-at-the-briefing-on-reconstruction-assistance-on-yolanda/
[11] http://www.gov.ph/2013/12/18/document-reconstruction-assistance-on-yolanda/
[12] https://www.dfa.gov.ph/index.php/2013-06-27-21-50-36/dfa-releases/1724-briefing-for-philippine-development-partners-on-reconstruction-assistance-on-yolanda-ray
[13] http://www.ndrrmc.gov.ph/attachments/045_RA%2010121.pdf

The NDRRM Council is responsible for submitting proposals to restore normalcy in the affected areas, to include calamity fund allocation as well as to endorse fund requests to the Office of the President for approval. The approval of fund requests is forwarded directly to the Department of Budget and Management (DBM) to release the funds.

(2) Local Disaster Risk Reduction and Management Fund (LDRRM Fund)

As well as the NDRRM Fund, Section 21 of RA No. 10121 stipulates establishment of the LDRRM Fund, and not less than five percent (5 %) of the total LGUs' revenue shall be allocated to it, and the thirty percent (30%) shall be allocated to the QRF or stand-by fund for relief and recovery programs as well. The fund shall support pre-disaster and post-disaster activities such as disaster risk management activities, pre-disaster preparedness programs including training, purchasing life-saving rescue equipment, supplies and medicines, and payment of premiums on calamity insurance.

The LDRRM Council shall monitor and evaluate the use and disbursement of the fund based on the LDRRM Plan in cooperation with the local development plans and annual work and financial plan.

(3) National Government Budget

Table 3.1-1 presents the overall National Government Budget, and the amounts allocated to the departments and for special purposes. The funds to be disbursed to Region VIII amount to 3% of the year 2014 National Budget.

Table 3.1-1 National Government Budget (PHP million)

		2012	2013	2014	%
Total of National Government Budget		1,816,000	2,006,000	2,268,000	100.0
Allocation to	1. Departments of the National Government	940,984	1,025,302	1,211,905	53.4
	2. Special Purpose Funds	875,016	980,698	1,056,095	46.5
	1) Allocation to LGUs	291,614	315,836	361,252	16.0
	2) Calamity Fund	7,500	7,500	13,000	0.6
	3) Others	575,902	657,362	681,843	29.9
Funds disbursed/to be disbursed to Region VIII from the above 1 & 2		-	125,367	275,920	3.0
(ref: the same as above to Manila)		-	56,477	67,785	12.2

Source: Department of Budget and Management (DBM)

(4) Ad-hoc Budget for Recovery and Rehabilitation for Yolanda

According to the "People's Budget 2014, Department of Budget and Management (DBM)", the National Economic and Development Authority (NEDA) has formulated the Rehabilitation Assistance for Yolanda (RAY), which estimates an amount of PHP 360.8 billion requirements for recovery and reconstruction investment until 2017 as presented in Table 3.1-2.

Table 3.1-2 Recovery and Reconstruction Investment Estimated by RAY (PHP billion)

Sector	Immediate	Short-term (2014)	Medium-term (2015-17)	Total
1.Shelter & Resettlement	15.6	57.5	110.2	183.3
2.Public Infrastructure	8.2	2.3	17.9	28.4
3.Education & Health Services	1.5	20.8	15.1	37.4
4.Agriculture	4.3	3.4	11.0	18.7
5.Industry & Services	1.2	2.7	66.7	70.6
6.LGUs	2.0	2.0	-	4.0
7.Social Protection	1.9	1.5	15.0	18.4
Total	34.7	90.2	235.9	360.8

Source: People's Budget 2014, DBM

According to the DILG, the RAY has disbursed PhP 1.8 billion from the funds of the DILG and the DPWH in April as shown in Table 3.1-3, of which PhP 1.1 billion, equivalent to 62% of total RAY disbursement, was allotted to the project target areas of Tacloban City and 17 municipalities.

Table 3.1-3 Disbursement of RAY (PHP million)

Areas Disbursed		Investment for Structures				Sources			
		Hall	Public Mkt	Civic Center	Total	DILG	DPWH	JICA	Total
1.Total RAY Disbursement		538.3	689.6	541.0	**1,768.9**	938.4	793.7	36.8	1,768.9
2. Disburse. to Leyte Province		348.5	613.4	411.3	1,373.1	801.8	571.3	-	1,373.1
Project Target Area	Province	-	-	47.0	47.0	47.0	-	-	47.0
	Tacloban	146.1	68.4	16.2	230.7	230.7	-	-	230.7
	Palo	-	211.1	5.0	216.1	5.0	211.1	-	216.1
	Tanauan	25.0	109.9	1.2	136.1	55.1	81.0	-	136.1
	Tolosa	20.0	35.3	42.0	97.3	-	97.3	-	97.3
	Dulag	4.4	6.3	5.7	16.4	16.4	-	-	16.4
	Mayorga	6.0	2.3	6.5	14.8	14.8	-	-	14.8
	Macarthur	1.0	18.6	6.7	26.3	16.2	10.2	-	26.3
	Javier	1.6		0.9	2.5	2.5	-	-	2.5
	Abuyog	1.6	0.8	5.1	7.5	7.5	-	-	7.5
	Total	205.7	452.7	136.3	794.7	395.1	399.6	0.0	794.7
3. Disburse. to Samar Province		73.3	33.9	10.7	117.8	16.5	85.5	15.8	117.8
Project Target Area	Basey	55.0	30.5	2.0	87.5	2.0	85.5	-	87.5
	Marabut	15.8	2.4	5.5	23.7	7.9	-	15.8	23.7
	Total	70.8	32.9	7.5	111.2	9.9	85.5	15.8	111.2
4. Disburse. to E.Samar Province		112.7	39.5	106.1	258.2	100.2	137.0		237.2
Project Target Area	Lawaan	21.0	2.1	1.8	24.9		3.9	21.0	24.9
	Balangiga	2.5	0.8	4.3	7.6	7.6		-	7.6
	Giporlos	1.5	0.4	25.0	26.9	1.9	25.0	-	26.9
	Quinapondan	1.5	3.3	6.0	10.7	4.7	6.0	-	10.7
	Salcedo	1.2	1.6	6.0	8.8	2.8	6.0	-	8.8
	Mercedes	2.4	4.0	0.5	6.9	2.9	4.0	-	6.9
	Guiuan	43.0	13.0	45.0	101.0	56.0	45.0	-	101.0
	Total	73.1	25.2	88.6	186.9	76.0	89.9	21.0	186.9
5. Total Disb. to Study Areas		349.6	510.8	232.4	**1,092.8**	481.0	575.0	36.8	1,092.8
% = 5/1		65%	74%	43%	**62%**	51%	72%	-	62%

Source: DILG

(5) Budget of Province, City and LGUs'

The budget of Leyte Province, Tacloban City and 17 other LGUs are presented in Table 3.1-4 and Table 3.1-5.

Table 3.1-4 Budget of Leyte Province (PHP million)

Budget Items		2012 Actual	2013 Estimate	2014 Proposed	Particulars
Revenue	Internal	255	234	215	12.8%
	External	1,166	1,255	1,460	87.2%
	Total	1,421	1,489	1,675	100.0%
Expenditures	Recurrent	-	-	896	PE: 41%
	Non-recurrent	-	-	872	
	Total	-	-	1,768	

Note: PE = personnel expenditures
Source: Provincial Budget Office of Leyte Province

Table 3.1-5 Budget of 1 City and 4 LGUs (PHP million)

City/LGUs	Budget Items		2012 Actual	2013 Estimate	2014 Proposed	Particulars
1.Tacloban	Revenue	Internal	474.4	452.7	72.3	13.2%
		External [1)]	408.5	433.8	478.5	86.8%
		Total	882.9	886.5	550.8	100.0%
	Expenditures	Recurrent	699.3	664.9	381.5	PE: 58% [2)]
		Non-recurrent	133.3	221.6	169.3	
		Total	832.6	886.5	550.8	
2.Palo	Revenue	Internal	15.4	18.0	19.1	14.7%
		External [1)]	87.5	108.9	110.9	85.3%
		Total	102.9	126.9	130.0	100.0%
	Expenditures	Recurrent	59.1	85.4	85.9	PE: 32% [2)]
		Non-recurrent	26.2	36.5	44.0	
		Total	85.3	121.9	129.9	
3.Tanauan	Revenue	Internal	20.3	20.7	21.8	21.3%
		External [1)]	63.5	71.0	80.7	78.7%
		Total	83.8	91.7	102.5	100.0%
	Expenditures	Recurrent	66.1	54.2	62.2	PE: 43% [2)]
		Non-recurrent	26.8	37.5	40.3	
		Total	92.9	91.7	102.5	
4.Basey	Revenue	Internal	2.4	4.5	4.5	3.5%
		External [1)]	99.6	107.5	122.3	96.5%
		Total	102.0	112.0	126.8	100.0%
	Expenditures	Recurrent	79.6	84.6	89.4	PE: 43% [2)]
		Non-recurrent	14.5	27.4	37.3	
		Total	94.1	112.0	126.7	
5. Guiuan	Revenue	Internal	14.3	18.9	11.9	12.1%
		External [1)]	66.7	75.8	86.2	77.9%
		Total	81.0	94.7	98.1	100.0%
	Expenditures	Recurrent	64.5	70.4	72.7	PE: 52% [2)]
		Non-recurrent	16.3	24.3	25.4	
		Total	80.8	94.7	98.1	
Total of revenues: above 1 City and 4 LGUs			1,252.6	1,311.8	1,008.2	
Total of revenues: other 13 LGUs			662.2	707.8	786.5	

Note: 1) Most of the external revenues are IRA (Internal Revenue Allotment), 2) PE = personnel expenditures
Source: Tacloban City Budget Office and Municipal Budget Office of LGUs

The revenues of these governments largely depend on external revenues, most of which is the allocation of the Internal Revenue Allotment (IRA) from the national government. The IRA dependency of Tacloban City was less than 50% in 2013; however, it soared to almost 90% in 2014 due to the sharp decline of the internal revenues (proposed basis) mostly generated from the business sectors that have badly affected by Yolanda. Also, Tanauan foresees a sharp decrease in the internal revenue due to the shutdown of a factory that was affected by Yolanda, although this is not yet estimated in the budget. According to the municipal budget officers of the other 16 municipalities, their own proposed internal revenues, as of the beginning of April, are not yet reviewed considering the business slowdown due to Yolanda disasters

(6) Investment Amounts proposed by Recovery and Rehabilitation Plan

The investment amounts proposed in the "Recovery and Rehabilitation Plan (RRP) formulated by Tacloban City and 17 LGUs are summarized and aggregated into 5 sectors according to the respective RRP as presented in Table 3.1-6. In terms of investment amount, the social sector ranked 1st (44.7%) and the infrastructure 2nd (27.4%). These RRPs were already submitted to the Central Government. A part of the proposed investments might be approved and disbursed as previously described in Chapter 3.1 (2).

Table 3.1-6 Summary of Investment Proposed in the RRP (PHP million)

Project Target Areas		Sector					
		Social	Economy	Infrastructure	Environment	Governance	Total
Leyte	Tacloban	98.6	0.0	697.0	135.5	-	931.1
	Palo	31.7	6.3	17.2	43.7	-	98.9
	Tanauan	0.0	86.4	172.4	0.0	-	258.8
	Tolosa	117.5	47.7	80.0	6.0	-	251.2
	Dulag	52.4	55.7	243.0	31.5	-	382.6
	Mayorga	0.0	3.1	20.0	10.0	-	33.1
	Macarthur	283.0	179.7	93.6	189.2	0.8	746.3
	Javier	209.5	3.0	5.0	281.5	-	499.0
	Abuyog	80.0	22.1	0.2	130.0	5.3	237.6
	Total	872.7	404.0	1,328.4	827.4	6.1	3,438.6
Samar	Basey	1,604.2	755.0	474.0	290.5	1.2	3,124.9
	Marabut	988.6	21.5	14.0	0.6	-	1,024.7
	Total	2,592.8	776.5	488.0	291.1	1.2	4,149.6
Eastern Samar	Lawaan	144.7	25.2	318.0	23.3	1.1	512.2
	Balangiga	116.0	16.5	70.0	57.6	-	260.1
	Giporlos	753.6	309.0	15.1	141.0	-	1,218.7
	Quinapondan	85.7	-	93.2		-	178.9
	Salcedo	75.1	8.1	370.3	22.0	-	475.5
	Mercedes	8.5	-	6.0	-	-	14.5
	Guiuan	0.8	-	163.9	-	-	164.7
	Total	1,184.4	358.8	1,036.5	243.9	1.1	2,824.6
Grand Total		4,649.9	1,539.3	2,852.9	1,362.4	8.4	10,412.8
		44.7%	14.8%	27.4%	13.1%	0.1%	100.0%

Note: The figures are classified to respective sectors according to "The Recovery and Rehabilitation Plan" of each City/LGU.
Source: Recovery and Rehabilitation Plan of Each City and LGU

3.1.3 Recovery and Rehabilitation Plan

(1) Reconstruction Assistance on Yolanda (RAY)

Based on the NDRRMP formulated under R.A. No. 10121, National Economic and Development Authority (NEDA) prepared a government strategic plan, Reconstruction Assistance on Yolanda (RAY) to guide the recovery and reconstruction of the economy, lives, and livelihoods in the affected areas. The plan for recovery and reconstruction stated in RAY are summarized below.

1) Core Principle

The major core principles for implementing RAY are as follows:

- Coordination between government agencies and engagement with international donors, civil society organizations, and the private sector will be based on common recovery and reconstruction goals with standards set by government
- Implementation shall be the responsibility of the local government, supported with capacity development, to ensure that the response is tailored to local conditions and promotes community participation, ownership and sustainability
- Recovery and reconstruction proactively shall address inclusiveness and sustainable livelihoods
- Consistent with the government's existing policies on gender, recovery and reconstruction activities will incorporate gender into the design and implementation of post-disaster interventions

2) Phases for Response

The response activities are phased as follows:

- Critical immediate needs during the first six months will be focused on priority repairs to housing and the provision of temporary shelter; reactivating social services; rehabilitating water supply and sanitation systems, transport and power infrastructure; restoring livelihoods (including agriculture and fisheries) and temporary employment; and resuming national and local government services.
- More detailed planning for some short-term activities, especially for the reconstruction of public infrastructure, facilities, and utilities that integrate affordable disaster resilient design features have already started. Other activities that involve making policy and budgetary choices will need to be expeditiously made in the first phase of RAY implementation.
- Much of the recovery and reconstruction of disaster-affected areas is targeted to be advanced or completed within one to two years. However, experience from other large post-disaster situations indicates that the reconstruction process may last for up to four years, especially for programs that involve addressing long-standing development challenges.

3) Implementation

The following seven areas are emphasized for the outcome-driven implementation.

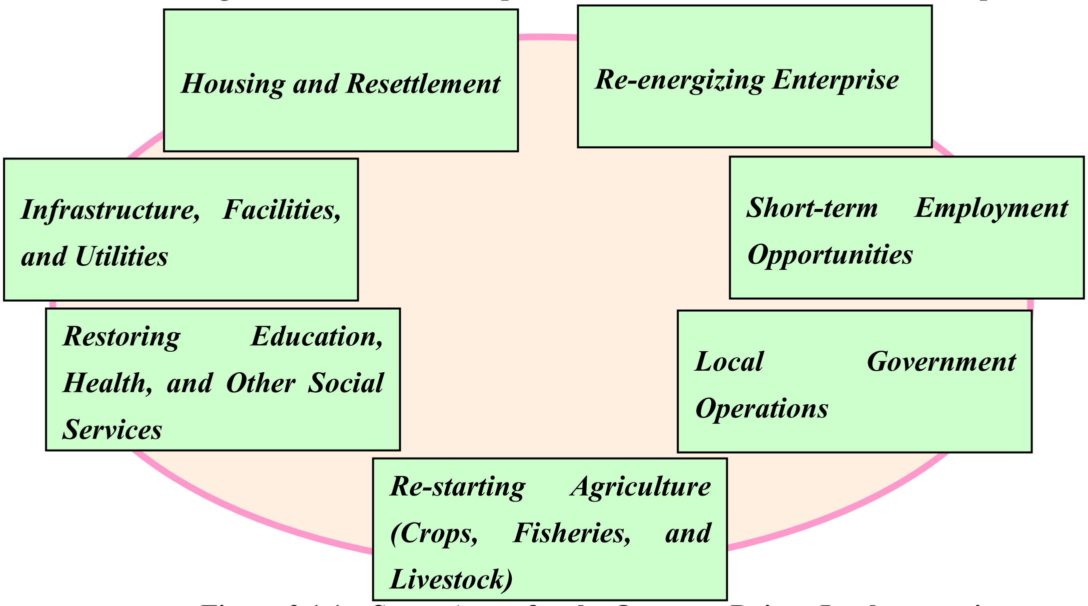


Figure 3.1.1 Seven Areas for the Outcome-Driven Implementation

4) Strengthening Disaster Risk Reduction and Management

The following are identified factors necessary for strengthening DRRM in the Philippines:

- Demarcating safe locations and hazard zones is pivotal in the recovery and reconstruction to ensure that communities, along with the economic assets and infrastructure, are rebuilt out of harm's way.
- Determining safe locations is complemented by upgrading of engineering standards and designs, particularly for critical infrastructure, such as hospitals and schools which are often used as emergency shelter.

5) Institutional Arrangements for RAY Implementation

As an oversight body, NEDA, in coordination with the Office of the PARR is responsible to undertake periodic outcome monitoring and evaluation, and report to the President and development partners on the status of RAY implementation.

(2) LGU Formulation of Rehabilitation Plan and Comprehensive Land Use Plan

Under the current decentralized administration in the Philippines, the significance of plans formulated by the LGUs that have impact on the rehabilitation and recovery in the Yolanda affected areas. All 18 LGUs in the study area have already been submitted to PARR through provincial government.

3.2 Community Response

3.2.1 Community Organizations

(1) Barangay

1) Legislative Background

Being positioned at the terminal level of local government bodies under the Local government Code (1991), the Barangay Local Government Unit (BLGU) serves as the main interface between the government and the local population. In addition to the basic functions of the BLGU, which are to provide to its constituents services such as; agricultural support, health and social welfare, hygiene and sanitation, law and order, maintenance of Barangay level infrastructure, etc., the Local Government Code also gives to the Punong Barangay (Barangay Captain), who is the elected chief executive of the BLGU, the responsibility to carry out emergency measures as may be necessary during and in the aftermath of natural disasters and calamities. The function of BLGUs in relation to disasters is further strengthened by the Republic Act No. 101211, also known as the Philippine Disaster Risk Reduction and Management Act of 2010, which dictates the compulsory establishment of a Barangay Disaster Risk Reduction and Management Committee (BDRRMC) in each BLGU, to set the direction, develop, implement and coordinate disaster risk management programs within their Barangays.

2) Structure of Barangay

A BLGU is comprised of 8 elective officials (1 Barangay Captain and 7 Sangguniang Barangay (Barangay Council) Members), together with several appointed officials. Appointed officials include the Barangay secretary and Barangay Treasurer, whose roles are indicated in the Local Government Code, and other officials that are dictated in laws and ordinances prepared by the BLGU. The later usually are comprised of Barangay Tanods (Barangay Police), Healthcare Workers, Daycare Workers and others.

The development issues of the BLGU are discussed under sectoral committees established under the BLGU in order to propose necessary measures to the Barangay Council. Such committees allocate funds for the BLGUs in several of the City / Municipalities of the Target Area for Finance, Infrastructure, Education, Peace and Order, Health, and, BDRRMCs.

In terms of territory, each BLGU is often[14] divided into 8 divisions called “Sonas” (also called Citios, Puroks). In the case of the Target Area, interviews indicate that one elective official is assigned to each Sona to look over the territory and its constituents.

(2) Identification of Community Organizations

Few community / social organizations were identified through the interview survey conducted in

[14] Out of the 15 interviewed BLGUs, one exception was seen where the Barangay was divided into 5 Sitios. The Barangay shows a characteristic of dispersed settlements in the mountain and a population of some 1,200.

the Study. In the 15 interviewed Barangays, organizations that were found present were mainly organizations for mutual benefit, such as Farmers Organizations, Fisherfolk Organization, and Women's Organizations who were working on livelihood activities. These organizations were either established under the initiatives of the Department of Agriculture (farmers / fisherfolk) or that of NGOs (women). Some of them were found to be active in their daily activities, while the rest were said to be inactive or not functioning. To the extent of the interviews conducted, there were no indications of social groups / organizations solely functioning for social welfare or other non-economic activities. The replies from interviewees were somewhat concentrated on "such activities are only done under government" or "whatever works are to be done, they should be paid." On the other hand, the sense of mutual help on an individual basis was widely observed among the interviewees. It seemed to be a common practice for local residents to share food with their neighbors, and contribute cash to those in need. Such practices were said to be common before Typhoon Yolanda, but only on an individual basis.

3.2.2 Community Activities for Recovery and Rehabilitation

(1) Barangay Level

The efforts of the BLGUs in recovery and rehabilitation from the damages of Typhoon Yolanda can be largely divided into two phases; 1) the time immediately after the Typhoon when the BLGUs struggled to support their constituents before the arrival of external support, and the 2) time after the supply of relief goods and external support became somewhat stable.

At times immediately after the Typhoon, common responses taken by all BLGUs were to first assess the situation of damage in their Barangays, and then to request the C/MLGUs for support in terms of relief goods and guidance. The timings of such responses were different among BLGUs, where in BLGUs highly damaged, it took up to some four days after the typhoon until Barangay Officials started their efforts since they themselves were also victims. In the majority of the interviewed BLGUs, most were seen to have taken their actions by the next day after the Typhoon. Assessment of damage was done mainly by Sona, where Barangay Officials walked around their responsible Sona to confirm the situation. Lists of families remaining in the area were later prepared for receiving relief material. Simultaneously, the Barangay Officials tried to contact their higher authorities (City / Municipality). However, this had to be done on foot since the roads were clogged and telephones were dysfunctional. While BLGUs located near the Poblacion managed to report to City/Municipal Offices, some of the distant BLGUs had to wait nearly three weeks until the roads were passable. However, such efforts did not immediately benefit the Barangays since the functions of the City/Municipality were also stagnated right after the Typhoon.

Another measure commonly taken by many of the BLGUs was to organize its constituents for clearing the main roads of the Barangay. Though this was difficult in Barangays with a high degree of damage because of the large size of debris clogging the road, improved access in other areas benefitted the Barangay by earlier delivery of relief material. In Palo and Tacloban, the constituents were also organized to form a vigilance group in response to the news that many inmates had escaped from the Leyte Provincial Jail during the Typhoon. Other measures such as provision of tarpaulins or other emergency goods (food, medicine) were seen in some BLGUs that had access to resources (one BLGU knew that the Department of Agriculture had available stock of tarpaulins, while another managed to hire a truck from a construction firm located in the barangay). Such measures were basically taken under the initiative of the BLGUs without prefixed protocol or guidance provided by the City /Municipalities.

Depending on access, it took from several days to weeks for relief material to reach the Barangays. However, once relief material came, the functions of the BLGUs were more concentrated in coordination for relief distribution. Alike the emergency response right after the Typhoon, there was no prefixed protocol for dealing with the external organizations, so the BLGUs responded to the instructions of individual aid organizations. Relief material by Government Organizations (i.e. DSWD) was usually handed over to the BLGUs for distribution, while International Organizations and NGOs tended to distribute their material themselves based on the list of families provided by the BLGUs. Aside from relief distribution, there are increasing works for nominating / organizing their constituents for Cash for Work activities.

(2) Resident Level

As mentioned prior, there were few if any community / social organizations consisting of locals identified in the interviewed Barangays. Voluntary activities by the community during the aftermath of Yolanda were observed to be mainly practiced in forms of individual to individual, or individuals responding to the BLGUs. Cases observed include; sharing of food, searching for missing people or belongings, clearing of debris, carrying and burying the bodies of the deceased, support to infants, elderly and the sick, and formulation of vigilance groups for patrolling their neighborhoods. Out of these, clearing of debris from roads, taking care of the bodies of the deceased, and formulation of vigilance groups were mostly done under the initiatives of the BLGU.

Nowadays, the efforts for rehabilitation by local residents tend to concentrate on Cash for Work activities done under various supporting organizations. In such situation, voluntary group activities for rehabilitation of the community were not observed during the series of interviews conducted through the Study.

3.3 Assistanace from International Organizations / Donors

3.3.1 Funding from International Organizations/ Donors

Aftermath Typhoon Yolanda, many international organizations started emergency assistance and surveys, and on November 12 the UN asked for 301 million USD for emergency assistance based on the result of surveys and assessments implemented in Tacloban city. On December 10, the UN raised 788 USD for the activities to help the most-affected victims to the end of 2014.

The Philippines government has offered FAiTH15, an online portal of information on calamity aid and assistance pledged or given by countries and intergovernmental organizations. According to FAiTH, total donation from these agencies reached 579 million USD as of April 28. The country which contributed the highest amount of funding, 122 million USD, is the United Kingdom, and Japan provided 53 million USD in total, which is equivalent to 7.4% of total funding.

The funding has been provided to DSWD, NDRRMC, DOH, CFO, LGUs and Local entities such as UN partner organizations, Philippine National Red Cross, and finally reached local people through various projects.

3.3.2 Assistance in Each Phase by International Organizations/ Donors

(1) Emergency Response in the Aftermath of Typhoon Yolanda

In response to Typhoon Yolanda, countries from all over the world immediately started emergency relief. On November 9, USAID activated a Disaster Assistance Response Team (DART) and DART conducted humanitarian assessments in Ormoc city.[16] On November 10, Japan sent a 25 member medical team to provide life-saving assistance to the Philippines.

On 11 November, the day after the declaration of a National Calamity by the President Aquino, the Government, through DOF and NEDA, requested all international and bilateral aid agencies to provide possible forms and amount to assistance for the needs of disaster recovery and rehabilitation[17]. On the same day, Canada offered 200 people to assess humanitarian needs and assist with the disaster response, and on November 12 the Government of Japan dispatched members of the Japan Self-Defense Forces (SDF) to conduct activities including medical assistance.[18] Other countries also provided assistance such as shelter kits, water purification units and communications equipment and so on. Some activities by some countries were not included in the total funding, 579 million USD stated in 3.4.1, for example, supply of relief goods by Japan and deployment of disaster relief teams by Korea.

Finally, Governments from more than 60 countries, together with multilateral organizations had

[15] Website of the Philippines Government, http://www.gov.ph/faith/full-report/
[16] Philippines-Typhoon Yolanda/Haiyan Fact Sheet #1, USAID, 2014
[17] WorldBank (2013), Supplemental Financing for the Philippines Second Development Policy Loan for Post Typhoon Recovery (DPL2), Washington DC.
[18] Website of Embassy of Japan in the Philippines, http://www.ph.emb-japan.go.jp/pressandspeech/press/pressreleases/2013/121.html

provided vital financial, material, and logistical support during this period.[19] The World Bank Group prepared a comprehensive package of recovery and reconstruction support, namely immediate technical assistance and loans, including budgetary support in total more than USD1 billion as follows:

The package consists of:

(i) just-in-time technical assistance, knowledge sharing on damage assessment and recovery and reconstruction planning;

(ii) restructuring of existing investment IBRD projects;

(iii) new IBRD operations, including delivery of an operation in final stages of preparation, the proposed quick-disbursing budget support operation, and a possible new investment or results-based operation to support medium and long-term reconstruction efforts; and
(iv) IFC support to the private sector (banks, small and medium-sized businesses, power companies, etc.).

(2) Humanitarian assistance by international organizations/ Donors

On December 27, UN issued a Strategic Response Plan with the objective to support the Government of the Philippines' response to the immediate humanitarian needs of the people affected by Typhoon Yolanda, and this complements the Government's Reconstruction Assistance for Yolanda. This plan covered the 12 months from the Typhoon Yolanda and requested $788 as stated above.

According to a financial tracking report by OCHA, total funding from these countries and private companies reached 799 million USD including pledges as of April 27.[20] Out of that, the funding from private companies was 194 million USD, so it shows that most of the funding from countries, international agencies and private companies has been utilized for humanitarian assistance.

In the Strategic Response Plan, requirements and co-lead agencies of 12 clusters were specified in Table 3.3-1. In addition, the number of partners was also shown and 14 UN organizations and 39 NGOs appealed for funding in the Plan.

Table 3.3-1 shows activities and projects of co-lead agencies for these clusters. IOM has handled 41% of the funding in the Camp Coordination and camp management (CCCM) cluster. IOM has 23 million PHP in total and most of the funding has been used in the Emergency shelter cluster. OCHA is a co-lead agency of the coordination cluster and their funding is 72% of the total funding in the cluster. UNDP has 10% of total funding in the Early recovery and livelihoods cluster and it is used mainly for cash work programs for debris removal and solid waste management. ILO is also a co-lead agency of the Early recovery and livelihoods, and has conducted a program aimed at providing emergency employment and also sustainable livelihood opportunities in Visaya area.[21]

[19] Reconstruction Assistance on Yolanda, RAY, National Economic and Development Authority, 2013
[20] Total Humanitarian Assistance per Donor, UN OCHA, 2014 April 27
[21] http://globalnation.inquirer.net/95959/ilo-more-job-creation-program-needed-in-yolanda-hit-areas

UNICEF is a co-lead agency of 3 clusters, Education, Nutrition and Water, and sanitation and Hygiene, which has managed 113 million PHP. Save the children is the co-lead agency of the Education cluster but has conducted various kinds of projects concerned with other 6 clusters. WFP is the co-lead agency of the Emergency telecommunication, Food security and agriculture and Logistics clusters. FAO is in charge of Food Security and Agriculture, and has supported farmer, fishing and coastal communities and livestock breeders. WHO and UNHCR are co-lead agencies of the Health and Protection clusters, respectively.

Table 3.3-1 Lead and Co-lead Agencies for each Cluster

Cluster	US$	Lead Agency	Co-Lead
Camp coordination and camp management (CCCM)	7,983,641	DSWD	IOM
Coordination	10,660,393	OCHA	-
Early recovery and livelihoods	117,146,708	OCD, DSWD	UNDP, ILO
Education	45,743,213	DepEd	UNICEF, Save the Children
Emergency shelter	178,442,176	DSWD	IFRC
Emergency telecommunications	3,113,854	OCD	WFP
Food security and agriculture	184,967,524	DSWD, DOA	FAO/WFP
Health	79,431,944	DoH	WHO
Logistics cluster	19,777,000	OCD	WFP
Nutrition	15,029,559	DoH	UNICEF
Protection	44,731,413	DSWD	UNHCR
Water, sanitation and hygiene (WASH)	81,007,660	DoH	UNICEF

Source: Typhoon Haiyan (Yolanda) Strategic Response Plan, OCHA

(3) Medium Term Assistance

The reconstruction process is indicated to last for up to 4 years. Although most of the funding is used for humanitarian assistance, medium-term needs from 2015 to 2017 occupy 65% of the total cost estimated as the overall resource needs for recovery and reconstruction in RAY. Medium term assistance is also important to secure the livelihood of the local people and formulate societies/ regions that are more resilient to disaster. This Study also aims at early recovery and reconstruction of the target area and the formulation of a disaster resilient nation/ society.

Asian Development Bank (ADB) has provided 23 million USD in grants, 3 million USD to provide humanitarian relief assistance and 20 million USD to rebuild and provide livelihoods as cash-for-work, as well as 500 million USD in emergency loans to help the Government of the Philippines cover immediate costs associated with rebuilding the area. In addition, ADB approved a 372.1 million USD loan to help restore basic social services and rebuild communities devastated by Typhoon Yolanda, which set the closing period at 2018.[22] Furthermore, as ADB indicated that up to 150 million USD from ongoing projects is reallocated to support conditional cash transfers, infrastructure reconstruction, and natural resource management, various kinds of projects have been planned and conducted including the view of medium-long term.

GIZ has been supporting sustainable development in the Philippines, including the area affected

22 Website of ADB, Project date sheet of the project, 46420-002

by Typhoon Yolanda, for more than 20 years on behalf of the German Government. As The Environment and Rural Development (EnRD) Program, GIZ is implementing the technical assistance for a 2-year period to December 2015. In EnRD, they support the formulation, rehabilitation and reconstruction plans of LGUs in Leyte, Samar and Antique and review comprehensive land use plans (CLUPs) and integrate disaster preparedness plans into zoning provisions.[23]

3.4 Assistance by Private Sector

As of April 27, various private companies from all over the world donated 194 million USD. Some companies have contributed to international organizations and NPOs, and other companies have supported the distribution of emergency aid.

In addition, on January 23[24] the Rehabilitation Secretary Panfilo Lacson announced that people in the damaged areas should depend on the private sector for the long-term task of rebuilding. He divided the affected areas, 171 cities and municipalities, into 24 development areas of intervention nad development, and assigned private companies as development sponsors to lead the rehabilitation through assistance in comprehensive land use plans of the municipalities and coordination wih various partners. Out of 24 areas, 18 areas were covered by development sponsors as of February 1 in Table 3.3-2. Furthermore, four priority sectors, health, education, housing and livelihood, were specified and some private companies were assigned as sector sponsors[25]. They ensure that development assistance and post-disaster intervention related to their sector will be fulfilled and properly organized.

Table 3.4-1 Private company development sponsors by area

	Province	District	Committed companies
1	Leyte	Tacloban 1	PLDT-SMART Metro Pacific Group
2	Leyte	Tacloban 2	ICTSI Group
3	Leyte	Palo	Metrobank Group
4	Leyte	Rest of 1st District	INJAP Group of Companies
5	Leyte	2nd District	EDC of the Lopez Group
6	Leyte	3rd District	
7	Leyte	Ormoc, Kananga	EDC, Aboitiz Group
8	Leyte	Rest of 4th District	Engineering Equipment Inc.(EEI)
9	Leyte	5th District	
10	Biliran	Lone District	
11	E. Samar	Guian, Salcedo	Nickel Asia Corporation
12	E. Samar	Rest of Lone District	

[23] GIZ, Factsheet: Environment and Rural Development (EnRD) Program Philippines
[24] http://www.rappler.com/business/economy-watch/48712-9-giant-firms-lead-yolanda-rehab
[25] Disaster Preparedness Initiatives and Updates on Yolanda Rehabilitation, June 26, 2014

13	Samar	2nd District	ABS-CBN Sagip Kapamilya Foundation
14	Cebu	3rd & 5th District	Vicsal Group of the Metro Gaisano Group
15	Cebu	4th District	Abotiz Foundation
16	Negros Occ.	1st, 2nd & 3rd District	Ayala Corporation
17	Aklan	Lone District	Group Telecom of the Ayala Group
18	Antique	Lone District	
19	Capiz	1st District	PLDT-SMART Metro Pacific Group
20	Capiz	2nd District	PLDT-SMART Metro Pacific Group
21	Iloilo	2nd & 3rd District	
22	Iloilo	4th District	JG Summit Holdings and Robinsons Group
23	Iloilo	5th District	Ayala Land Corporation, (Phinma Group)
24	Palawan	1st District	Secours Populaire Francais (a French NGO)

Source:

http://www.gmanetwork.com/news/story/360363/news/nation/government-not-corporations-in-charge-of-post-yolanda-rehab-oparr

Chapter 4 Topographic Map Preparation

4.1 Topographic Map Preparation

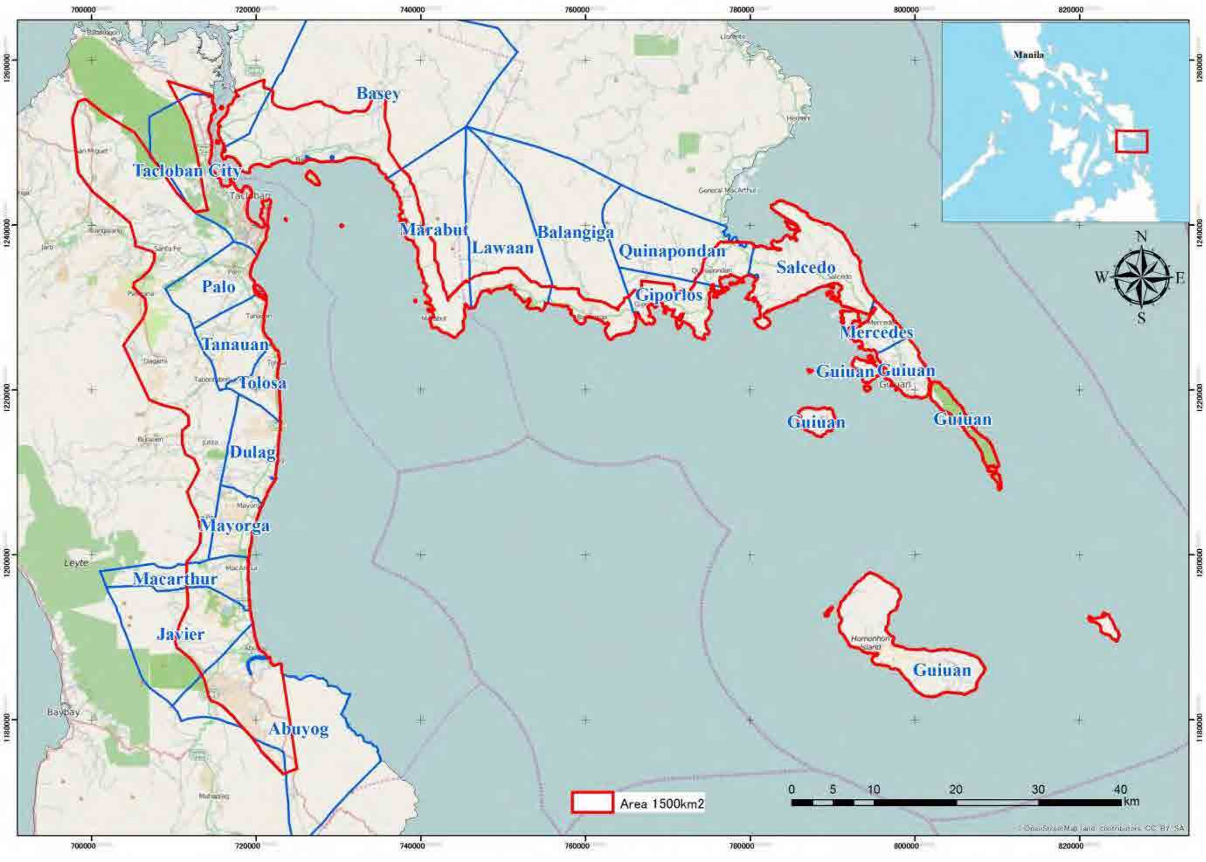
4.1.1 Procurement of satellite image

Pleiades: (c)CNES 2014, Distribution Astrium Services / SpotImage

Worldview-2: (c)DigitalGlobe

(1) Procurement area

Procurement area of satellite images was 1500 square kilometers, the same as the simplified topographic mapping area. (As shown in Figure 4.1-1.)

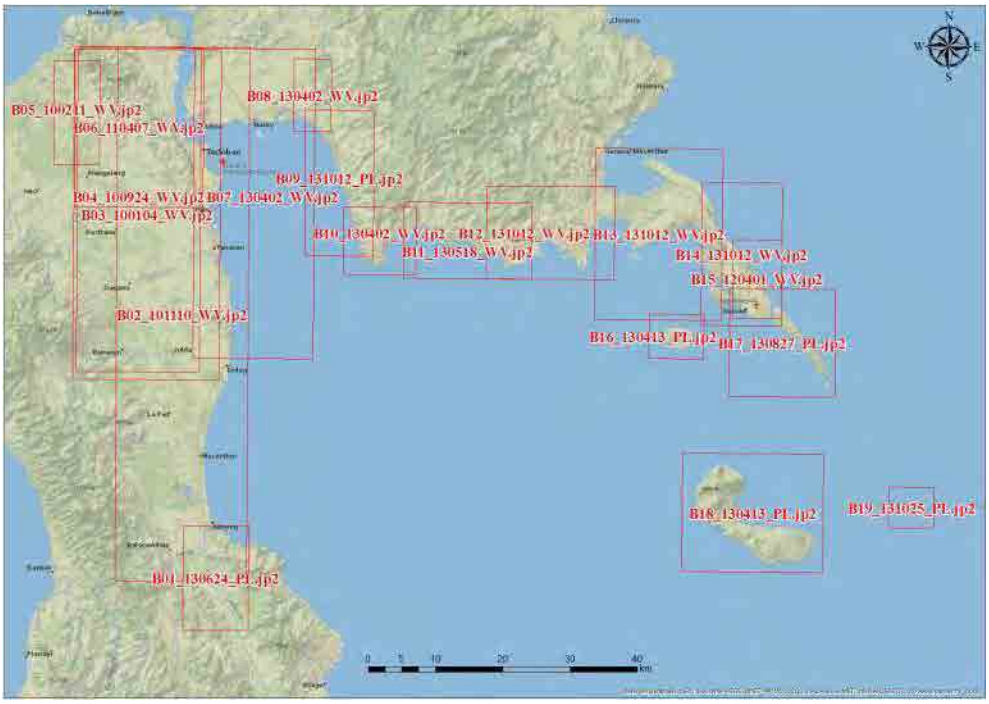


Source : © OpenStreetMap (and) contributors, CC-BY-SA, GADM, JICA Study Team

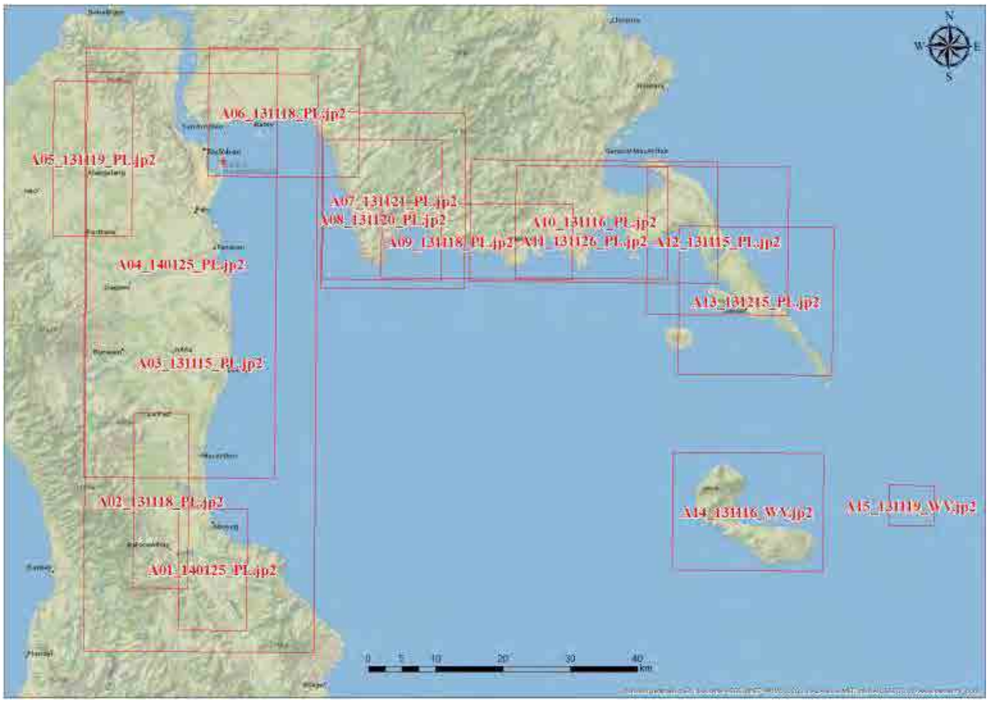
Figure 4.1-1 Procurement area of Satellite image

(2) Specifications for satellite image

Satellite image to be procured should be a high resolution image that can be used for creating 1/5000 simplyfied topographic maps. Therefore, its ground resolution was less than 1m. In this study, The JICA Study Team procured the satellite imagery of Pleiades and Worldview-2. Pleiades satellite imagery has 0.7m ground resolution, and Worldview-2 imagery has 0.5m ground resolution. Further, in order to carry out the interpretation of the damage caused by the disaster, satellite image to be procured had to be for 2 periods. One was before typhoon Yolanda, and the other was after typhoon Yolanda.



"Before Yolanda" (2010-Feb ~ 2013-Oct)



"After Yolanda" (2013-Nov-15 ~ 2014-Jan-25)

Source : National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp, JICA Study Team

Figure 4.1-2 Index of Satellite Image Data

Figure 4.1-2 is showing the location and number of procured Satellite Image Scenes.

The number of procured Satellite Image Scenes are the following Table 4.1-1. “Before Yolanda” is procured 19 scenes “Pleiades : 6 Scenes” and “Worldview-2 : 13 scenes”. “After Yolanda” is procured 15 scenes “Pleiades : 13 Scenes” and “Worldview-2 : 2 scenes”.

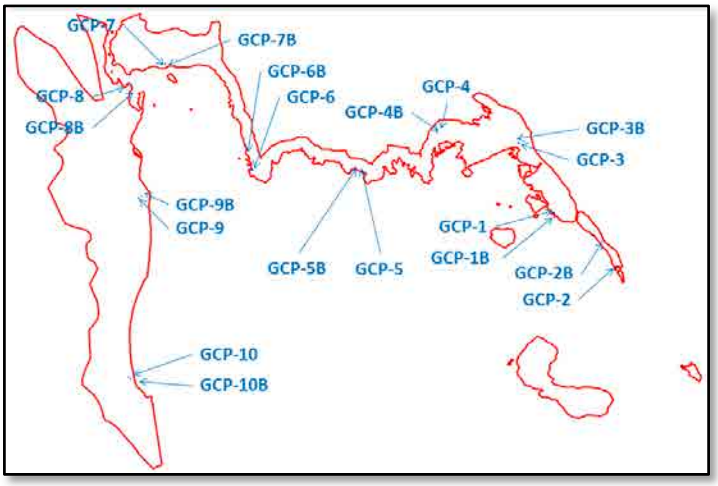
Table 4.1-1 Satellite Image Scene List

No.	Before Yolanda			After Yolanda		
	file name	source	date	file name	source	date
1	B01_130624_PL.jp2	Pleiades	2013/6/24	A01_140125_PL.jp2	Pleiades	2014/1/25
2	B02_101110_WV.jp2	Worldview-2	2010/11/10	A02_131118_PL.jp2	Pleiades	2013/11/18
3	B03_100104_WV.jp2	Worldview-2	2010/1/4	A03_131115_PL.jp2	Pleiades	2013/11/15
4	B04_100924_WV.jp2	Worldview-2	2010/9/24	A04_140125_PL.jp2	Pleiades	2014/1/25
5	B05_100211_WV.jp2	Worldview-2	2010/2/11	A05_131119_PL.jp2	Pleiades	2013/11/19
6	B06_110407_WV.jp2	Worldview-2	2011/4/7	A06_131118_PL.jp2	Pleiades	2013/11/18
7	B07_130402_WV.jp2	Worldview-2	2013/4/2	A07_131121_PL.jp2	Pleiades	2013/11/21
8	B08_130402_WV.jp2	Worldview-2	2013/4/2	A08_131120_PL.jp2	Pleiades	2013/11/20
9	B09_131012_PL.jp2	Pleiades	2013/10/12	A09_131118_PL.jp2	Pleiades	2013/11/18
10	B10_130402_WV.jp2	Worldview-2	2013/4/2	A10_131116_PL.jp2	Pleiades	2013/11/16
11	B11_130518_WV.jp2	Worldview-2	2013/5/18	A11_131126_PL.jp2	Pleiades	2013/11/26
12	B12_131012_WV.jp2	Worldview-2	2013/10/12	A12_131115_PL.jp2	Pleiades	2013/11/15
13	B13_131012_WV.jp2	Worldview-2	2013/10/12	A13_131215_PL.jp2	Pleiades	2013/12/15
14	B14_131012_WV.jp2	Worldview-2	2013/10/12	A14_131116_WV.jp2	Worldview-2	2013/11/16
15	B15_120401_WV.jp2	Worldview-2	2012/4/1	A15_131119_WV.jp2	Worldview-2	2013/11/19
16	B16_130413_PL.jp2	Pleiades	2013/4/13			
17	B17_130827_PL.jp2	Pleiades	2013/8/27			
18	B18_130413_PL.jp2	Pleiades	2013/4/13			
19	B19_131025_PL.jp2	Pleiades	2013/10/25			

Source : JICA Study Team

(3) GCP measurement

In order to orient the satellite imagery, 20 GCPs (Ground Control Points) were established on the field. The GCP which JICA team established are located as Figure 4.1-3.



Source : JICA study team

Figure 4.1-3 Distribution of GCP for Satellite image

After establishment of the GCP, these points were observed by GNSS (Global Navigation Satellite System) survey. After that, the coordinates of the GCP were calculated.

Source : JICA study team

Figure 4.1-4 GCP establishment (Left), GCP survey (Right) "GCP 3B"

Table 4.1-2 is the information in terms of GCP which JICA team has used to orient the satellite imagery. The elevation standard is related by the Benchmark elevation of NAMRIA (National Mapping and Resource Information Authority).

Table 4.1-2 Coordinate list of GCP for satellite image

Coordinate System

Name: UTM
Datum: WGS 1984
Zone: 51 North (123E)
Geoid: EGM2008 1X1MIN

Point List

ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)
ICP1	797478.430	1220831.478	1.388
ICP1B	797623.971	1220716.396	0.849
ICP2	809046.164	1210370.732	1.298
ICP2B	806483.642	1215518.216	8.633
ICP3	791046.061	1233627.127	0.505
ICP-3B	790950.279	1233808.172	1.910
ICP4	776041.131	1235941.287	2.112
ICP-4B	775933.950	1235748.646	2.819
ICP5	760919.856	1229019.514	1.351
ICP5-B	760779.724	1229113.094	1.847
ICP6	741684.704	1228822.525	0.589
ICP6B	741727.325	1228692.419	1.159
ICP7	725596.532	1248396.720	0.340
ICP7B	725878.894	1247724.436	1.242
ICP8	719314.409	1244367.776	0.538
ICP8B	718710.329	1244441.824	2.523
ICP9	720601.964	1223448.793	3.053
ICP9B	721082.768	1223849.525	2.470
ICP10	718703.525	1190342.238	1.592
ICB-10B	719140.397	1189965.317	2.055

Source : JICA Study Team

(4) Creation of ortho image

The satellite imagery was converted into an ortho image by using the GCP coordinates(as shown in Table 4.1-2). The ortho image can be used for base data for the simplified topographic mapping. In addition, the ortho photo image data was shared in JICA study team in order to be used as the initial base map for the first stage of our study. Figure 4.1-5 is the one of sample map which is based on the ortho photo imagery after Yolanda with the boundary of Balangay and the main road. This sample map (Figure 4.1-5) could be confirmed the location of the disaster area.

Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe, GADM, JICA Study Team

Figure 4.1-5 Sample map of Ortho Image in the Study

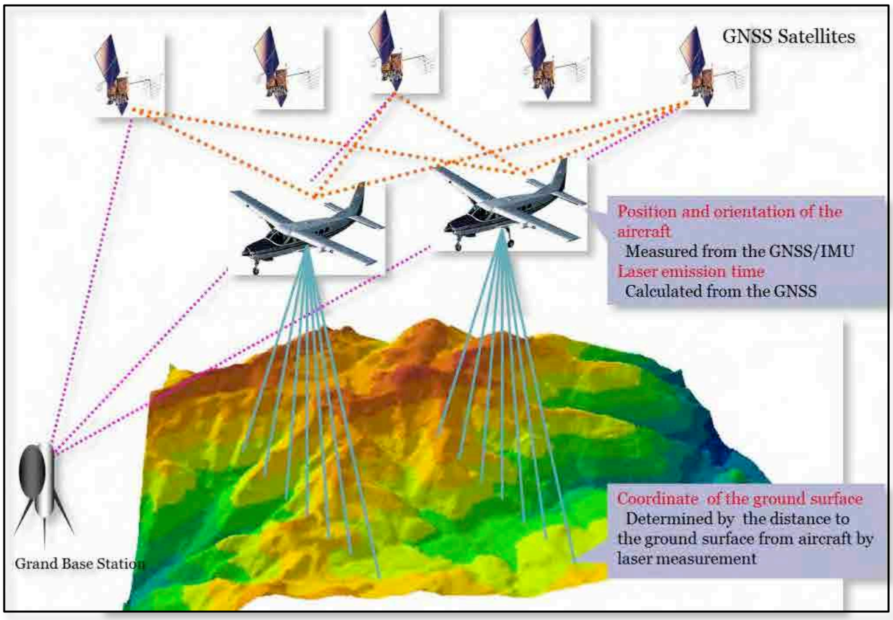
4.1.2 LiDAR measurement

(1) Measurement area

The target area was 1500 square kilometers, and the area is similar to the simplified topographic mapping area. (As shown in Figure 4.1-1.)

What is LiDAR?

LiDAR (Light Detection And Ranging) is a remote sensing technology that measures distance by illuminating a target ground with a laser and analyzing the reflected light (Figure 4.1-6). As shown in the figure. LiDAR is popularly used as a technology to make high-resolution maps with contour line.



Source : JICA Study Team

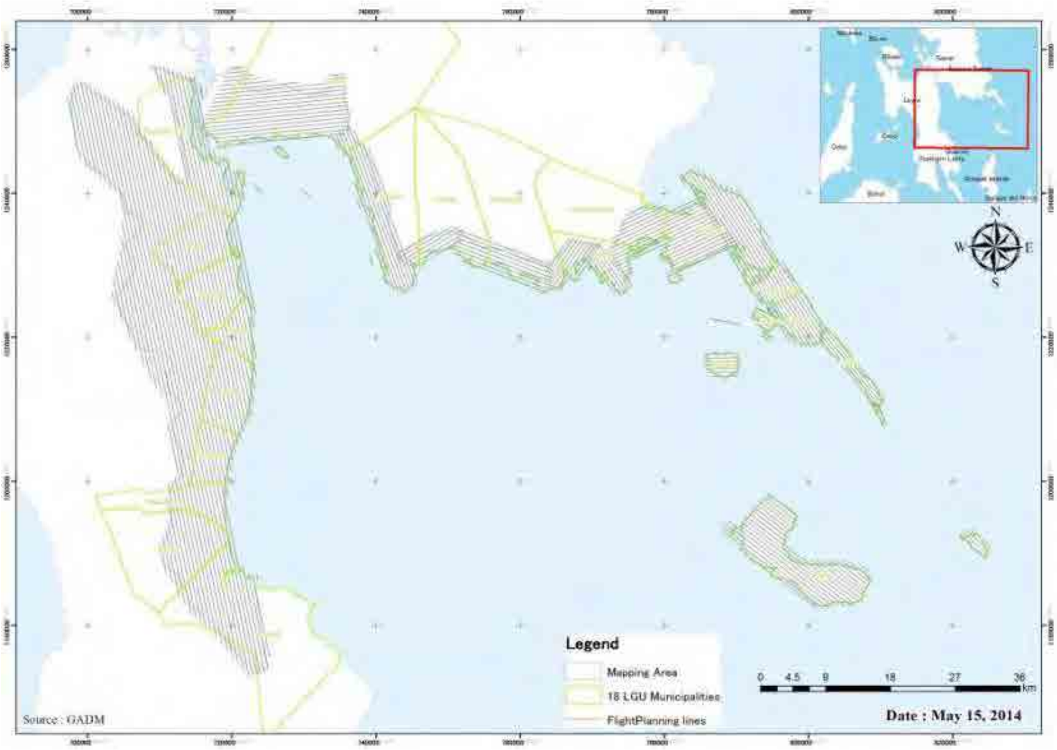
Figure 4.1-6 Conceptual diagram of LiDAR measurement

(2) Specifications for LiDAR measurement

The outcome of the LiDAR measurement is 1m mesh point data and 1m interval contour line data. In order to create them, the density of the point cloud should be less than 1m.

(3) Flight plan for LiDAR measurement

For conducting LiDAR measurement efficiently and to meet measurement specifications, The JICA Study Team made a Flight plan for LiDAR measurement as Figure 4.1-7. The aircraft which is attached the LiDAR sensor flew on the "Flight planning lines" to measure.

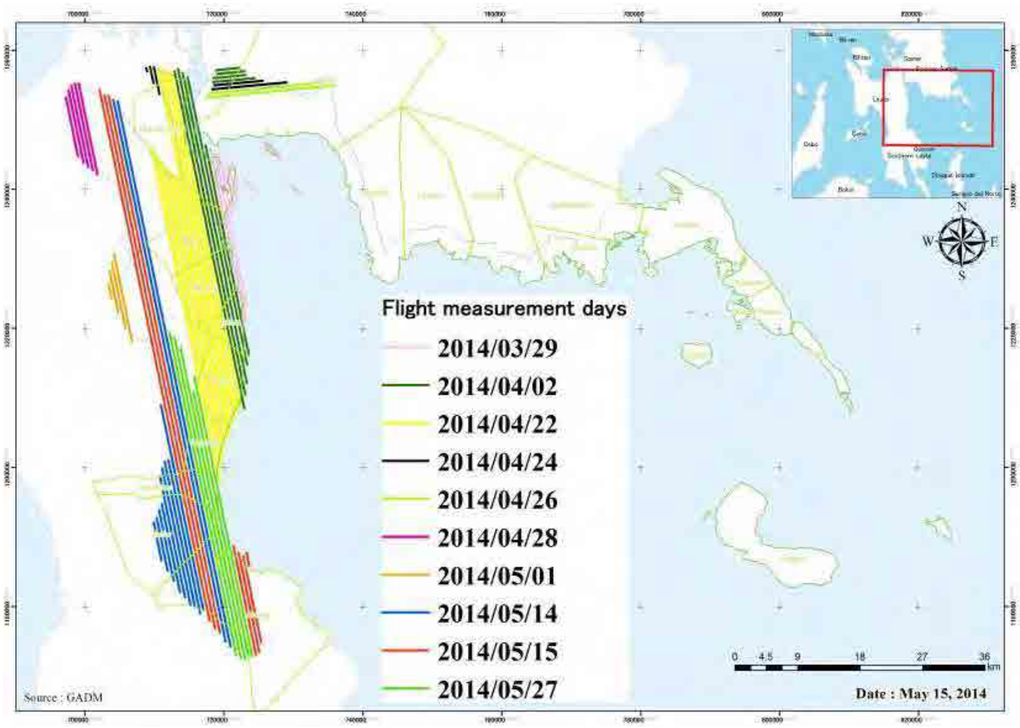


Source : GADM, JICA Study Team

Figure 4.1-7 Flight Plan for LiDAR measurement

(4) LiDAR Measurement

From March 27, The JICA Study Team started the stand by for LiDAR measurement in Cebu international airport. This measurement was originally scheduled to finish by the end of April. However, the measurement did not progress as planned because of bad weather. Therefore, The JICA Study Team had to extend the measurement period to the beginning of June, and in the negotiation with JICA on June 3, The JICA Study Team decided to interrupt the measurement standby. At the end, measurement progress was 51% of the original plan. The measurement flight days has been spent for 10 days around Leyte (As shown in Figure 4.1-8).

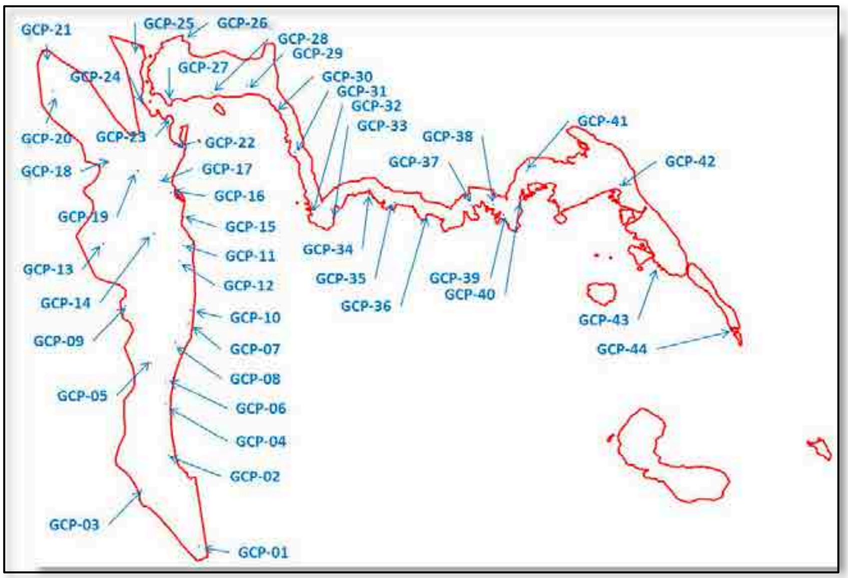


Source : GADM, JICA Study Team

Figure 4.1-8 Final result of LiDAR measurement

(5) Survey for adjustment points

The 44 GCPs were established as adjustment reference points in order to calculate the LiDAR data to adjust it to the actual terrain. The coordinates of the adjustment reference points were measured by GNSS and a leveling survey. The 44 GCPs are located as Figure 4.1-9.



Source : JICA Study Team

Figure 4.1-9 Distribution of GCP for LiDAR

Utilization surveying equipment as of Figure 4.1-10 had implemented GNSS and Leveling survey. The elevation standard is related by the mean sea level of the tide station (Tacloban and Guiuan).

Source : JICA Study Team

Figure 4.1-10 Scene of GNSS survey (Left), Scene of Leveling survey (Right)

Table 4.1-3 is the coordinate list in terms of the 44 GCPs which JICA team has used to calculate the LiDAR data to adjust it to the actual terrain. The elevation standard is related by the mean sea level of the tide station (Tacloban and Guiuan).

Table 4.1-3 Coordinate list of GCP for LiDAR

ID	Easting (Meter)	Northing (Meter)	Elevation (Meter)
GCP-01	723515.060	1175760.622	16.317
GCP-02	718703.422	1190342.262	1.491
GCP-03	714256.461	1184733.683	9.348
GCP-04	718194.797	1198536.879	2.204
GCP-05	715893.834	1205102.937	9.29
GCP-06	718199.226	1202018.852	2.697
GCP-07	721827.842	1211400.843	2.941
GCP-08	719799.384	1208291.232	2.869
GCP-09	711695.061	1214295.53	27.98
GCP-10	722208.09	1213574.622	3.286
GCP-11	721082.715	1223849.547	2.82
GCP-12	720375.929	1221403.024	2.576
GCP-13	708207.468	1224190.251	23.516
GCP-14	716219.946	1226320.853	7.274
GCP-15	720834.027	1228605.145	2.074
GCP-16	719038.151	1232321.251	1.211
GCP-17	717385.131	1234395.21	5.094
GCP-18	709050.151	1237196.113	17.881
GCP-19	713751.45	1235867.052	9.172
GCP-20	700050.144	1248716.184	12.355
GCP-21	699217.575	1253845.031	4.416
GCP-22	719572.524	1240067.556	1.929
GCP-23	719314.423	1244367.772	1.045
GCP-24	714791.31	1246507.586	1.141
GCP-25	713319.524	1254877.553	3.281
GCP-26	720845.493	1257450.14	3.575
GCP-27	719082.764	1247352.953	6.777
GCP-28	725596.538	1248396.742	0.094
GCP-29	731296.465	1249550.331	0.192
GCP-30	735954.498	1245677.888	3.544
GCP-31	738982.657	1238754.767	1.771
GCP-32	741684.706	1228822.541	0.33
GCP-33	745009.523	1228350.976	2.205
GCP-34	751109.293	1232150.506	0.324
GCP-35	754939.843	1230843.675	2.114
GCP-36	760919.855	1229019.524	1.088
GCP-37	767138.476	1230358.451	1.552
GCP-38	770723.704	1230498.042	1.575
GCP-39	772338.371	1228824.593	16.985
GCP-40	774955.48	1231443.176	-0.156
GCP-41	776041.123	1235941.275	3.183
GCP-42	791046.07	1233627.135	0.841
GCP-43	797478.432	1220831.493	1.987
GCP-44	809046.164	1210370.731	1.299

Source : JICA Study Team

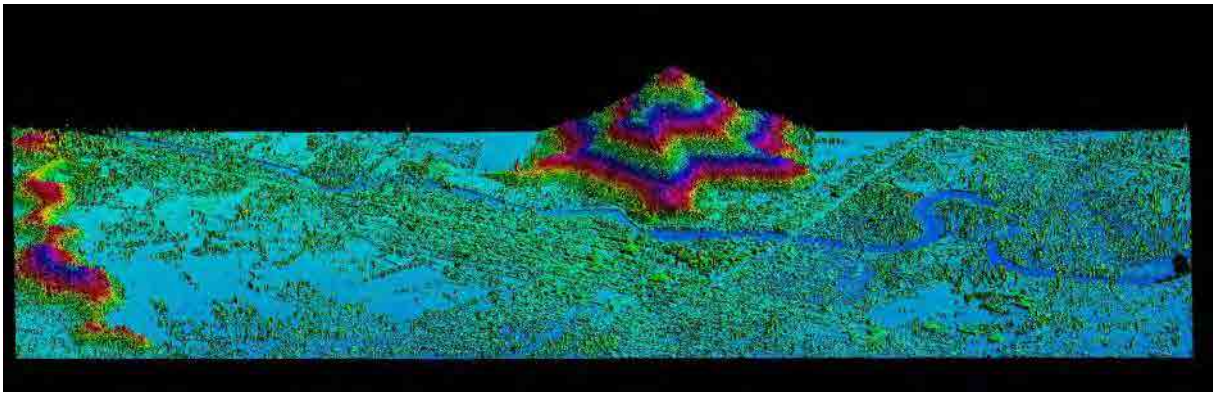
(6) Adjustment between courses

After confirming the differences in the LiDAR data between courses, The JICA Study Team conducted adjustment calculations using the adjustment reference points. By this adjustment, the differences in the LiDAR data between courses were resolved.

(7) Filtering

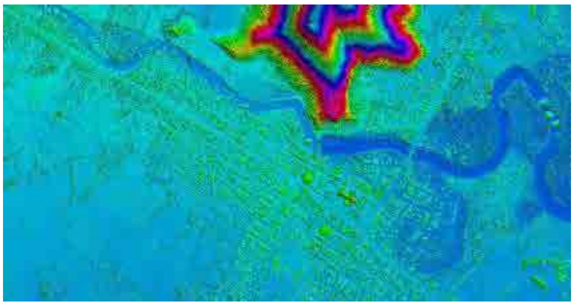
In order to remove the buildings, trees, and so on that were included in the point cloud data of the LiDAR data after the adjustment calculations, The JICA Study Team conducted a "Filtering" process using filtering software. After filtering, The JICA Study Team acquired the ground point cloud data.

Figure 4.1-11 is shown in DSM (Digital Surface Model) which is included buildings and trees elevation data, so it has to be processing to remove the included buildings and trees elevation data. Figure 4.1-12 can see the Digital Terrain Model (DTM) between before processing (left image) and after processing (right image).

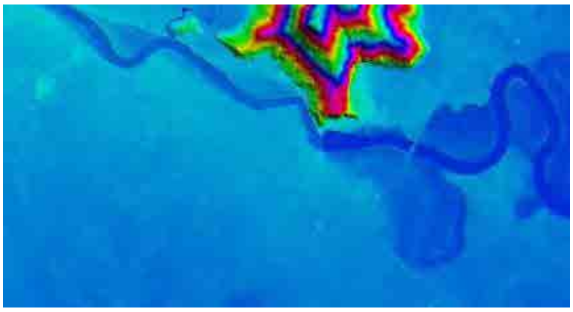


Source : JICA Study Team

Figure 4.1-11 3D representation of the point cloud in Palo



Before Filtering



After Filtering

Source : JICA Study Team

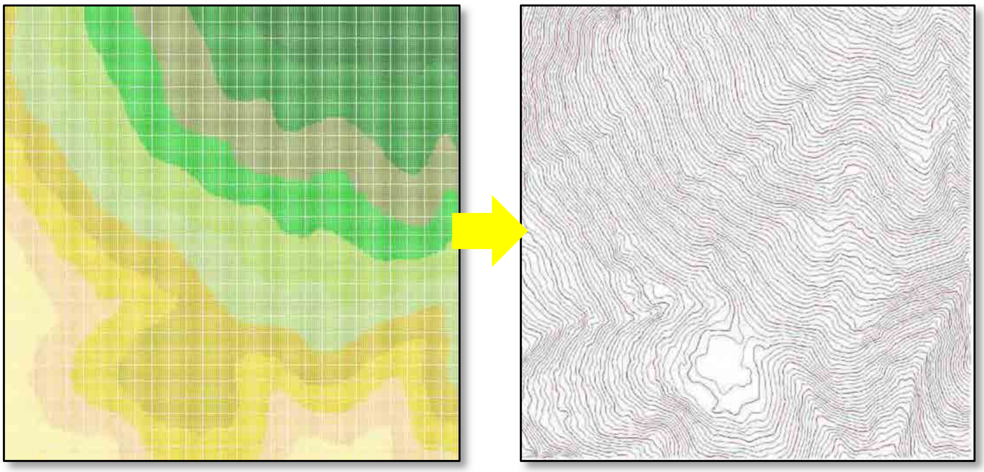
Figure 4.1-12 Sample image of Filtering in Palo

(8) Creation of mesh data

The 1m mesh data of the ground surface was created using point cloud data after filtering. In addition, the 10m and 30m mesh data were also created for the various analyses by the study team.

(9) Creation of contour data

The contour line data was created from the mesh data of the ground surface. The contour line data was edited for use as part of the simplified topographic map data (As shown in Figure 4.1-13).



Mesh Point Data

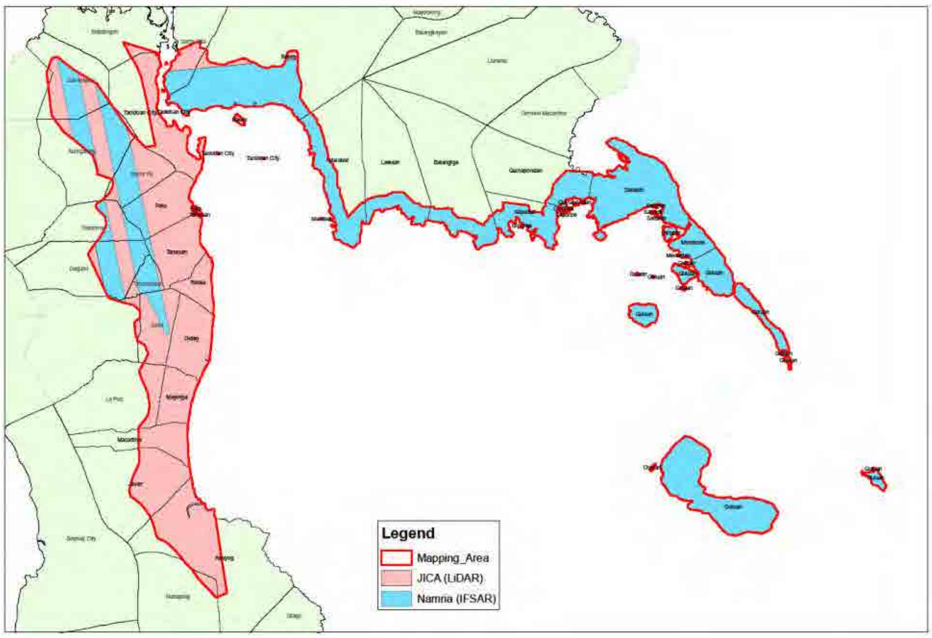
Contour Line Data

Source : JICA Study Team

Figure 4.1-13 Sample image of contour creation

(10) Collection of existing data

For the target area that could not be measured in this study, The JICA Study Team investigated the existing terrain data. The JICA Study Team had a procedure for borrowing “LiDAR data from the University of the Philippines (UP)” and “IFSAR data owned by The National Mapping and Resource Information Authority (NAMRIA)”. The JICA Study Team acquired the data then. The JICA Study Team decided to create terrain data of the whole target area by merging the measurement results of this study and the existing data “NAMRIA IFSAR”. However, the data from NAMRIA’s IFSAR was 5m mesh, therefore The JICA Study Team could not create terrain data which has equal accuracy over the entire the target area. The JICA Study Team did not utilize UP LiDAR data. Because JICA study team LiDAR data is covered UP LiDAR data in Leyte. And a part of UP LiDAR data is insufficient for data processing in Samar. So JICA study team utilized our LiDAR and NAMRIA’s IFSAR to create contour line . The each area which The JICA Study Team used is shown in Figure 4.1-14.

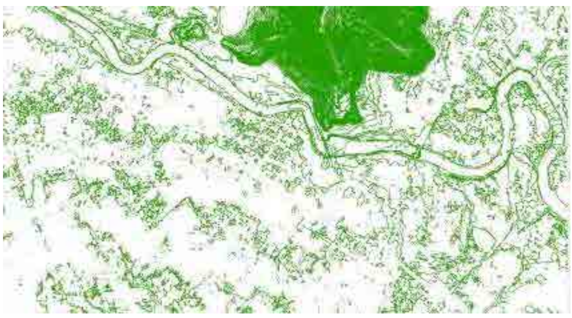


Source : NAMRIA, JICA Study Team

Figure 4.1-14 Data source index

(11) Products

JICA Study Team created the contour line to utilize the simplified topographic map from our LiDAR measurement data and NAMRIA IFSAR (As shown in Figure 4.1-15 Sample area : Palo in Leyte).



Contour Line

Merge Contour Line and topographic map

Source : JICA Study Team

Figure 4.1-15 Products

4.1.3 Simple topographic mapping

(1) Mapping area

The target area of simple topographic mapping was from Tacloban to Abyog on Leyte island and from Basey to Guiuan on Samar island. The target area was chosen from the 18 Municipalities that were our target in this study. It was mainly chosen in areas where the altitudes were less than 10m. Our target area was 1500 square kilometers. (As shown in Figure 4.1-1.)

(2) Specifications for mapping

The specifications for simplified topographic map were as follows. This map was prepared in accordance with “The guideline for simple mapping” (JICA : 2008).

Table 4.1-4 Mapping Specifications

ITEM	CONTENT	REMARK
Map Scale	1:5,000	
Accuracy (standard deviation)	Horizontal : within **3.5m**	
	Vertical (Elevation point) : **0.33m**	LiDAR area * JICA Study Team
	Vertical (Contour line) : **0.5m**	
	Vertical (Elevation point) : **3.33m**	IFSAR area * NAMRIA
	Vertical (Contour line) : **5.0m**	
Cordinate system	WGS 1984 UTM Zone 51N	
Unit	Meter	
Size of a sheet	1’30” * 1’30”	Longitude and latitude
Number of sheets	363 Sheets	

Source : JICA Study Team

(3) Map digitalization

In this simplified topographic map, the acquisition items were as Table 4.1-5. The items acquired from the satellite image were "Map-digitalized" using CAD software on computers. The map digitalization image is as shown in Figure 4.1-16.

Table 4.1-5 Acquisition items list

CLASSIFICATION	NAME	DATA TYPE	REMARK
Administrative boundary	Provincial Boundary	Line	From Existing data
	City or Municipal Boundary	Line	
Road	Divided Highway /Expressway	Line	From Satellite image
	Road	Line	
	Trail	Line	
Road infrastructure	median strip	Line	
	Bridge	Line	
Building	Building	Polygon	
	Small Building	Point	
Water	Water (River, Lake, Sea Shoreline)	Line	
	Narrow River	Line	
Boundary of Vegetation	Vegetation boundary	Line	
Contour	Index Contour	Line	From LiDAR or IFSAR
	Intermediate Contor	Line	
Annotation	Administrative Areas Landmark Features	Text	From Filed compilation and Existing map

Source : JICA Study Team

Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe ,
JICA Study Team

Figure 4.1-16 Sample of map digitizing

(4) Field compilation

In order to check the local information of the feature from the satellite image interpretation, and to get the name of the feature, The JICA Study Team conducted a field survey (As shown in Figure 4.1-17). In the field survey, the positions and name of most schools, churches, barangays halls, etc., were confirmed. After the field survey, the position and name was allocated on the map data.

Source : JICA Study Team

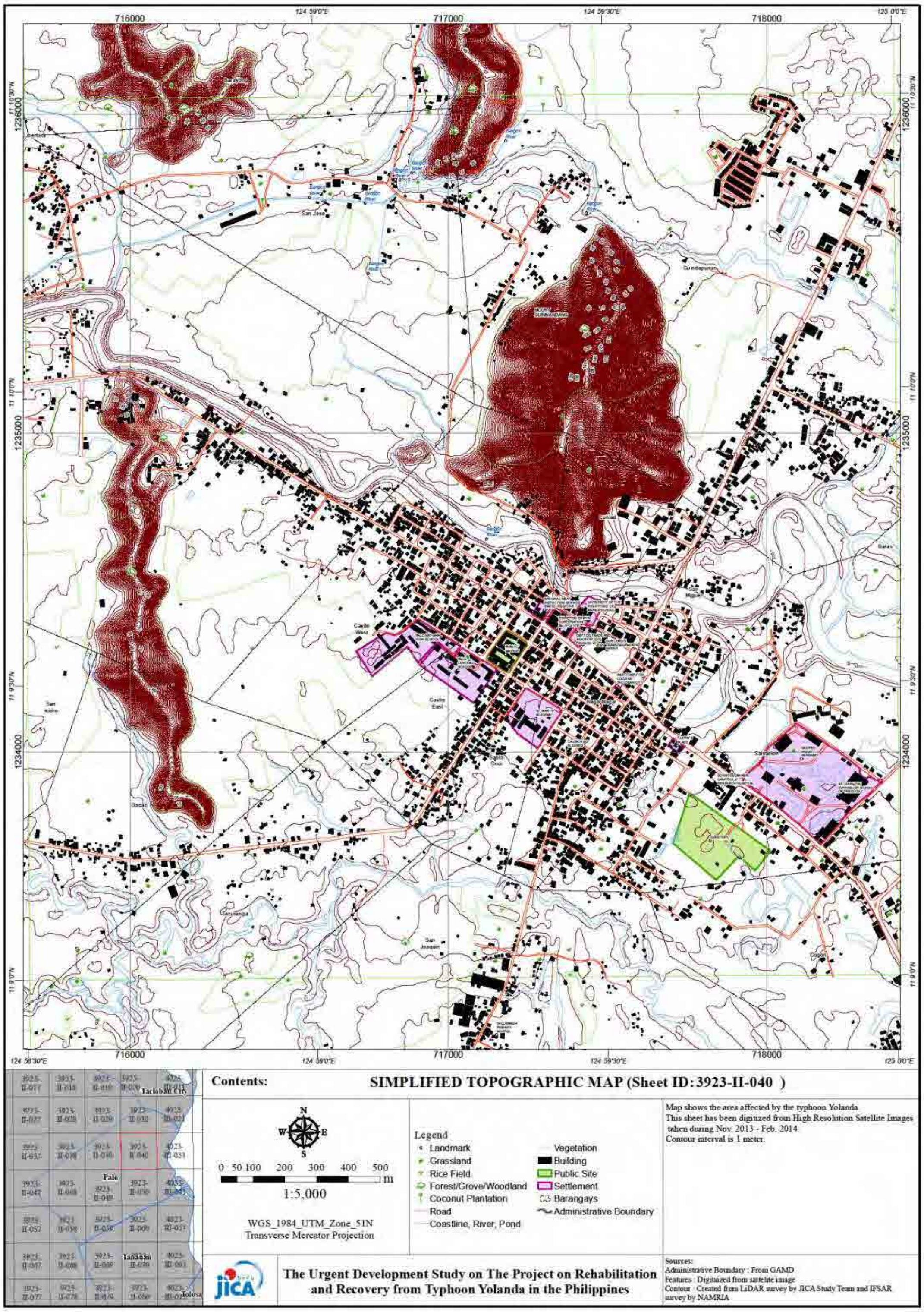
Figure 4.1-17 Scenes of field compilation

(5) Digital compilation

The feature data acquired from satellite ortho images, the contour data from LiDAR survey, and the annotation data from the field survey were edited to integrate them into the topographic map data. By this process, our simple topographic mapping data has been completed.

(6) Data creation for plotting

The simplified topographic mapping data was symbolized using GIS software. After that the PDF data for output maps was created for each map. The following Figure 4.1-18 is the one of map sheet “Sheet_3923-II-040” in Palo.



Source : JICA Study Team

Figure 4.1-18 Sample of output map

The following Figure 4.1-19 is included the index in all of JICA project area. The each in index is shown the number of 1/5000 simplified topographic map sheet.

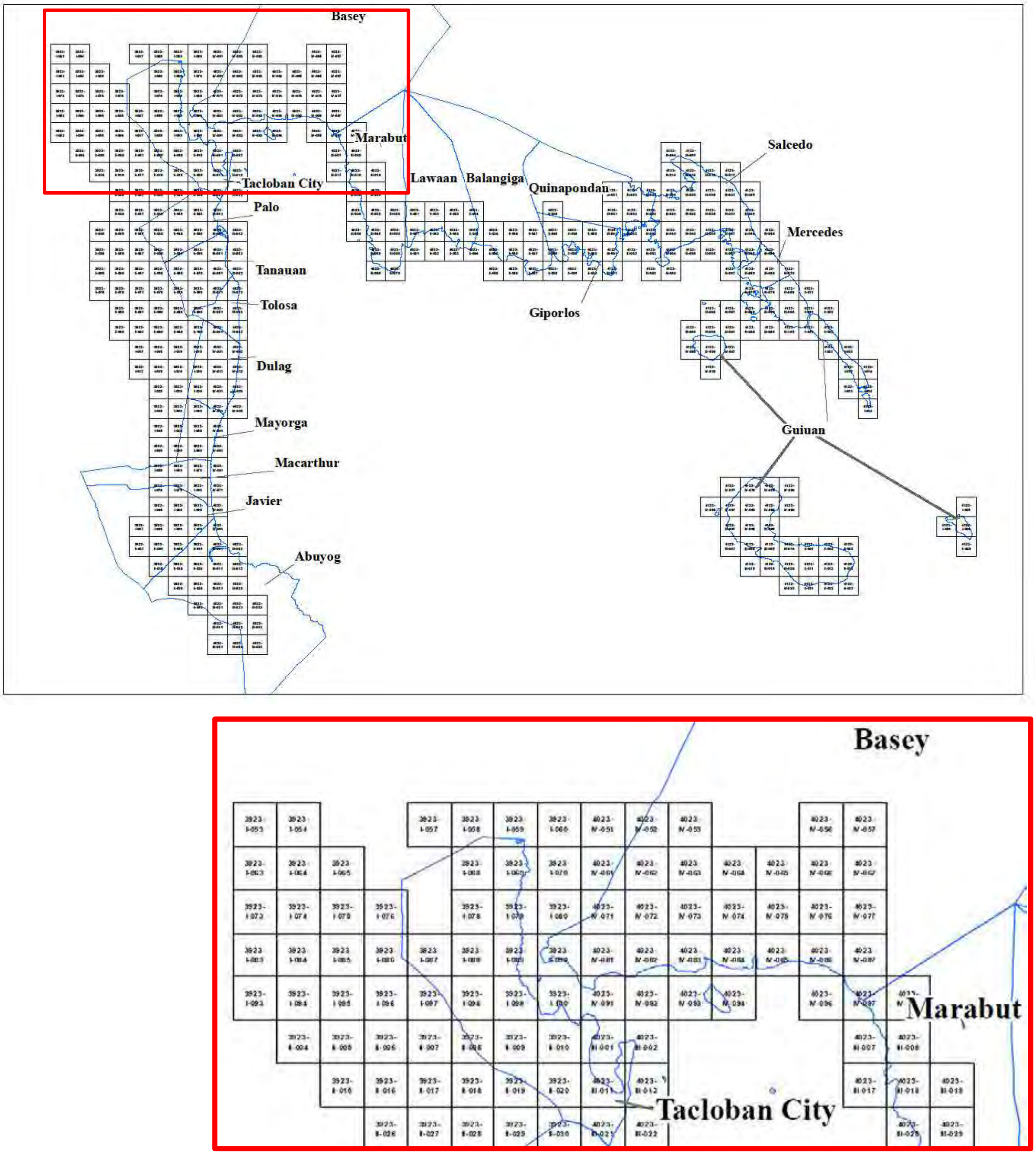


Figure 4.1-19 Index of 1/5000 Simplified Topographic Map

The each municipalities have classified map sheets as the following Table 4.1-6.

Table 4.1-6 1/5000 Simplified Topographic Map Sheets List

Leyte & Other

No.	TACLOBAN	PALO	TANAUAN	TOLOSA	DULAG	MAYORGA	MACARTHUR	JAVIER	ABUYOG	Other	
1	3923-I-058	3923-II-030	3923-II-050	3923-II-090	3923-II-090	3922-I-030	3922-I-070	3922-II-019	4022-III-001	4023-IV-051	3923-II-065
2	3923-I-059	3923-II-040	3923-II-060	3923-II-100	3923-II-100	3922-I-040	3922-I-080	3922-II-018	4022-III-011	4022-III-051	3923-II-078
3	3923-I-068	3923-II-050	3923-II-070	4022-IV-002	3922-I-010	3922-I-050	3922-I-090	3922-II-008	4022-III-021	3923-I-093	3923-II-077
4	3923-I-069	3923-II-060	3923-II-080	4023-III-062	3922-I-020	3922-I-060	3922-I-079	3922-II-007	4022-III-031	3923-I-094	3923-II-076
5	3923-I-076	3923-II-029	3923-II-090	4023-III-071	3922-I-030	3922-I-070	3922-I-078	3922-II-009	4022-III-041	3923-I-095	3923-II-075
6	3923-I-078	3923-II-039	3923-II-059	4023-III-072	3922-I-040	3922-I-069	3922-I-069	3922-II-010	4022-III-002	3923-I-096	3923-II-088
7	3923-I-079	3923-II-038	3923-II-058	4023-III-081	3922-I-029	3922-I-059	3922-I-068	3922-I-080	4022-III-052	3923-I-083	3923-II-087
8	3923-I-086	3923-II-049	3923-II-069	4023-III-082	4022-IV-001	3922-I-049	4022-IV-061	3922-I-090	4022-III-042	3923-I-084	3923-II-086
9	3923-I-087	3923-II-048	3923-II-068	4023-III-092	4022-IV-011	3922-I-039	4022-IV-071	3922-I-100	4022-III-043	3923-I-085	3923-II-099
10	3923-I-088	3923-II-047	3923-II-079	4023-III-091	4022-IV-021	3922-I-029	4022-IV-081	3922-I-099	4022-III-053	3923-I-073	3923-II-098
11	3923-I-089	3923-II-059	3923-II-089		4022-IV-031	4022-IV-031		3922-I-098	4022-III-032	3923-I-074	3923-II-097
12	3923-I-097	3923-II-058	4023-III-041		4022-IV-002	4022-IV-041		3922-I-097	4022-III-022	3923-I-075	3923-II-096
13	3923-I-098	3923-II-057	4023-III-042		4022-IV-012	4022-IV-051		3922-I-089	4022-III-012	3923-I-063	3922-I-009
14	3923-I-099	3923-II-068	4023-III-051		4022-IV-022	4022-IV-061		3922-I-088	3922-II-040	3923-I-064	3922-I-008
15	3923-I-100	4023-III-021	4023-III-052		4022-IV-032			3922-I-079	3922-II-030	3923-I-054	3922-I-058
16	4023-IV-091	4023-III-031	4023-III-061		4023-III-092			3922-I-078	3922-II-020	3923-I-065	3922-I-048
17	3923-II-008	4023-III-041	4023-III-062		4023-III-091			4022-IV-091	3922-II-029	3923-I-070	3922-I-038
18	3923-II-009		4023-III-071					4022-IV-081	3922-II-019	3923-I-060	3922-I-028
19	3923-II-010		4023-III-072						3922-II-018	3923-I-057	3922-I-019
20	4023-III-001		4023-III-081						3922-II-009	3923-II-007	3922-I-018
21	4023-III-002								3922-II-010	3923-II-006	4023-IV-096
22	3923-II-018								3922-I-100	3923-II-005	3923-I-053
23	3923-II-019								4022-III-033	3923-II-004	3923-II-045
24	3923-II-020								4022-IV-091	3923-II-017	3923-II-055
25	4023-III-011									3923-II-016	3922-I-007
26	4023-III-012									3923-II-015	3922-I-017
27	3923-II-030									3923-II-028	4023-II-052
28	4023-III-021									3923-II-027	4123-III-052
29	4023-III-022									3923-II-026	4123-III-056
30										3923-II-037	
31										3923-II-036	
32										3923-II-046	
33										3923-II-056	
34										3923-II-067	
35										3923-II-066	

Samar

No.	BASEY	MARABUT
1	4023-IV-091	4023-IV-097
2	4023-IV-092	4023-IV-098
3	4023-IV-097	4023-III-007
4	4023-IV-098	4023-III-008
5	4023-IV-081	4023-III-017
6	4023-IV-082	4023-III-018
7	4023-IV-083	4023-III-019
8	4023-IV-084	4023-III-028
9	4023-IV-085	4023-III-029
10	4023-IV-086	4023-III-038
11	4023-IV-087	4023-III-039
12	4023-IV-071	4023-III-049
13	4023-IV-072	4023-III-050
14	4023-IV-073	4023-III-059
15	4023-IV-074	4023-III-060
16	4023-IV-075	4023-III-070
17	4023-IV-076	4023-III-069
18	4023-IV-077	4023-II-051
19	4023-IV-061	4023-II-041
20	4023-IV-062	4023-II-031
21	4023-IV-063	4023-III-040
22	4023-IV-064	
23	4023-IV-065	
24	4023-IV-066	
25	4023-IV-067	
26	4023-IV-057	
27	4023-IV-056	
28	4023-IV-052	
29	3923-I-100	
30	3923-I-090	
31	3923-I-080	
32	4023-IV-053	
33		
34		
35		
36		
37		
38		
39		
40		

Eastern Samar

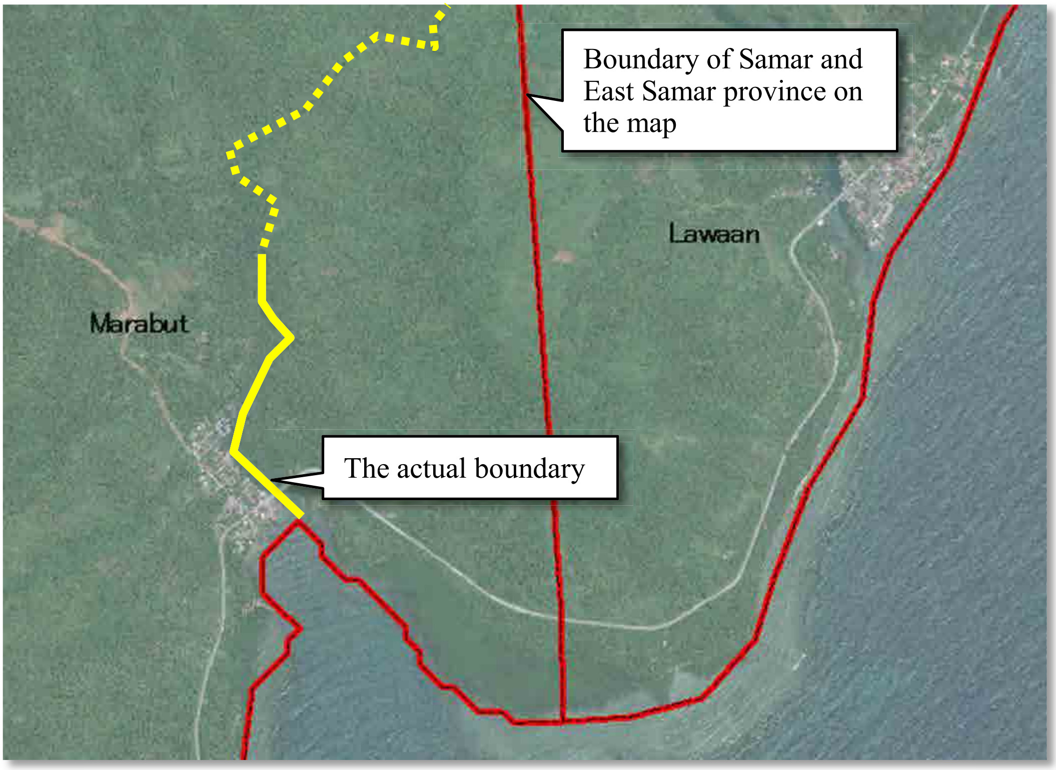
No.	LAWAAN	BALANGIGA	GIPORLOS	QUINAPONDAN	SALCEDO	MERCEDES	GUIUAN	
1	4023-II-051	4023-II-054	4023-II-058	4023-II-050	4123-III-053	4123-III-058	4123-III-070	4122-IV-098
2	4023-II-053	4023-II-055	4023-II-059	4123-III-041	4123-III-054	4123-III-059	4123-III-069	4122-IV-097
3	4023-II-054	4023-II-065	4023-II-060	4123-III-042	4123-III-055	4123-III-070	4123-III-078	4122-IV-086
4	4023-II-041	4023-II-056	4023-II-070	4123-III-043	4123-III-057	4123-III-069	4123-III-079	4122-IV-087
5	4023-II-042	4023-II-057	4023-II-069	4123-III-031	4123-III-058	4123-III-068	4123-III-080	4122-IV-088
6	4023-II-043	4023-II-058	4023-II-068	4123-III-032	4123-III-059	4123-III-067	4123-III-090	4122-IV-089
7	4023-II-044	4023-II-068	4023-II-047	4123-III-033	4123-III-063	4123-III-078	4123-III-089	4122-IV-090
8	4023-II-031	4023-II-066	4023-II-048	4123-III-021	4123-III-064	4123-III-079	4123-III-088	4122-IV-077
9	4023-II-032	4023-II-067	4023-II-049	4123-III-022	4123-III-043		4123-III-098	4122-IV-078
10	4023-II-033	4023-II-044	4023-II-050	4123-III-023	4123-III-044		4123-III-087	4122-IV-079
11	4023-II-034	4023-II-045	4123-III-051	4023-II-038	4123-III-045		4123-III-097	4122-IV-080
12		4023-II-046	4123-III-061		4123-III-046		4123-III-086	4122-III-007
13		4023-II-047	4123-III-041		4123-III-047		4123-III-096	4122-III-008
14		4023-II-048	4023-II-038		4123-III-048		4123-III-095	4122-III-018
15		4023-II-034			4123-III-049		4122-IV-005	4122-III-009
16					4123-III-033		4122-IV-006	4122-III-010
17					4123-III-034		4122-IV-016	4122-III-020
18					4123-III-035		4122-IV-007	4122-III-019
19					4123-III-036		4123-III-099	4122-I-002
20					4123-III-037		4123-III-100	4122-I-003
21					4123-III-038		4123-II-081	4122-I-013
22					4123-III-023		4123-II-071	4122-I-014
23					4123-III-024		4123-II-091	4122-I-023
24					4123-III-025		4123-II-092	4122-I-024
25					4123-III-026		4123-II-082	4122-I-034
26					4123-III-027		4122-I-098	
27					4123-III-028		4122-I-089	
28					4123-III-014		4122-I-099	
29					4123-III-015		4122-II-009	
30					4123-III-016		4122-II-001	
31					4123-III-017		4122-II-002	
32					4123-III-004		4122-II-003	
33					4123-III-005		4122-II-013	
34							4122-II-012	
35							4122-II-011	
36							4122-III-030	
37							4122-II-021	
38							4122-II-022	
39							4122-II-023	
40							4122-IV-099	

(7) Problems

In the map data created in this study, there are some problems that remain as follows.

- Accuracy of Administrative boundaries

For this mapping, The JICA Study Team acquired the administrative boundaries data from GADM. In the map, The JICA Study Team use the administrative boundaries data as they are. Since the boundary data is related to the political problems, the data cannot be modified easily. But the accuracy of the boundary data from GADM was not confirmed. There are some differences between the data and the actual boundary.



Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe, GADM, JICA Study Team

Figure 4.1-20 Problem regarding Administrative boundaries

- Accuracy degradation due to cloud cover

In the satellite image The JICA Study Team procured, there are some areas covered by clouds. In these areas, the features cannot be shown clearly. Therefore, the accuracy of the map-digitalized data is lower than in the cloudless areas. The features were acquired from another period (before Yolanda) in this case. For this reason, there are some problems in that the time of acquiring the features differed.

Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe

Figure 4.1-21 Problem of Accuracy degradation due to cloud cover

- Misinterpretation of the post-disaster tents

After Yolanda, there were many tents erected in the disaster area. In the satellite image, tents look like permanent buildings in some cases. For this reason, there is a possibility that there are some problems of misinterpretation regarding the tents.

Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe, JICA Study Team

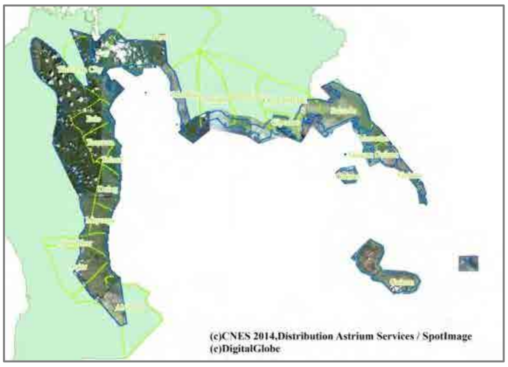
Figure 4.1-22 Problem of Misinterpretation of the tents

4.2 Damage Interpretation

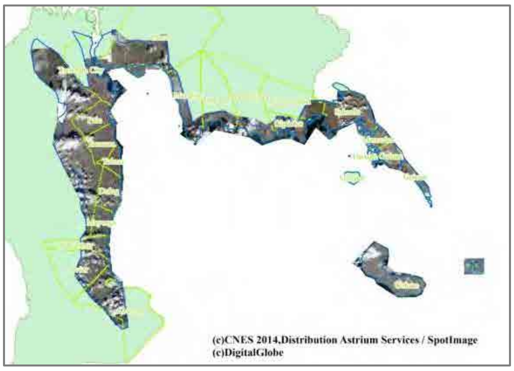
4.2.1 Satellite images

(1) Satellite images utilized:

Pleiades : (c)CNES 2014, Distribution Astrium Services / SpotImage
Worldview-2 : (c)DigitalGlobe



Map 1: Satellite Image Data before Yolanda 2010-Feb ~ 2013-Oct



Map 2: Satellite Image Data after Yolanda 2013-Nov-15 ~ 2014-Jan-25

Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe, GADM, JICA Study Team

Figure 4.2-1 Satellite Images used for Damage Interpretation

(2) Criterion for Damaged Building Interpretation

The team obtained all of the building data from the satellite images before typhoon Yolanda and conducted satellite image interpretation to classify the damaged buildings under four categories (Table 4.2-1).

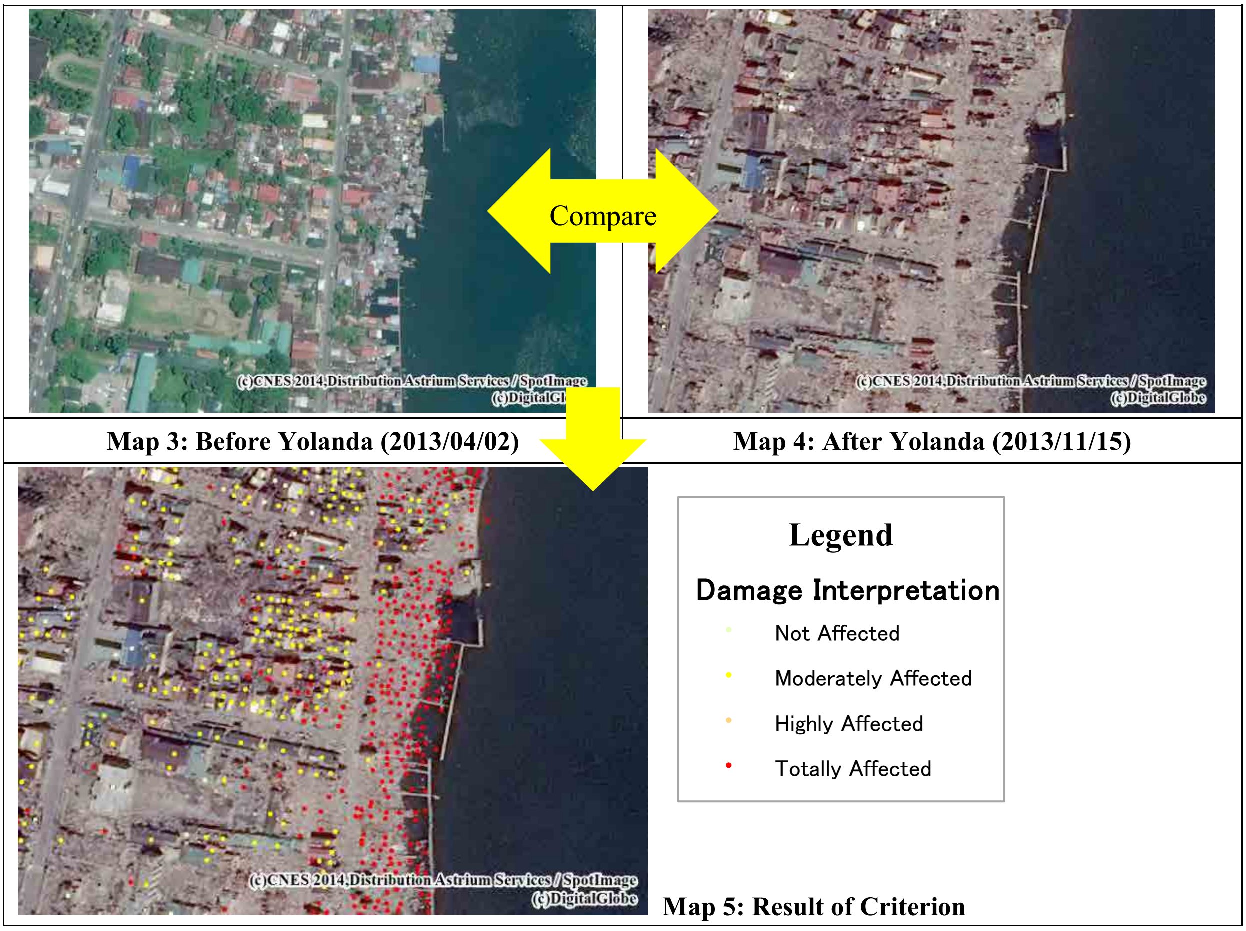
The results of the interpretation were used to calculate the percentage of damaged buildings by 300m or 100m mesh to create a map. In the case of the center of a big city like Tacloban City or Palo, it uses the 100m mesh to calculate.

The buildings which were established after Yolanda are not included in the satellite image interpretation.

Table 4.2-1 Criterion for Damage Interpretation

1	Not Affected
2	Moderately Affected (Roof is damaged)
3	Highly Affected (Roof is gone “No roof”)
4	Totally Affected

Source : JICA Study Team



Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe, JICA Study Team

Figure 4.2-2 Process of Satellite image interpretation

(3) Criterion for Damaged Coconut Palm Interpretation

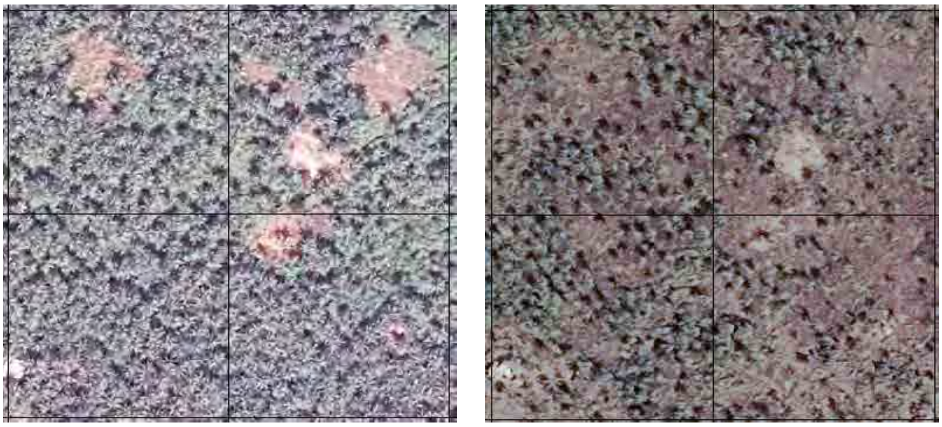
The team conducted the satellite image interpretation for the fallen coconut trees to create the fallen coconut tree distribution map. The subsequent chapter shows "The situation of damaged coconuts trees" regarding the fallen coconut tree distribution map. The criteria for interpretation of coconuts trees are shown in Table 4.2-2.

Table 4.2-2 Criterion for Damage Interpretation

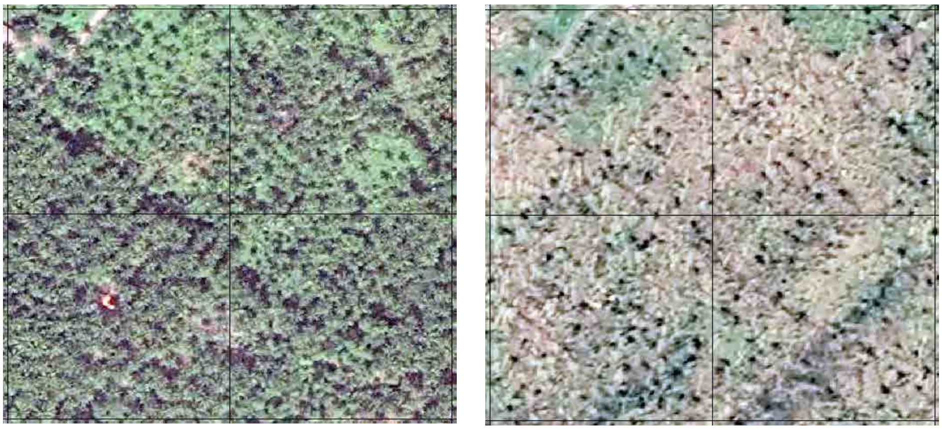
1	Slight of Coconut Trees Lost
2	Moderate of Coconut Trees Lost
3	Severe of Coconut Trees Lost

Source : JICA Study Team

Map 6: Sligh of Coconut Trees Lost



Map 7: Moderate of Coconut Trees Lost



Map 8: Severe of Coconut Trees Lost

Source : (c)CNES 2014,Distribution Astrium Services / SpotImage , (c)DigitalGlobe

Figure 4.2-3 Sample Image for Criterion for Coconut Damage Interpretation

4.2.2 Damage Interpretation

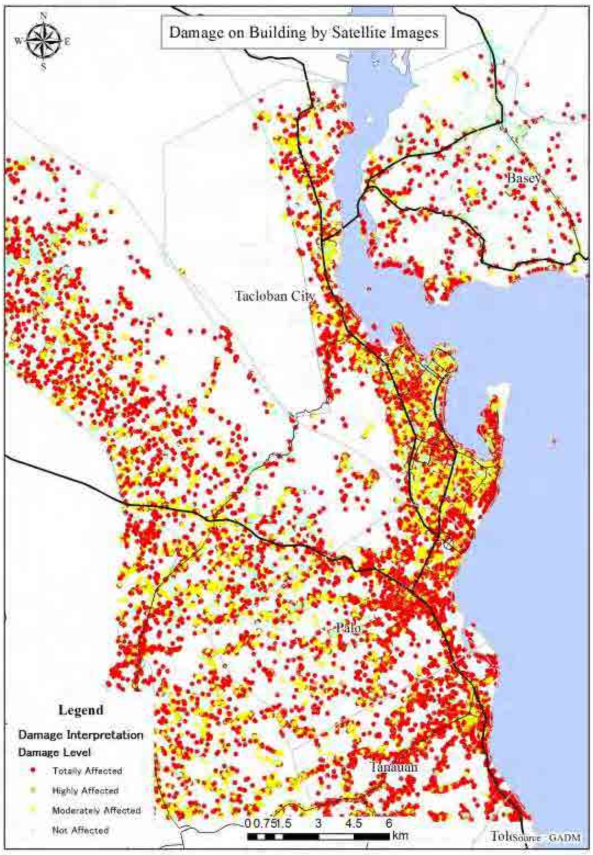
(1) Process for Damaged Coconut Tree Interpretation

Interpretation of coconut tree damage has three steps;

- make 100m data mesh,
- select the mesh of the Coconut Tree Field on the satellite image, and
- identify the damage with satellite images before and after Yolanda.

1) Preliminary Results regarding Buildings and Houses

The interpretation calculated the percentage of “Totally Damaged Buildings” and “Partially Damaged Buildings” by a 300m or 100m mesh to create the map. In the case of the center of a big city like Tacloban City or Palo, it uses the 100m mesh to calculate.



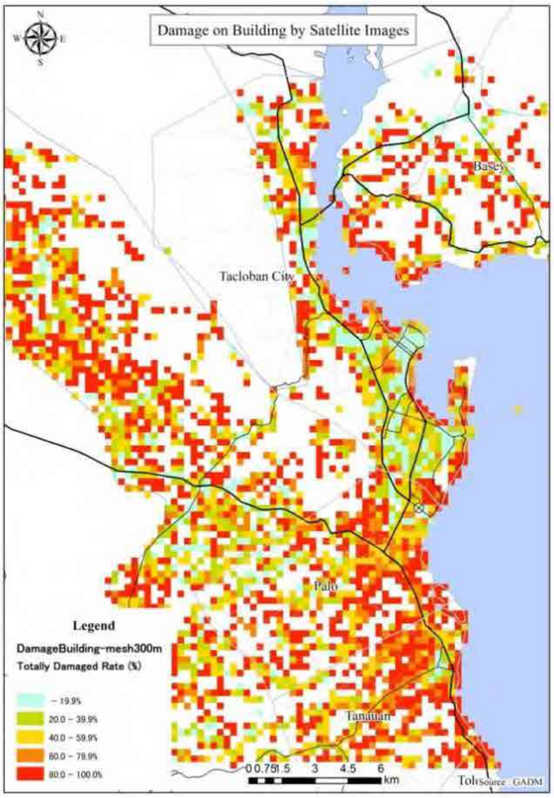
Source : GADM, JICA Study Team

Figure 4.2-4 Damaged Building Points Data for Tacloban and Palo Areas

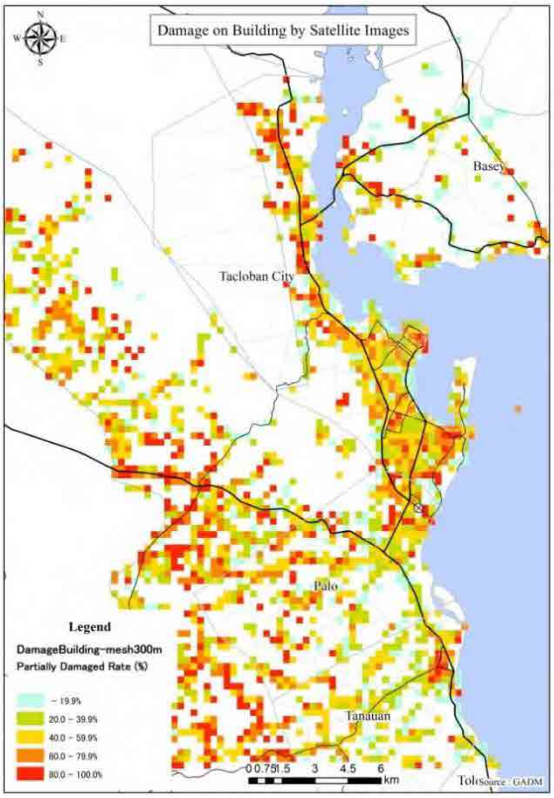
The points data does not present a clear picture of the damaged classification.

Create 300m or 100m mesh to calculate the percentage of “Totally Damaged Buildings” and “Partially Damaged Buildings”.

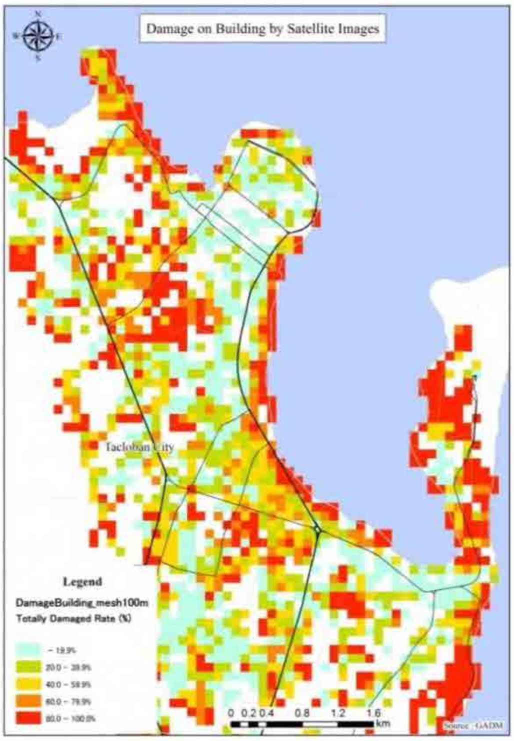
Create the mesh to calculate from the points data.



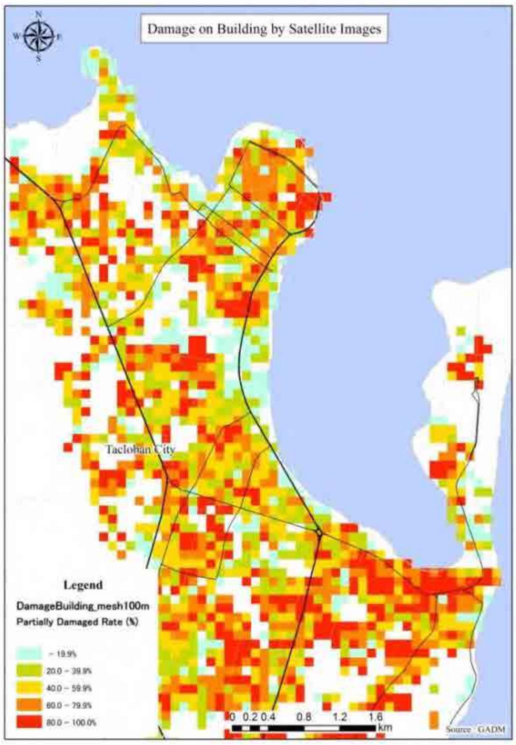
Map 9: Totally Affected (300m mesh)



Map 10: Partially Affected (300m mesh)



Map 11: Totally Affected (100m mesh)

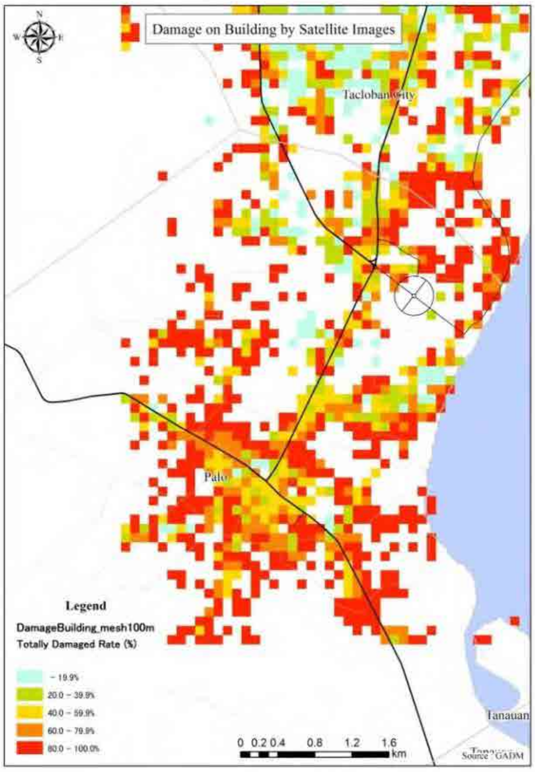


Map 12: Partially Affected (100m mesh)

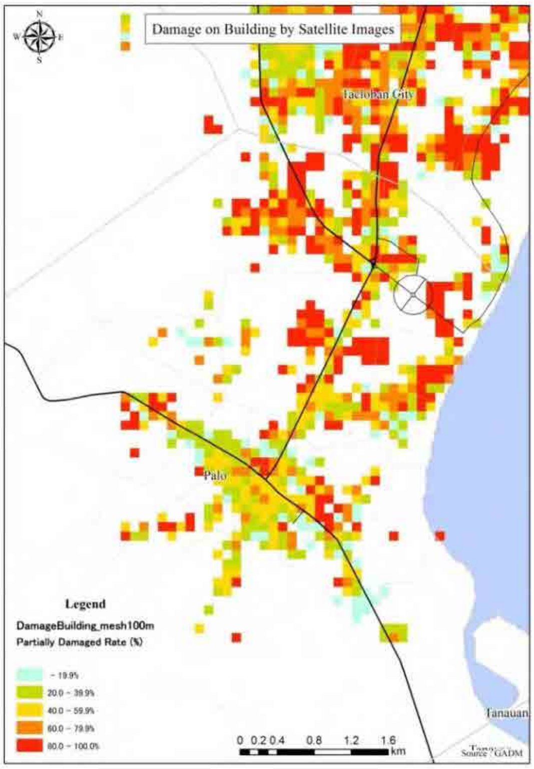
Tacloban City

Source : GADM, JICA Study Team

Figure 4.2-5 Preliminary Presentation of Damaged Building Distribution (300 m mesh) for Tacloban and Palo Areas



Map 13: Totally Affected (100m mesh)



Map 14: Partially Affected (100m mesh)

Palo

Source: JICA Study Team

Figure 4.2-6 Preliminary Presentation of Damaged Building Distribution (100 m mesh) for Tacloban and Palo Areas

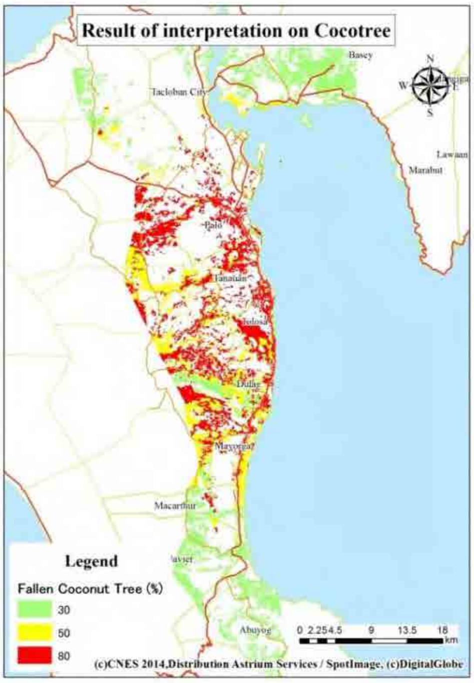
The higher percentage of “Totally affected” areas is spread over the coastline and the valley field area. The coastline was the area most affected by the storm surge; the strong wind went through the valley field area. The reason for the high percentage of "Totally Affected" is expected to be the following.

- The coastline was affected by storm surge
- The valley area was damaged by strong wind.

The results of the interpretation show that the majority of “Partially Affected” buildings are located in the center of Tacloban City. This area doesn’t have many "Totally affected" buildings because rigid edge buildings are clustered close together.

2) Preliminary Results of Coconut tree damage Interpretation

The image below is a sample of coconut damage interpretation. Each cell is categorized into 30%, 50% and 80% damage to the coconut trees.

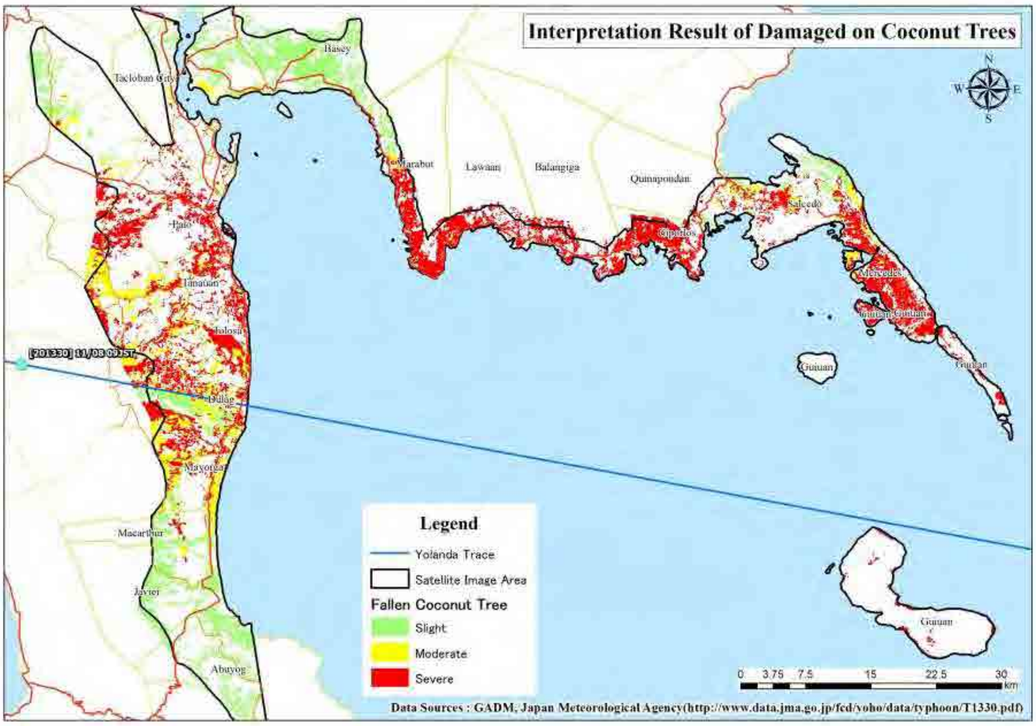


Map 15: Satellite images showing damage to coconut trees

Source : JICA Study Team

Figure 4.2-7 Results of Coconut tree Damage Interpretation

Figure 4.2-8 shows the preliminary interpretation of coconut damage in the study Area. The heavily affected areas are concentrated in Palo, Tanauna in Leyte, and Marabut and Lawaan in Eastern Samar.



Source: JICA Study Team

Figure 4.2-8 Preliminary Presentation of Damaged Coconut Distribution

Tabel 4.2-3 shows the calculation results which JICA study team executed the damage interpretation interms of Buildings and Coconut trees. The JICA Study Team counted buildings from the satellite image data by manual, so the number of buildings is proximally. Regarding the number of coconut trees, The JICA Study Team have counted as the assuming that it is 100 trees per 1 mesh.

Table 4.2-3 Damage interpretation result of Building

Province	Municipalitiy	Basic Information		Victims				Mapping Area (km2)		Interpretation on Damaged Building					
		Area (km2)	Population	Dead	Injuryed	Missing	Total			Total Buildings	No Damaged	Partial Damaged		Totally Damaged	
Leyte	Tacloban City	118.5	221,174	2,394		594	2,988	66.1	55.8%	47,013	8,363	22,954	48.8%	15,696	33.4%
	Palo	65.3	62,727	1,089	5,887	292	7,268	65.3	100.0%	14,024	481	6,188	44.1%	7,355	52.4%
	Tanauan	62.8	50,119	1,252		754	2,006	62.8	100.0%	8,603	92	3,676	42.7%	4,835	56.2%
	Tolosa	28.2	17,921	32			32	28.2	100.0%	4,484	13	1,597	35.6%	2,874	64.1%
	Dulag	63.6	41,757	26	1,240	3	1,269	63.6	100.0%	7,710	135	3,171	41.1%	4,404	57.1%
	Mayorga	39.5	14,694	4	141		145	39.5	100.0%	3,096	9	1,127	36.4%	1,960	63.3%
	Mac Arthur	57.9	18,724	10	255		265	32.2	55.7%	3,091	115	1,529	49.5%	1,447	46.8%
	Javier	153.1	23,878	5	63		68	60.4	39.4%	3,918	349	2,043	52.1%	1,526	38.9%
	Abuyog	256.6	57,146	33	13		46	95.1	37.1%	10,619	800	6,150	57.9%	3,669	34.6%
Samar	Basey	628.0	50,423	193	320	25	538	127.4	20.3%	9,403	2,071	4,466	47.5%	2,866	30.5%
	Marabut	148.8	15,115	30	2,058		2,088	56.4	37.9%	3,192	50	1,618	50.7%	1,524	47.7%
Eastern Samar	Lawaan	141.7	11,612	11	238		249	26.0	18.3%	2,748	235	994	36.2%	1,519	55.3%
	Balangiga	206.5	12,756	14	328		342	30.1	14.6%	1,972	144	719	36.5%	1,109	56.2%
	Giporlos	53.2	12,040	14	2,004		2,018	39.6	74.5%	2,653	10	797	30.0%	1,846	69.6%
	Quinapondan	136.5	13,841	10	190		200	25.6	18.7%	2,031	201	1,039	51.2%	791	38.9%
	Salcedo	121.4	19,970	29	782		811	121.4	100.0%	5,142	253	2,209	43.0%	2,680	52.1%
	Mercedes	22.8	5,369	1	469		470	22.8	100.0%	1,882	42	1,073	57.0%	767	40.8%
	Guiuan	179.2	47,037	106	3,626	16	3,748	179.2	100.0%	10,828	368	5,370	49.6%	5,090	47.0%
Total			696,303	5,253	17,614	1,684	24,551			142,409	13,731	66,720	46.9%	61,958	43.5%

Source : GADM, Census 2010, NDRRMC(SitRep No.61 Effects Typhoon Yolanda 13 Dec "013), JICA Study Team

Table 4.2-4 Damage interpretation result of Coconut tree

Province	Municipalitiy	Basic Information		Mapping Area (km2)		Interpretation on Damaged Coconut Tree (100m mesh) in Mapping Area						
		Area (km2)	Population			Severe (80%)		Moderate (50%)	Slight (30%)	Total	Total Coco Trees Area(km2)	
						Num/Tree	%	Num/Tree	Num/Tree	Num/Tree		
Leyte	Tacloban City	118.5	221,174	66.1	55.8%	21,300	27.1%	12,600	44,800	78,700	7.9	11.9%
	Palo	65.3	62,727	65.3	100.0%	151,000	95.2%	7,600	0	158,600	15.9	24.3%
	Tanauan	62.8	50,119	62.8	100.0%	174,500	81.0%	40,200	600	215,300	21.5	34.3%
	Tolosa	28.2	17,921	28.2	100.0%	132,200	84.4%	24,500	0	156,700	15.7	55.6%
	Dulag	63.6	41,757	63.6	100.0%	157,500	45.6%	124,400	63,700	345,600	34.6	54.3%
	Mayorga	39.5	14,694	39.5	100.0%	63,000	41.9%	78,300	9,000	150,300	15.0	38.1%
	Mac Arthur	57.9	18,724	32.2	55.7%	14,800	11.6%	20,600	91,800	127,200	12.7	39.4%
	Javier	153.1	23,878	60.4	39.4%	1,800	0.7%	10,100	241,900	253,800	25.4	42.0%
	Abuyog	256.6	57,146	95.1	37.1%	400	0.1%	300	319,300	320,000	32.0	33.6%
Samar	Basey	628.0	50,423	127.4	20.3%	500	0.1%	33,300	619,200	653,000	65.3	51.2%
	Marabut	148.8	15,115	56.4	37.9%	273,500	80.7%	21,500	43,800	338,800	33.9	60.0%
Eastern Samar	Lawaan	141.7	11,612	26.0	18.3%	123,700	100.0%	0	0	123,700	12.4	47.6%
	Balangiga	206.5	12,756	30.1	14.6%	137,000	100.0%	0	0	137,000	13.7	45.5%
	Giporlos	53.2	12,040	39.6	74.5%	223,700	99.5%	700	500	224,900	22.5	56.8%
	Quinapondan	136.5	13,841	25.6	18.7%	38,600	53.3%	19,200	14,600	72,400	7.2	28.3%
	Salcedo	121.4	19,970	121.4	100.0%	245,800	59.9%	74,600	90,000	410,400	41.0	33.8%
	Mercedes	22.8	5,369	22.8	100.0%	147,800	94.7%	8,200	0	156,000	15.6	68.3%
	Guiuan	179.2	47,037	179.2	100.0%	343,500	99.3%	2,300	0	345,800	34.6	19.3%
Total			696,303			2,250,600	52.7%	478,400	1,539,200	4,268,200		

Source : GADM, Census 2010, NDRRMC(SitRep No.61 Effects Typhoon Yolanda 13 Dec "013), JICA Study Team

Chapter 5 Hazard Map Preparation

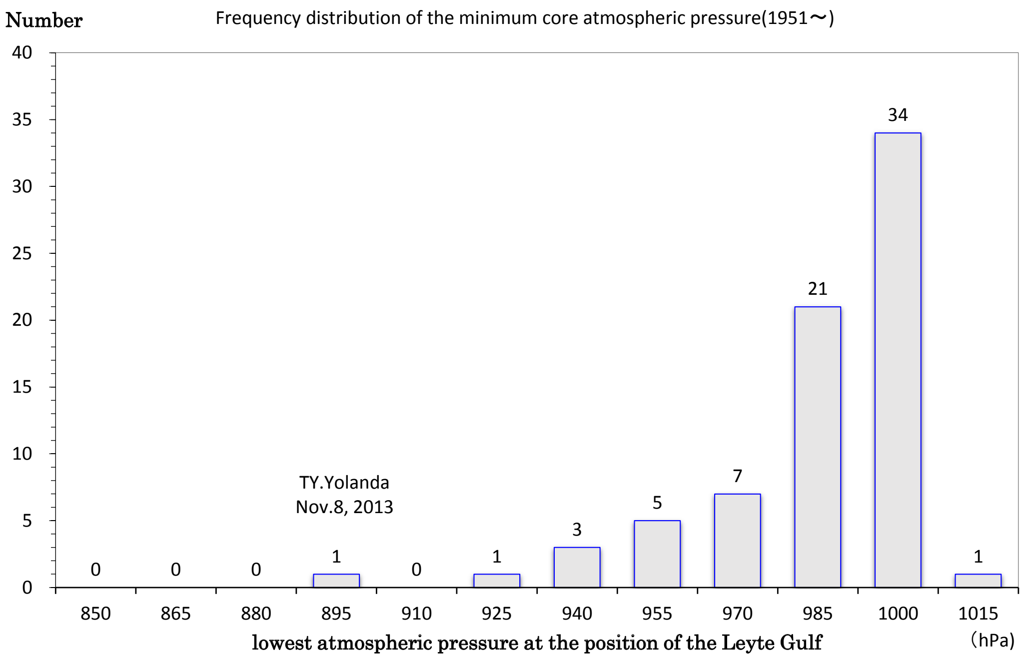
5.1 General

5.1.1 Past Typhoon Analysis

The JICA Study Team collected information about 70 typhoons which entered the Leyte Gulf from 1951 to present (60 years) (Table 5.1-1). The typhoon information is the central pressure, moving speed, and track (direction). The frequency distributions on the lowest central pressure, moving speed and moving direction are shown in Figure 5.1-1, Figure 5.1-2 and Figure 5.1-3, respectively.

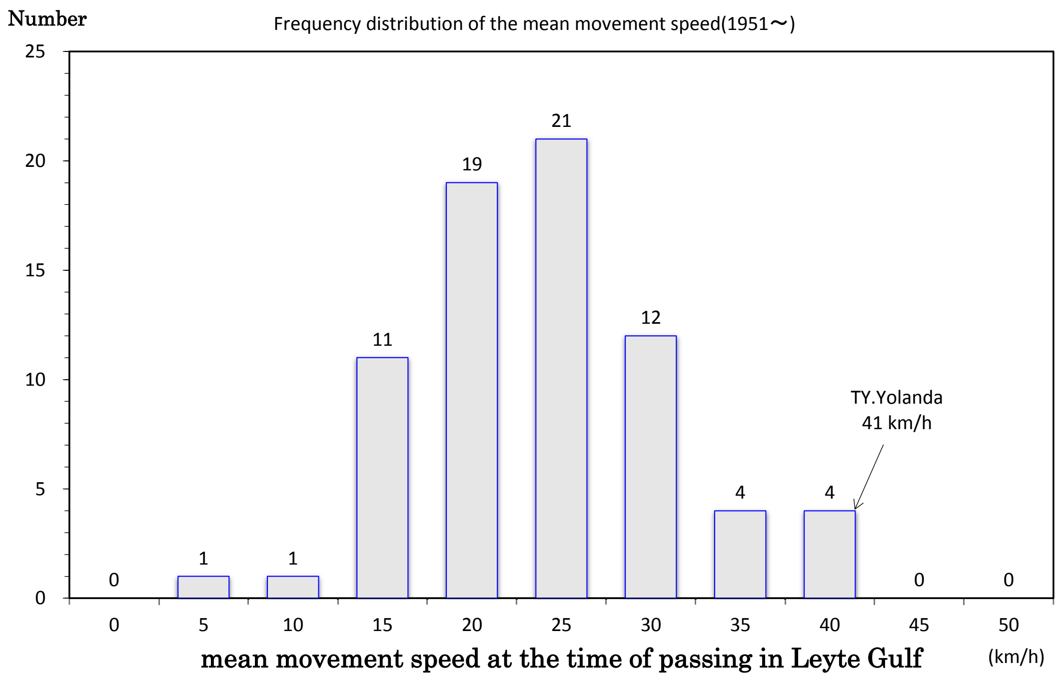
Based on the analysis of this typhoon information, the following was revealed regarding typhoon Yolanda.

- The central pressure of Yolanda, 895 hPa, was the lowest among the past typhoons on record.
- The movement speed of 41 km/h was the fastest on record, which had caused the highest storm surge.
- The track was the average course comparing with the past typhoons.



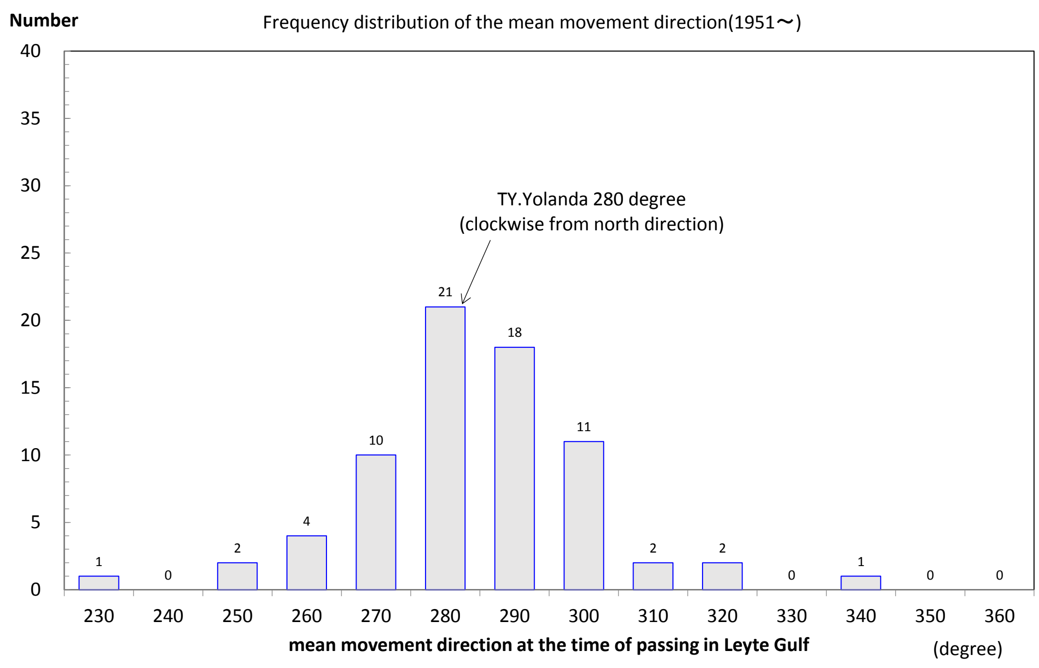
Source: JICA Study Team made from
http://www.ncdc.noaa.gov/ibtracs/index.php?name=ibtracs-data-access

Figure 5.1-1 Frequency Distribution of the Lowest Atmospheric Pressure



Source: JICA Study Team made from
http://www.ncdc.noaa.gov/ibtracs/index.php?name=ibtracs-data-access

Figure 5.1-2 Frequency Distribution of Movement Speed



Source: JICA Study Team made from
http://www.ncdc.noaa.gov/ibtracs/index.php?name=ibtracs-data-access

Figure 5.1-3 Frequency Distribution of Movement Direction

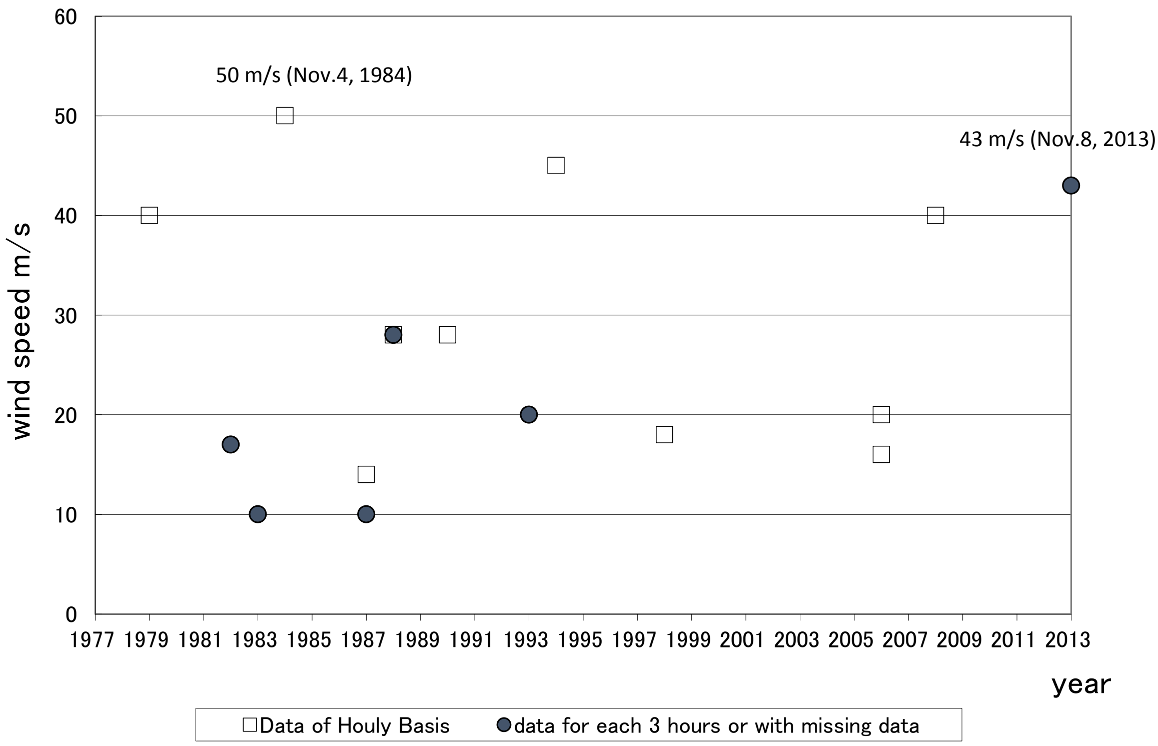
Table 5.1-1 List of Collected Typhoon Data

ID	Year	Number	Pressue (hPa)	Speed (km/h)	Direction Degree	Remark
1	1951	31	985	22.0	294.7	
2	1951	33	950	17.6	260.9	
3	1952	5	974	21.6	282.4	
4	1954	1	990	20.2	275.2	
5	1954	33	980	38.4	275.5	
6	1954	34	990	20.5	280.4	
7	1957	1	1,000	13.3	286.1	
8	1959	2	1,006	19.1	258.6	
9	1962	3	990	17.8	301.3	
10	1962	41	990	28.0	287.4	
11	1963	37	1,006	17.4	288.6	
12	1964	45	920	17.5	288.6	
13	1965	2	1,004	18.6	14.6	
14	1965	8	1,006	25.7	232.1	
15	1966	2	974	15.6	290.8	
16	1967	3	988	24.3	278.8	
17	1968	43	975	19.1	253.2	
18	1968	44	980	15.6	249.2	
19	1969	4	955	5.1	260.1	
20	1969	5	1,006	32.8	289.7	
21	1969	13	1,006	24.7	292.0	
22	1970	6	990	16.0	293.8	
23	1970	46	1,006	24.0	278.9	
24	1970	49	1,008	27.3	270.0	
25	1971	8	994	16.4	270.0	
26	1971	18	985	14.7	300.1	
27	1971	19	990	39.3	292.1	
28	1971	22	980	30.2	295.3	
29	1971	53	985	31.3	276.8	
30	1972	1	975	11.6	259.6	
31	1974	41	1,004	22.0	274.8	
32	1974	42	1,000	27.8	268.1	
33	1977	36	998	18.8	283.3	
34	1978	2	985	26.6	292.4	
35	1979	3	965	23.4	300.9	
36	1980	8	1,004	22.0	312.0	
37	1981	28	1,004	26.7	301.3	
38	1982	2	940	14.8	277.2	
39	1984	18	955	22.6	284.2	
40	1984	32	940	31.2	276.8	
41	1986	26	992	22.5	284.2	
42	1986	30	990	28.7	301.0	
43	1986	36	980	31.6	280.1	
44	1986	38	996	36.9	278.6	
45	1988	5	996	39.4	292.0	
46	1988	36	1,004	18.3	270.0	
47	1988	37	1,004	18.3	270.0	
48	1988	38	955	28.8	288.7	
49	1989	4	992	29.5	292.1	
50	1990	34	945	29.7	280.7	
51	1991	1	1,000	23.2	307.1	
52	1993	9	1,006	23.8	302.9	
53	1993	33	998	18.6	281.4	
54	1993	37	975	27.0	298.5	
55	1994	2	980	18.5	272.9	
56	1994	39	960	17.0	289.3	
57	1995	22	998	19.5	319.2	
58	1995	30	985	29.7	280.7	
59	1996	3	998	24.4	283.1	
60	1996	4	1,000	16.8	301.7	
61	1999	4	1,004	29.1	341.8	
62	2000	33	998	23.0	288.7	
63	2001	29	996	14.7	273.6	
64	2001	32	998	21.7	282.4	
65	2003	8	1,000	25.4	291.3	
66	2004	8	1,006	24.5	290.0	
67	2005	2	990	34.6	270.0	
68	2006	26	975	24.3	283.2	
69	2007	24	1,004	25.7	274.1	
70	2008	25	1,006	36.1	300.7	
71	2011	24	1,004	25.1	316.9	
72	2012	24	996	25.4	300.5	
73	2013	30	895	40.8	280.4	Yolanda

Source: JICA Study Team made from
http://www.ncdc.noaa.gov/ibtracs/index.php?name=ibtracs-data-access

In Table 5.1-1, the Number means the sequential number of typhoons in North Western Pacific Ocean in the relevant year. The pressure is the lowest atmospheric pressure in the core of the typhoon. The speed is the movement speed calculated from the track record. The direction is the track direction of the typhoon by clockwise from north.

Historical wind speed observational data were therefore collected and sorted to see the particularity of Yolanda. Figure 5.1-4 shows observed sustained wind speed at Guiuan station. 50 m/s wind speed recorded at Guiuan station in Nov.4, 1984 is seemingly the highest. The highest wind speed observed during Yolanda was recorded as 43 m/s on record at 4 am, November 8, 2013, however the data went missing afterwards, meaning the maximum wind speed might have been much higher.



Source: JICA Study Team

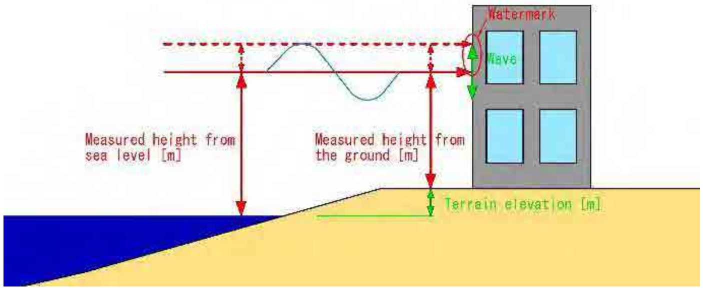
Figure 5.1-4 Annual Maximum Velocity Record at Guiuan

5.1.2 Survey for Storm Surge Marks by Yolanda

At the time of the typhoon Yolanda, unexpected tsunami-like storm surges were reported and observed in many places along the coastal area of the Leyte Gulf. Especially the areas of Tacloban, Palo and Tanauan suffered from higher storm surge, up to several meters, which resulted in several hundred meters of run-up inland.

The JICA Study Team conducted a spot elevation survey for the storm surge marks in the study area. The total number of survey points was over 200 from Guiuan in East Samar to Abujog in Leyte. The height above ground and the sea level elevations were obtained for each water mark on objects on land as shown in Figure 5.1-4.

Figure 5.1-5 is the plotting result of the Storm Surge Mark Survey. The value is the elevation above sea level. The higher elevations of the storm surge run-up are concentrated in Tacloban, Palo of Leyte and the coastal area of Samar such as Basey. It is understood that there are many higher elevations observed in the inner part of the Leyte Gulf.



Source: JICA Study Team

Figure 5.1-5 Parameters of Storm Surge Mark Survey

Source: JICA Study Team

Figure 5.1-6 Preliminary Result of Storm Surge Mark Survey

5.1.3 Present Hazard Maps

(1) READY Project

The multi-hazard map preparation has been done by the Philippine Institute of Volcanology and Seismology (PHIVOLCS), Department of Science and Technology, under the framework of the READY project (Hazards Mapping and Assessment for Effective Community-Based Disaster Risk Management) implemented by multi-agency participation (PHIVOLCS, PAGASA, MGB, NAMRIA and OCD, chaired by OCD) and financed by the United Nations Development Program (UNDP) and the Australian Agency for International Development (AusAID).

The READY project has prepared a set of multi-hazard maps covering (1) earthquake-related hazards (ground rupture, ground shaking, liquefaction, earthquake-induced landslide and tsunami) and (2) hydro-meteorological hazards, such as rain-induced landslide, floods/flashfloods and storm surge. The READY project has finished hazard mapping for 27 provinces, including Leyte and Eastern Samar. But Samar is not on the list. The available hazard maps for the project area are shown in Table 5.1-2.

Table 5.1-2 Available Hazard Maps from READY Project for the Project Area

Hazard map	Leyte	Eastern Samar	Samar
Seismic hazard	Ground shaking map	Ground shaking map	-
Tsunami hazard	Inundation map	Inundation map	-
Earthquake-induced landslide	Susceptibility map	Susceptibility map	-
Rain-induced landslide	Susceptibility map	Susceptibility map	-

Source: JICA Study Team

Basically the map scale of those hazard maps is 1:50,000 or 1:10,000 for each LGU.

5.2 Storm Surge Simulation Analysis

Typhoon Yolanda, which made landfall on Leyte Island on Nov. 8th, 2013, caused serious damage to the islands in the southern Philippines due to the extreme storm surge and wind. The central pressure of Yolanda was the lowest among the past typhoons that have struck the region and its moving speed was the fastest. Abnormally high storm surge was generated inside the San Pedro and San Pablo Bays, causing many deaths as a consequence. Furthermore, many buildings were damaged due to extreme wind in a wide area.

The southern part of the Philippines is a typhoon-prone area where half a dozen typhoons have had struck in a year; however, damage caused by typhoon Yolanda was far more severe than expected. In order to prevent disasters, it is necessary to comprehend the mechanism of how such abnormal storm surge was generated by Yolanda as well as the assumption of the appropriate scale of external force (e.g. storm surge level, etc.) required to create reliable disaster management plans for the future.

5.2.1 Objectives

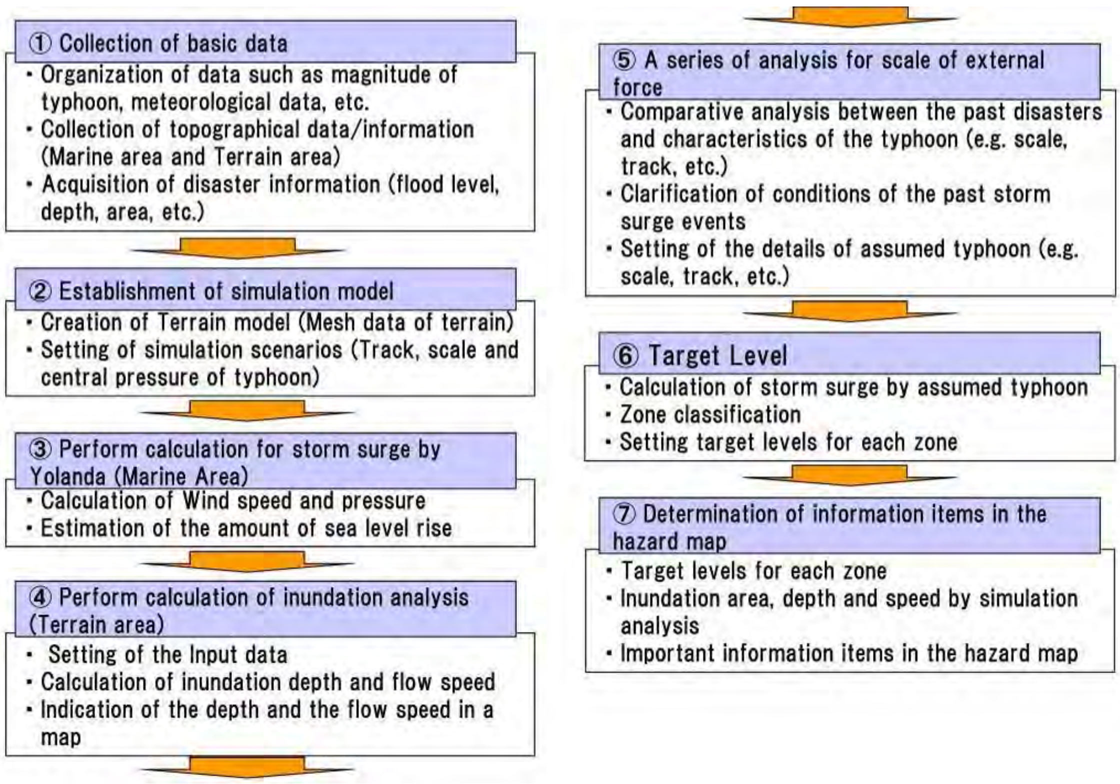
The objectives of the storm surge simulation are as follows:

- Clarification of mechanism for storm surge by Typhoon Yolanda as well as factors causing the storm surge disaster
- Establish the target level or scale of external forces, which will be reflected into the disaster management planning
- Determination of information items which need to be indicated in the hazard map

5.2.2 Procedure of Storm Surge Simulation

The flow chart of storm surge simulation is as follows:

- Establishment of the simulation model by using the data which we collected and setting of the simulation scenarios.
- Performance of the simulation of storm surge and inundation analysis by typhoon Yolanda.
- Setting of the details of assumed typhoon by clarification of conditions of the past storm surge events.
- Performance of the simulation for the assumed typhoon and determination of the information items in the hazard map.



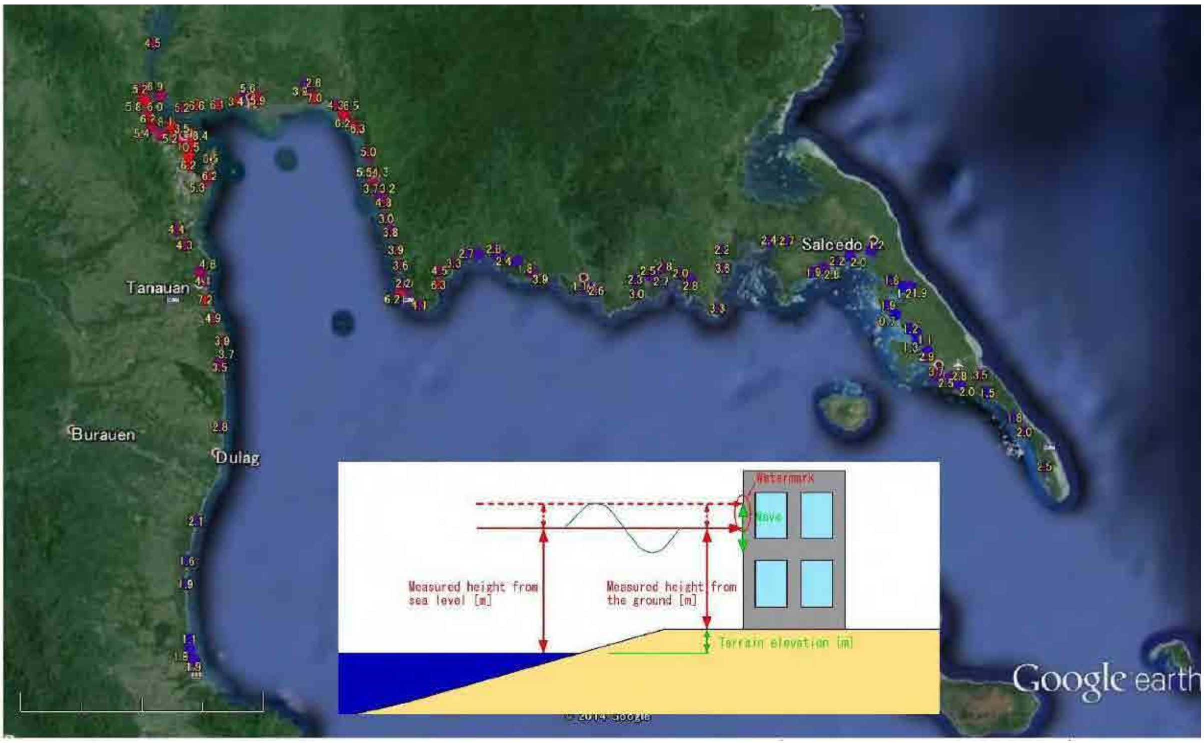
Source: JICA Study Team

Figure 5.2-1 Flow Chart of Storm Surge Simulation

5.2.3 Trace Survey for Storm Surge

We investigated the storm surge trace of Typhoon Yolanda along the coastline of the Leyte Gulf. The summaries of the results are as follows:

- The inundation height (height from MSL level) and the inundation depth (height from the ground) was measured based on eyewitness accounts after interviewing residents.
- The map below shows inundation elevations (height above MSL level) obtained in the investigation. Inundation depths measured along the San Pedro and San Pablo bay were particularly deep, with figures easily surpassing 6m.



Source: JICA Study Team

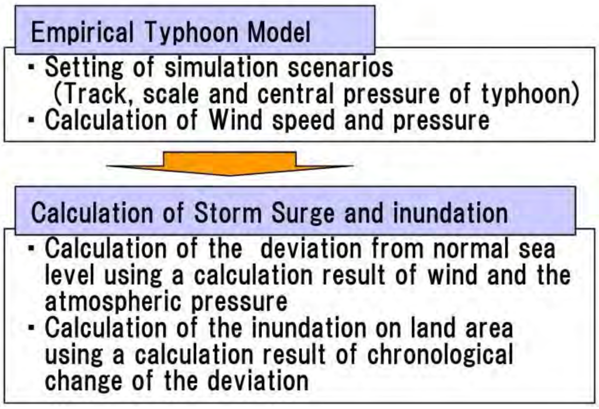
Figure 5.2-2 Result of Trace Survey (height from MSL level)

5.2.4 Outline of the Storm Surge Simulation Model

The outline of the calculation model of the storm surge and the Inundation calculation are as follows:

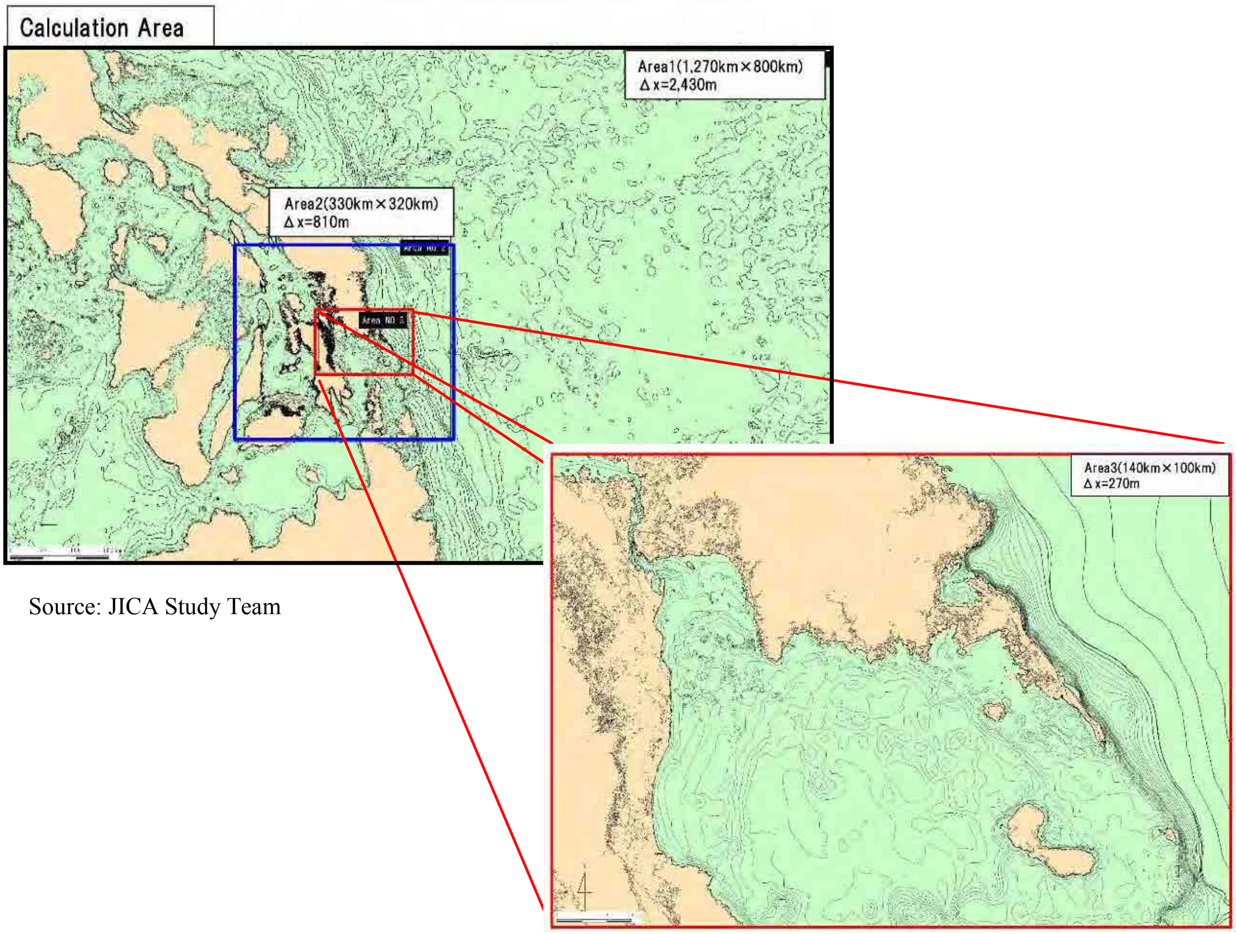
- Pressure-driven surge and Wind-driven surge will be calculated by making use of an Empirical Typhoon Model. Pressure and wind will be calculated by Myers equation. As for the storm surge, a continuity equation and a motion equation are solved by differential calculus. This is the technique that is used in PAGASA now.
- Data set (sea bottom terrain) will be created from the marine chart. The smallest mesh size of bathymetry at the Leyte Gulf (Area 3) is 270 meters.

- Inundation calculation for the land area will be conducted using the amount of sea level rise obtained from the storm surge simulation. A two-dimensional unsteady flow model will be used and relief of terrain is modeled on a grid of 30m to 90m.



Source: JICA Study Team

Figure 5.2-3 Flow Chart of Calculation



Source: JICA Study Team

Figure 5.2-4 Calculation Area (mesh size is a condition of storm surge simulation)

Source: JICA Study Team

Figure 5.2-5 Location map of assessment points for storm surge simulation

5.2.5 Determination of the External Force

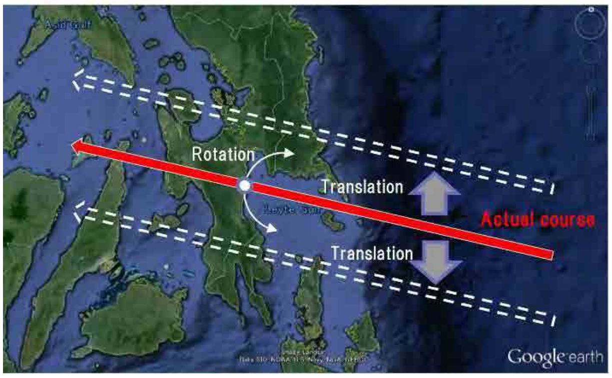
The policy on how to define the external force of the calculation model of the storm surge and the Inundation calculation are as follows:

- Yolanda was the strongest typhoon since 1951, with the lowest central pressure and the fastest moving speed among past typhoons. It has recorded an unprecedented height of storm surge anomaly.
- In the storm surge simulation, the course of Yolanda will be shifted towards the north and south to specify the course with the highest storm surge anomaly, for which the external force will be set. The rotation of the course will be also taken into consideration as shown in Figure 5.2-6.
- Regarding the effect of rotation of the course, the simulation results shows the Yolanda course without rotation would cause the largest storm surge.
- The simulation analysis was performed to confirm the effectiveness of the difference of the typhoon course of Yolanda. The course was shifted to the north and south direction within one degree in latitude direction. The differences of the storm surge height are shown in Figure 5.2-7 and Figure 5.2-8.
- The actual course of Yolanda was possibly the most hazardous one for regions on the northern side of the Leyte Bay. On the other hand, the storm surge heights in the southern part such as Abuyog, *etc*. are higher than that of the actual typhoon for the case of the southern course of the typhoon. In addition, the heights in the eastern part of Samar Island

such as Guiuan are higher for the northern course.

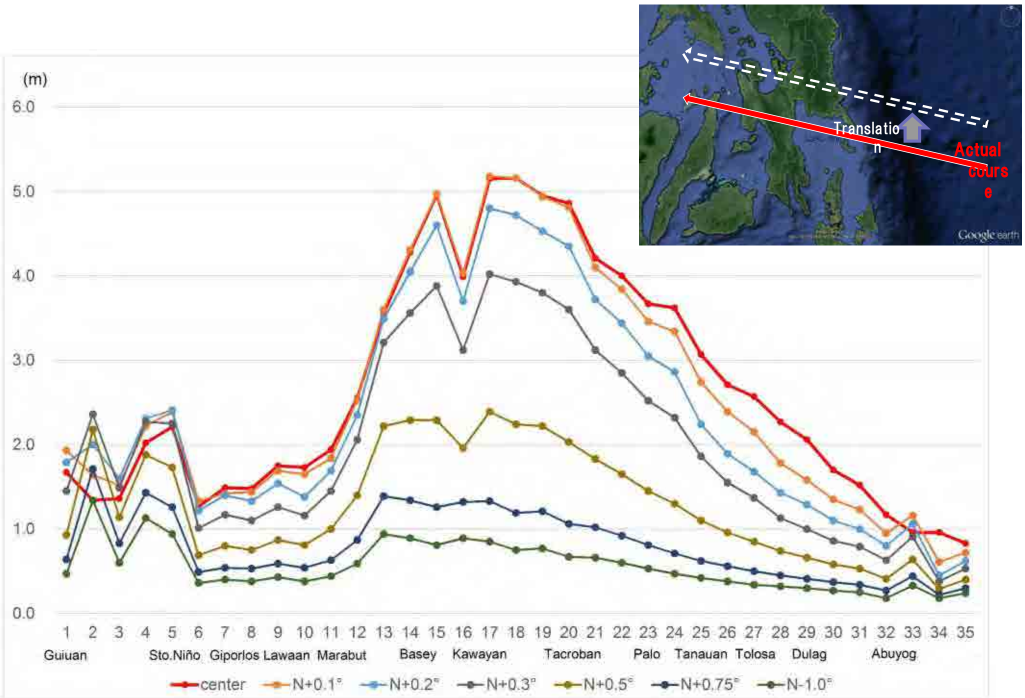
- The determining course of the external force may differ from area to area. As shown in Figure 5.2-6, the external force will be fixed for each defined area.

The defined deviation of each LGU for storm surge hazard mapping is shown in Table 5.2-1. In LGUs of Leyte, the southern direction shifted cases were applied except for Tacloban. For Tacloban, the Yolanda case was regarded as the worst case. In LGUs of Samar and Easter Samar, the northern direction shifted cases were applied for Basey, Giporlos, Quinapondan, Salcedo, Mercedes and Guiuan. For Marabut, Lawaan and Balangiga, the Yolanda case was regarded as the worst case.



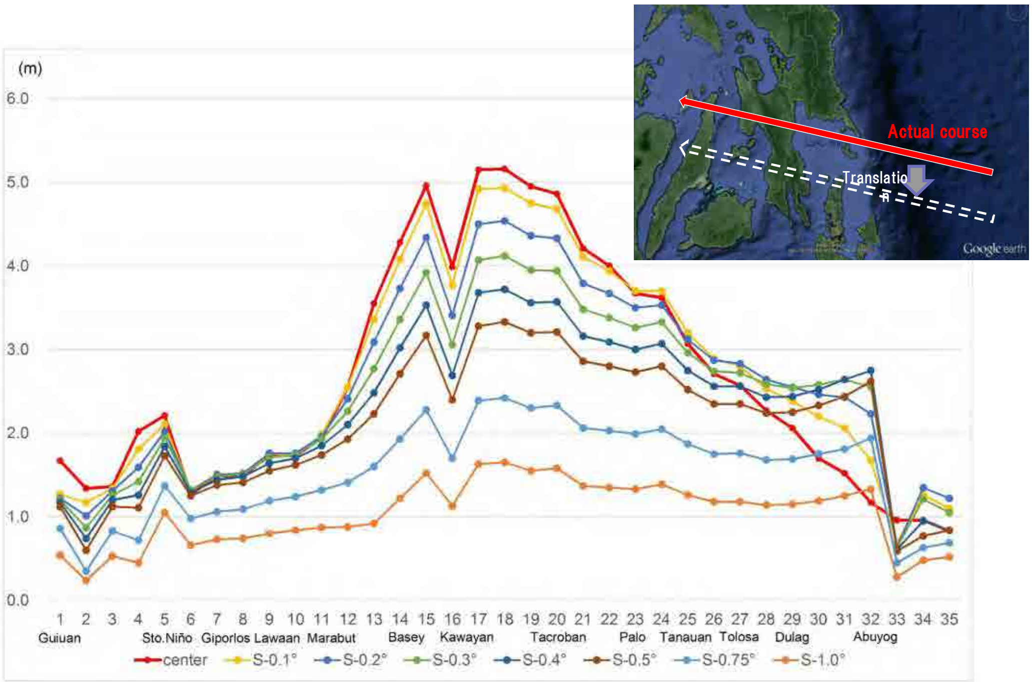
Source: JICA Study Team

Figure 5.2-6 Method for Setting the Assumption of Maximum External Force



Source: JICA Study Team

Figure 5.2-7 Simulation results of storm surge heights with the cases of shifted typhoon course to northern side



Source: JICA Study Team

Figure 5.2-8 Simulation results of storm surge heights with the cases of shifted typhoon course to southern side

Table 5.2-1 Defined Deviation of Each LGU for Storm Surge Hazard Mapping

Leyte LGU	Adoption course	Mean Deviation in each LGU (MSL +m)				
		Yolanda	S-0.1°	S-0.2°	S-0.3°	S-0.4°
Tacloban	Yolanda	4.58	4.39	4.05	3.69	3.33
Palo	S-0.1°	3.66	3.72	3.56	3.34	3.08
Tanauan	S-0.1°	3.14	3.28	3.19	3.02	2.81
Tolosa	S-0.2°	2.59	2.82	2.85	2.74	2.58
Dulag	S-0.3°	2.04	2.39	2.55	2.57	2.46
Mayorga	S-0.3°	1.69	2.21	2.48	2.63	2.58
Macarthur	S-0.4°	1.45	1.99	2.40	2.65	2.69
Javier	S-0.4°	1.29	1.84	2.32	2.62	2.76
Abuyog	S-0.4°	1.18	1.72	2.26	2.59	2.79

Samar & E. Samar LGU	Adoption course	Mean Deviation in each LGU (MSL +m)			
		Yolanda	N+0.1°	N+0.2°	N+0.3°
Basey	N+0.1°	4.21	4.26	4.05	3.59
Marabut	Yolanda	2.23	2.21	2.06	1.80
Lawaan	Yolanda	1.84	1.81	1.65	1.41
Balangiga	Yolanda	1.61	1.57	1.46	1.26
Giporlos	N+0.1°	1.74	1.74	1.71	1.50
Quinapondan	N+0.2°	2.39	2.55	2.66	2.58
Salcedo	N+0.3°	1.50	1.78	2.04	2.19
Mercedes	N+0.3°	0.99	1.10	1.20	1.26
Guiuan	N+0.1°	1.17	1.64	1.64	1.45

Source: JICA Study Team

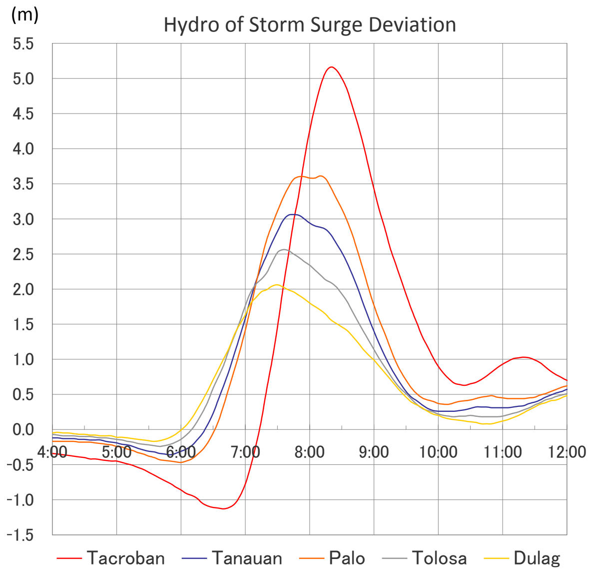
5.2.6 Flood Simulation on Landside

A series of storm surge flood simulation on landside was carried out by making use of terrain Lidar data collected by the JICA team.

The simulation area covers the area of Tacloban to Dulag.

The calculation method applied in this analysis was two dimensional unsteady flow methodology with the grid size of 30 meters. The boundary conditions were the storm surge heights at the 270 m intervals along the coastal lines from Tacloban to Dulag on the basis of actual typhoon Yolanda situation.

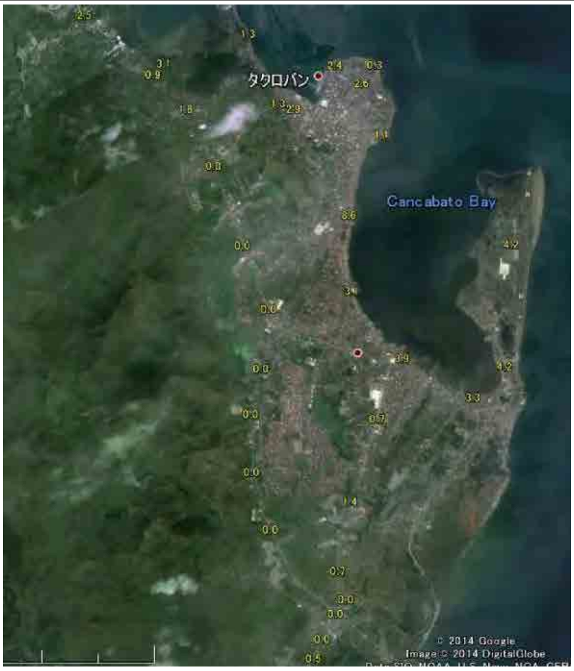
The hydrograph of the storm surge heights at the representative points are shown in Figure 5.2-9.



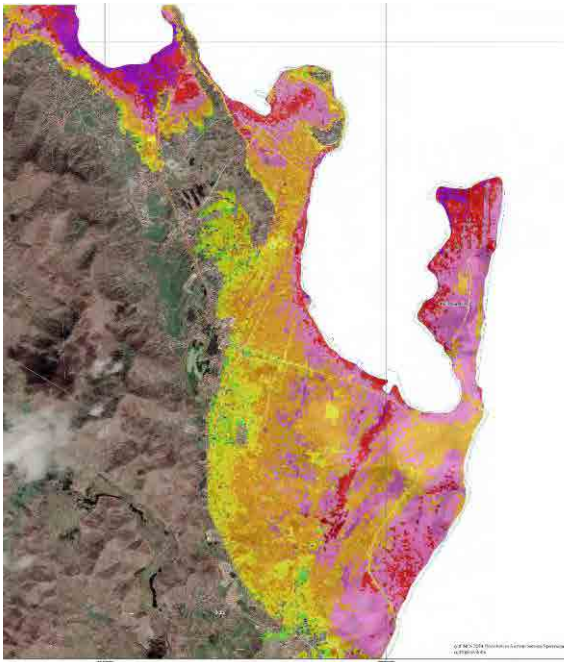
Source: JICA Study Team

Figure 5.2-9 Hydrograph of the storm surge heights at the representative points

Figure 5.2-10 indicates the comparison between flood mark survey results with flood simulation analysis for Tacloban city



Flood mark survey results



Flood on landside simulation results

Source: JICA Study Team

Figure 5.2-10 Comparison between flood mark survey results with flood simulation analysis for Tacloban city

5.2.7 Preparation of Hazard Map by JICA Study Team

The necessary information items to be indicated in the hazard map of storm surge will be the followings:

① Inundation area

② Inundation depth

③ Arrival time of storm surge（Not described）

The map contains the contour lines, which was surveyed recently and, the inundation depths in the map are shown, following to the classification table below.

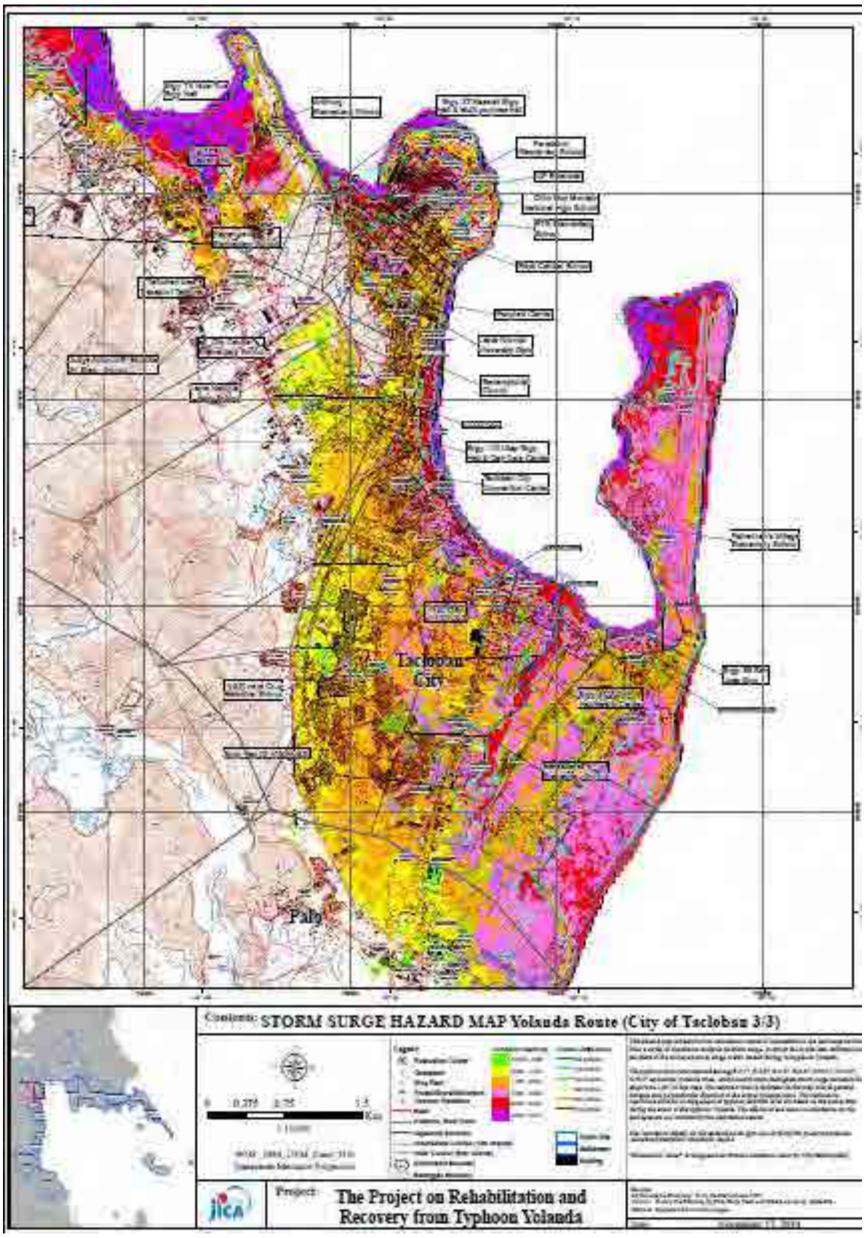
Table 5.2-2 Classification of map contour

Inundation depth	Color
Above 5m	Dark Blue
More than 4m ～ Less than 5m	Purple
More than 3m ～ Less than 4m	Red
More than 2m ～ Less than 3m	Pink
More than 1m ～ Less than 2m	Orange
More than 0.3m ～ Less than 1m	Yellow
Less than 0.3m	Light Green

Source: JICA Study Team

The base map is the simplified topographic map which was prepared by JICA Study Team (refer to Chapter 4 of Technical Supporting Report).

Figure 5.2-11 is an example of storm surge hazard map by JICA Study Team. This example is a southern part of Tacloban City including the locations of existing evacuation centers.



Source: JICA Study Team

Figure 5.2-11 Storm-Surge Hazard Map of Tacloban City

5.3 Wind Simulation Analysis

5.3.1 Objectives

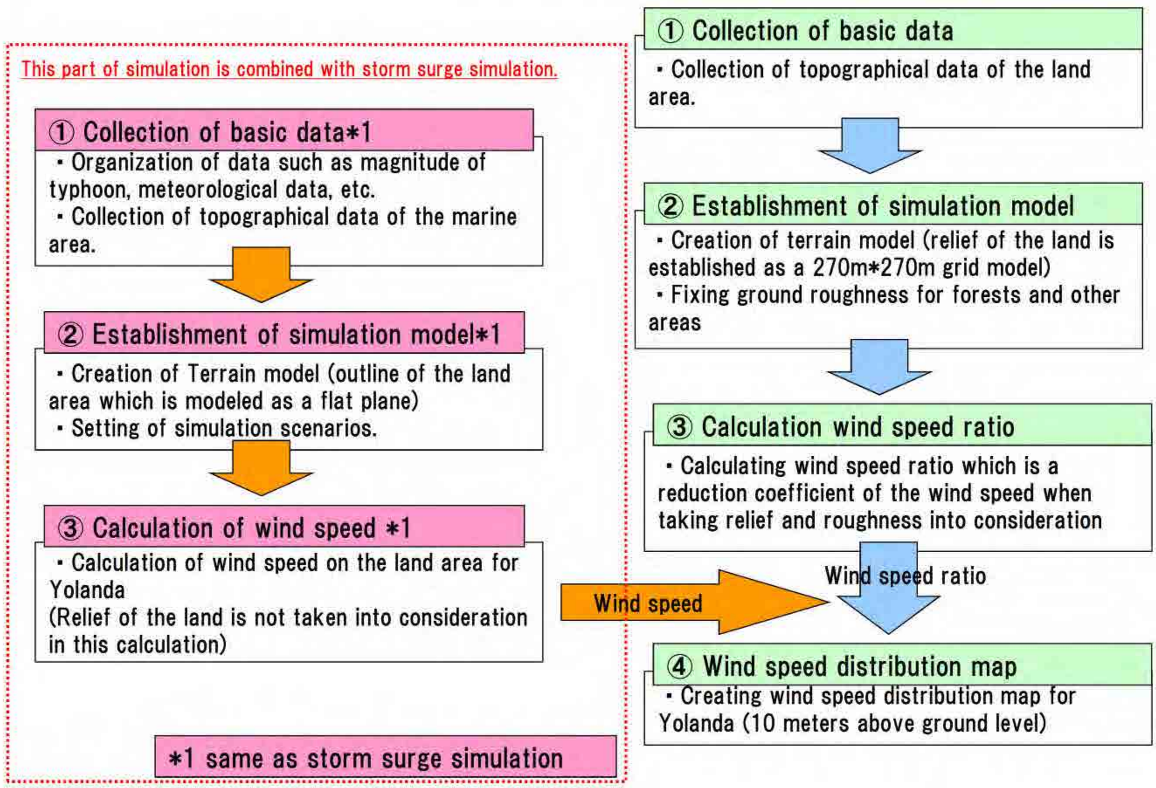
Strong wind brought by typhoon Yolanda has widely affected the region, causing substantial damage to residents and their properties, not only for coastal areas but also for inland areas.

Understanding the characteristics of wind brought by Yolanda becomes, therefore, necessary to assess disaster mitigation measures for future typhoons. Wind simulation will be conducted in this context and its objectives are as follows;

- Evaluate the wind speed caused by Typhoon Yolanda whose data are missing due to the damaged meteorological station. The simulation results will be calibrated using existing data and a wind speed distribution map will be made for the whole study area as an outcome of the simulation.
- Estimate the distribution of the wind speed as well as its time series variation to know when to evacuate safely, which will contribute to disaster mitigation planning.

5.3.2 Work Flow of Wind Simulation

The wind simulation will be conducted through the following procedures.



Source: JICA Study Team

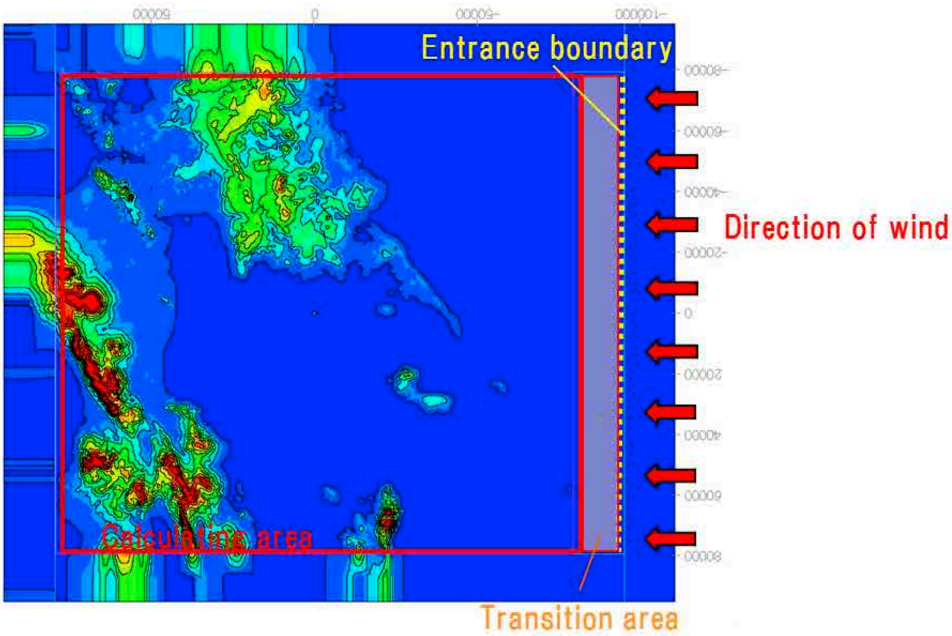
Figure 5.3-1 Flow Chart of Wind Simulation

5.3.3 Outline of the Simulation Model

Wind simulation consists of two parts, the former part for the wind speed calculation (shown on the left side of the Figure 5.3-1 and the latter part for the wind speed calculation (shown on the right side of the Figure 5.3-1).

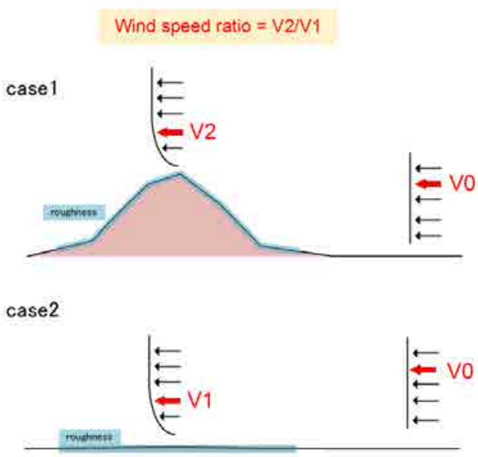
The former part, in which wind speed is calculated is conducted as part of the storm surge simulation and the model is the same as explained in 5.1, where land area is modelled as a flat plain without land form. Only the roughness of the ground is taken into account.

The model of the latter part is shown in the Figure 5.3-2. This part of the simulation is for calculating the wind speed ratio, which is a reduction coefficient expressed in V2/V1 in the Figure 5.3-3, where V2 is calculated wind speed with land form and roughness taken into account, whereas V1 is wind speed calculated with roughness but without land form. Initial wind speed is given as V0 at a height where the roughness of the ground has no affect. V2 and V1 are calculated at a height of 10 meters above the ground since this is the standard height of wind speed observations in meteorological stations. Two cases, one for leading V1 and another for V2 will be evaluated in each calculation.



Source: JICA Study Team

Figure 5.3-2 Wind Simulation Model



Source: JICA Study Team

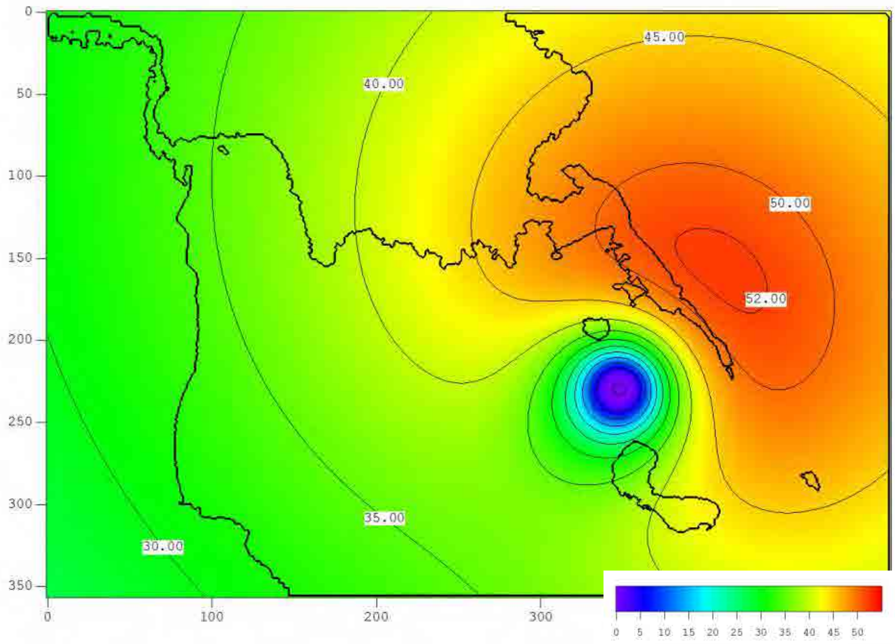
Figure 5.3-3 Concept of Wind Speed Ratio

The grid size for calculation of wind speed in the land area will be 270 meters. Figure 5.3-2 shows one of these calculating areas along with a transition area and entrance boundary given the wind direction is from the east. The calculation will be conducted for all sub-areas and for 16 different wind directions. This part of the simulation will discretely use Navier–Stokes equations and a Continuity equation to evaluate wind speed affected by land form and roughness of the ground.

The model was calibrated and verified by comparing the calculation result to the actual observation records, resident's testimony and damage of coconut trees.

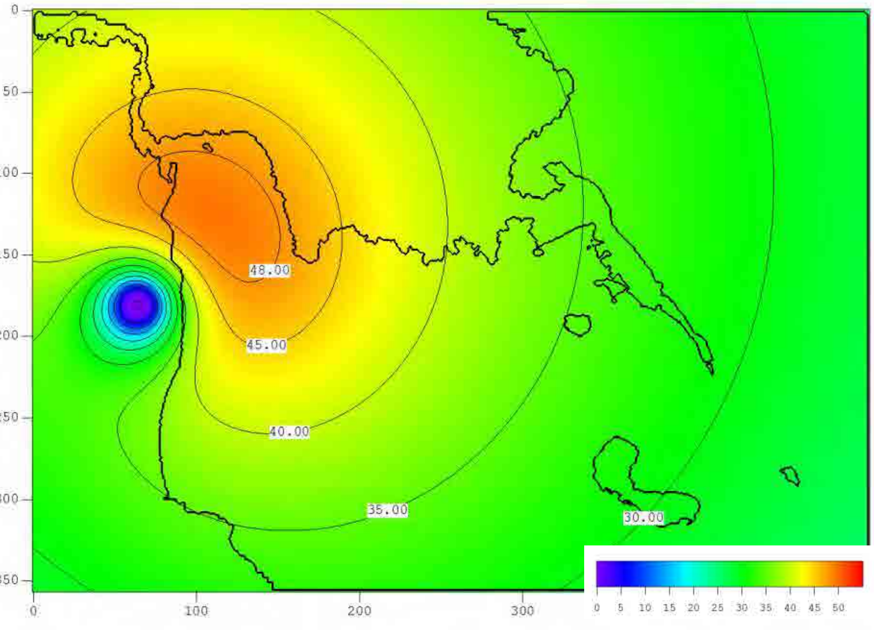
5.3.4 Calculation of wind speed

Figure 5.3-4 and Figure 5.3-5 show calculation results of wind speed at 5:30 am and at 7:30 am respectively. This wind speed will be multiplied by wind speed ratio to obtain relief-adjusted wind speed.



Source: JICA Study Team

Figure 5.3-4 Result of wind speed calculation (Nov. 8 2013 5:30am)

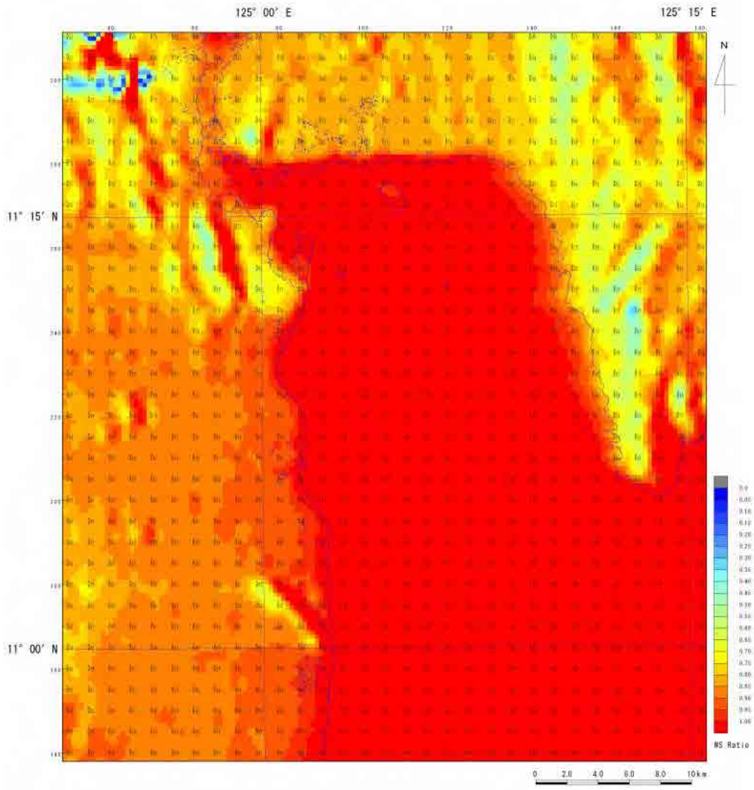


Source: JICA Study Team

Figure 5.3-5 Result of wind speed calculation (Nov.8 2013 7:30am)

5.3.5 Calculation of wind speed ratio

Figure 5.3-6 shows calculation result of wind speed ratio for an easterly wind. Calculation was made for each of the 16 cardinal directions. Sea surface and summit ridge of mountains show high wind speed ratio whereas mountain shadows show low wind speed ratio.



Source: JICA Study Team

Figure 5.3-6 Result of wind speed ratio calculation (Easterly wind)

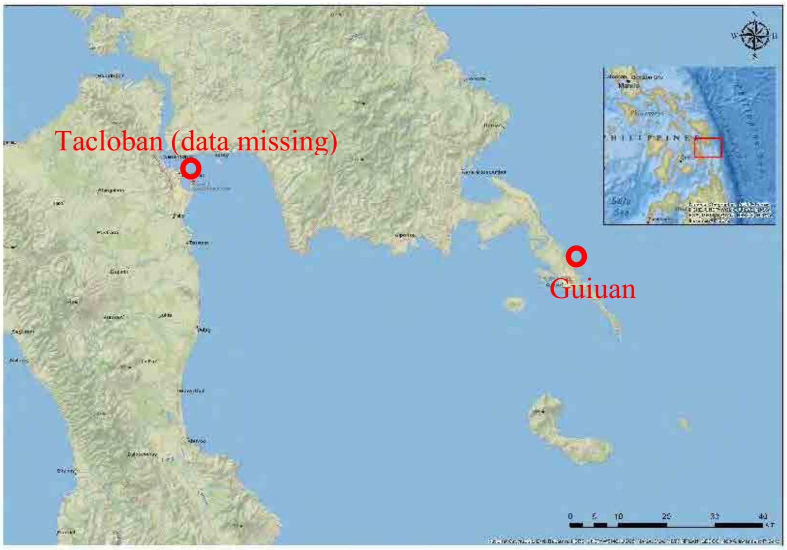
5.3.6 Verification of the simulation result

The model was calibrated and verified by comparing the simulation results to the actual observation records, resident's testimony.

(1) Observed wind speed and pressure

1) Observed value

Among meteorological stations operated by PAGASA, there were two stations in the study area, Guiuan and Tacloban. Only data from Guiuan station are partially available whereas data from Tacloban station are not due to the severe damage caused by storm surge.



Source: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC,NASA,ESA,METI,NRCAN,GEBCO,NOAA,increment P Corp.

Figure 5.3-7 Location of meteorological station

Table 5.3-1 shows the observed value of 10-minute sustained wind speed at Guiuan station. Sustained wind speed reached 43 m/s at 4:00 am and gustiness of 53 m/s was recorded at 4:10 am. But due to the damage of the station, no data have been reported afterwards.

The meteorological station of Guiuan was reportedly damaged around 5:00 am on Nov. 8th 2013 when the recorded pressure was as low as 910 hpa.

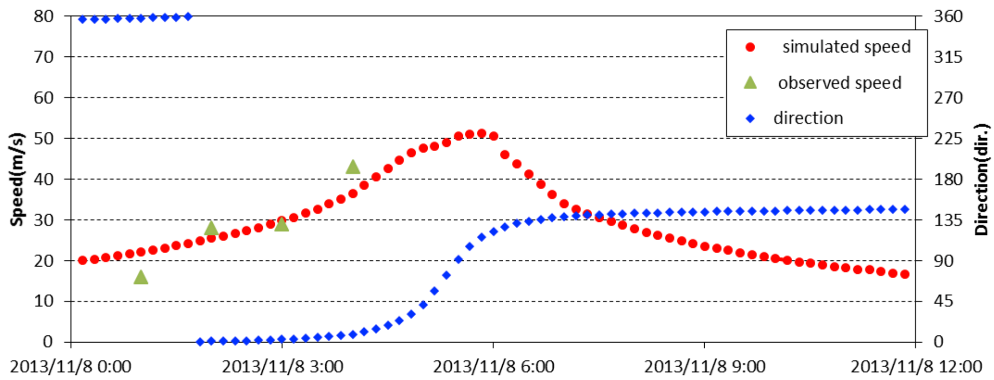
Table 5.3-1 Observed wind speed at Guiuan

date (m/d/y)	time (local time)	pressure (hPa)	wind direction	wind speed (m/s)	gustiness (m/s)
Nov. 7 2013	17:00	1004.0	NNE	12	
Nov. 7 2013	18:00	1004.0	NE	8	
Nov. 7 2013	19:00	1004.5	NNE	9	
Nov. 7 2013	20:00	1004.5	NNE	7	
Nov. 7 2013	21:00	1005.2	NNE	13	
Nov. 7 2013	22:00	1003.6	NE	3	
Nov. 7 2013	23:00	1003.1	NE	3	
Nov. 8 2013	0:00	1000.1	NE	5	
Nov. 8 2013	1:00	997.4	NNE	16	
Nov. 8 2013	2:00	993.9	NNE	28	
Nov. 8 2013	3:00	988.8	NNE	29	
Nov. 8 2013	4:00	976.8	NNE	43	NNE / 53 (04:10)
Nov. 8 2013	5:00	NO DATA	NO DATA	NO DATA	

Source: PAGASA

2) Simulated Value

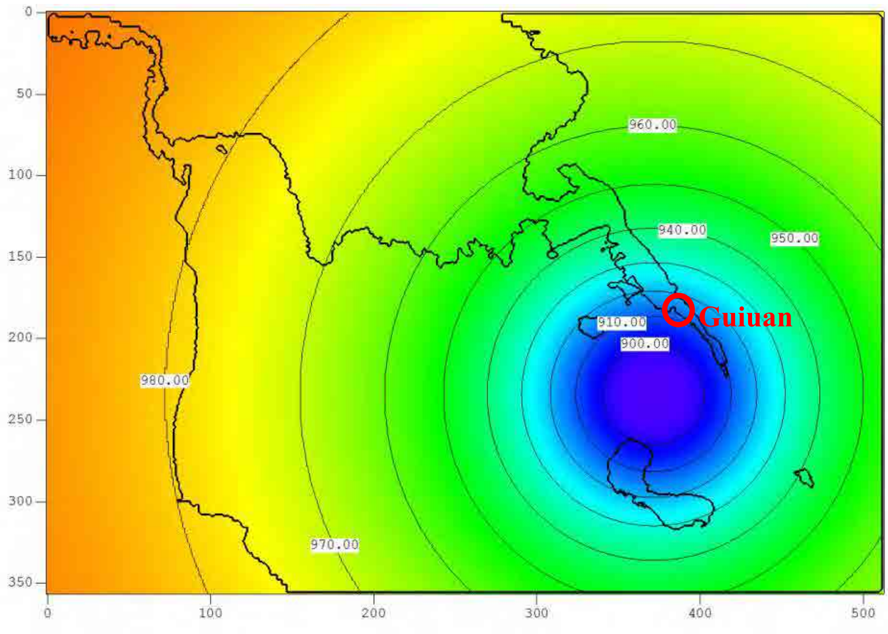
Figure 5.3-8 shows simulated wind speed / direction in relation to the observed wind speed at Guiuan. The simulated wind speed at 4:00 am is 36.6 m/s where the observed value is 43 m/s, and at 3:00 am, the simulated value is 29.8 m/s and the observed value is 29 m/s. The change in wind speed for both values is well accorded with each other.



Source: PAGASA, JICA Study Team

Figure 5.3-8 Simulated wind speed / direction and observed wind speed at Guiuan

Figure 5.3-9 shows simulated pressure at 5:20 am showing 910-920 hPa at Guiuan station, where the observed value was 910 hPa at around 5 am.



Source: JICA Study Team

Figure 5.3-9 Simulated pressure at 5:20 am on Nov.8 2013

(2) Resident's testimony

Testimony from the residents of Guiuan, where the observational records of wind speed exist, indicates that major damage (break of window glass, flying of large roofing) was brought by the wind whose sustained wind speed was greater than 30 m/s.

Testimonies from other municipalities are utilized to verify the result of wind speed analysis.

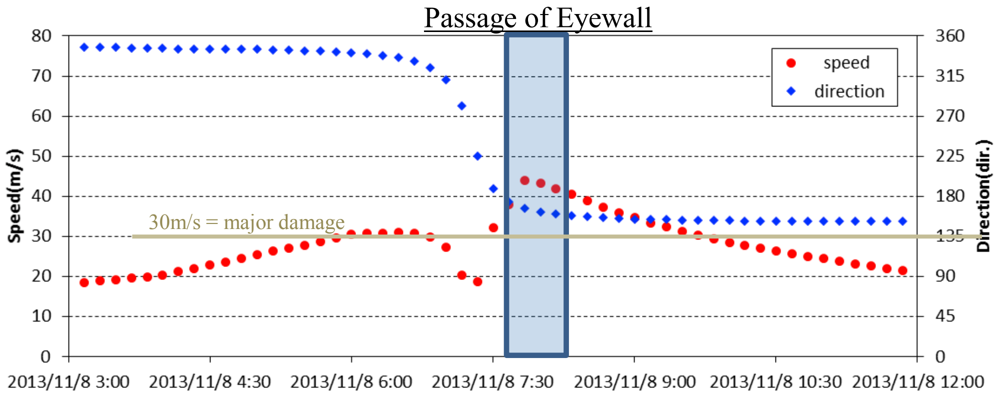
1) Guiuan

According to the testimony of an officer in charge at Guiuan PAGASA station, the break of the window glass took place at around 3:30 am on Nov. 8 2013. The sustained wind speed at that time is estimated to have been 29-43 m/s from the observed wind speed at 3:00 am and 4:00 am. The simulated wind speed at 3:30 am is 32.7 m/s which is between the range. Given that the observed wind speed at 2:00 am was 28 m/s, wind speed of more than 25 m/s continued to blow for more than an hour before the break of the window. This implies that the threshold of the break of window glass was greater than 30 m/s for the Guiuan PAGASA station, a typical building with reinforced concrete in the region.

Another testimony from the Guiuan municipal in downtown relates that roofing of high school got blown at around 3:00 am to 4:00 am, wind speed being estimated to have easily surpassed 30 m/s.

2) Dulag

At the municipality of Dulag, near the landfall point of Yolanda, passage of the eyewall was evident. Testimony relates that some of the window glass got broken before the landfall, which conforms to the simulation result with 30 m/s-wind speed around that time. According to municipal personnel, a pause of wind came suddenly at 7:00 am on Nov.8 2013, with a clear blue sky on their head. Then abruptly came a more stronger wind from the south wreaking far more damage on the municipal buildings. This strong wind after the passage of eyewall brutally shattered the window glass of the municipality building. This testimony verifies the simulation result which shows clearly the pause of wind and change in direction of wind during the passage of eyewall, as well as the more stronger wind after the landfall.

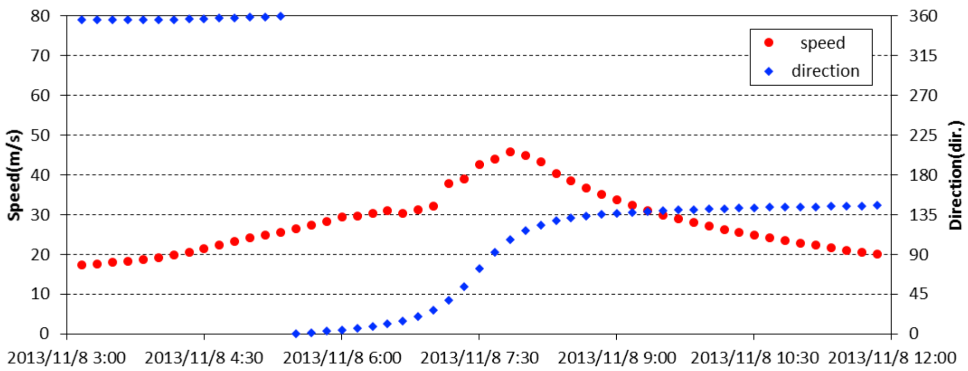


Source: JICA Study Team

Figure 5.3-10 Simulated wind speed and direction at Dulag

3) Palo

Passage of eyewall was not evident in Palo. Major damage was caused after 7:00 am although houses made by light wood material, bamboo and nippa began to suffer damage before 6:00 am. The testimony verifies the simulation results shown in Figure 5.3-11.

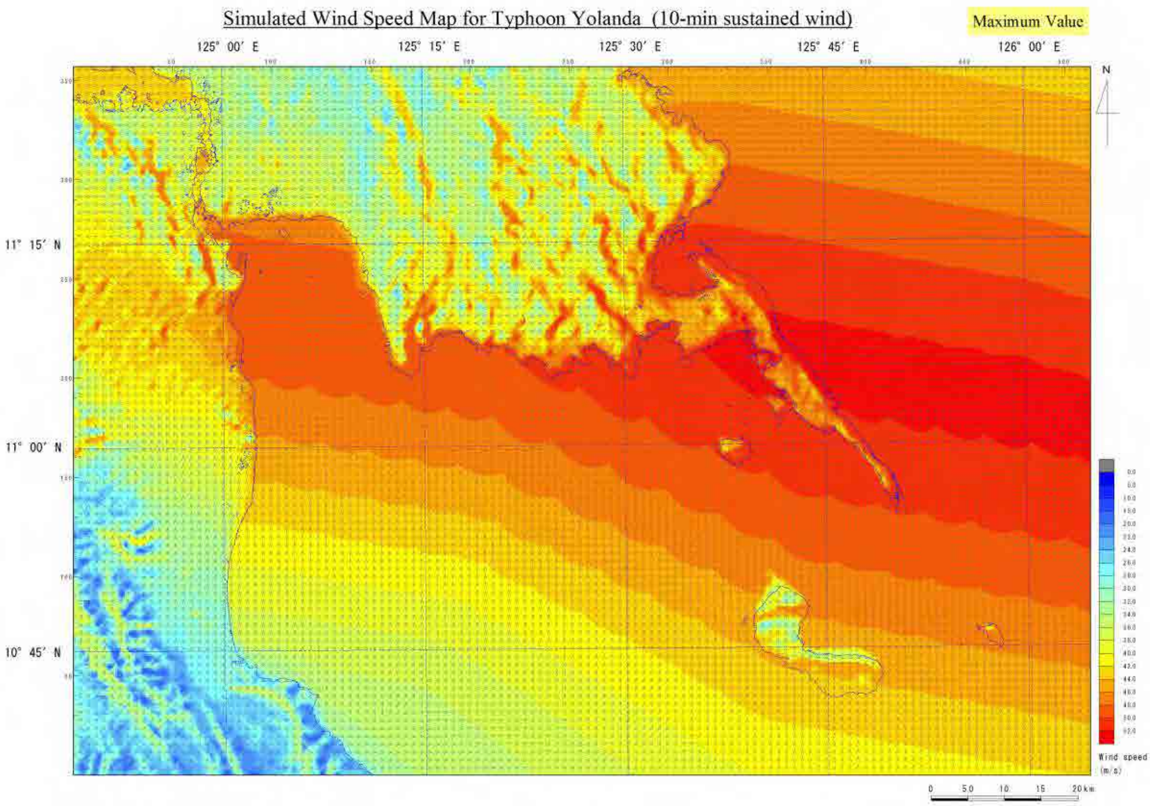


Source: JICA Study Team

Figure 5.3-11 Simulated wind speed and direction at Palo

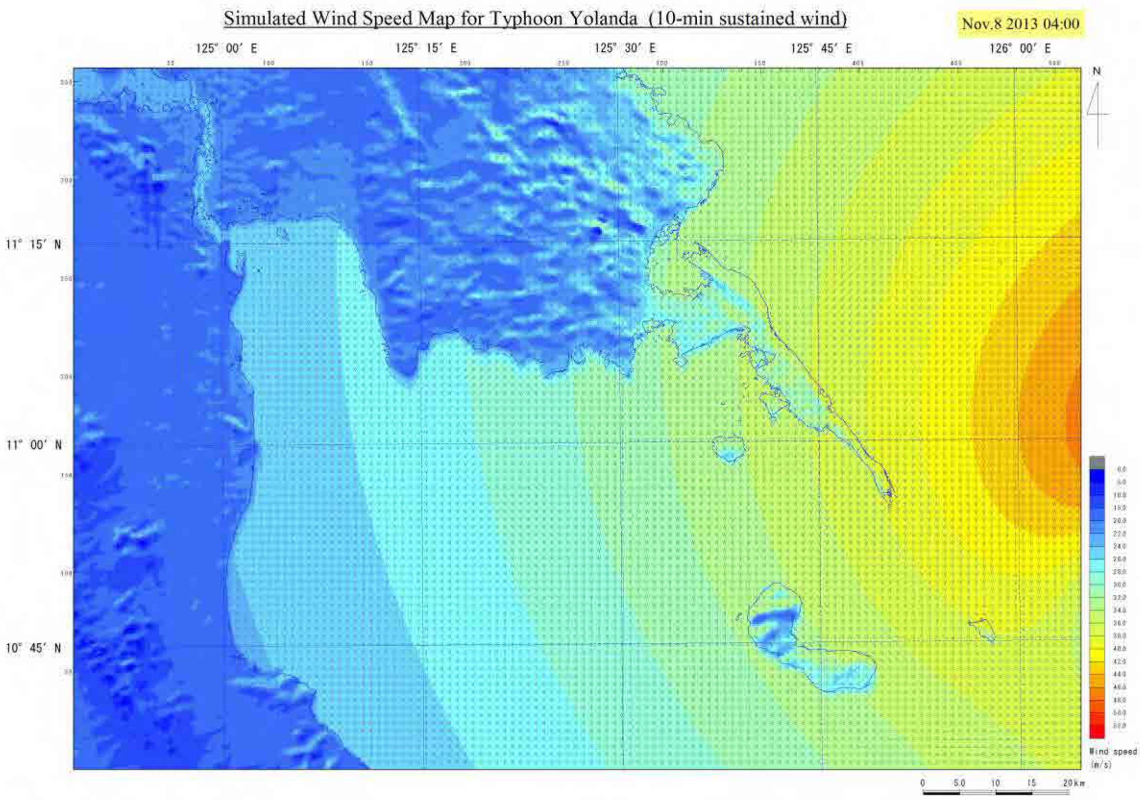
5.3.7 Simulation results

The Simulation results are shown in Figure 5.3-12 to Figure 5.3-19. Figure 5.3-12 shows maximum value and Figure 5.3-13 to Figure 5.3-19 show wind speed at every 30 minutes from 4:30 am Nov.8 2013 to 7:30 am Nov.8 2013. Note that these maps show 10-min sustained wind speed and that gustiness was higher than this.



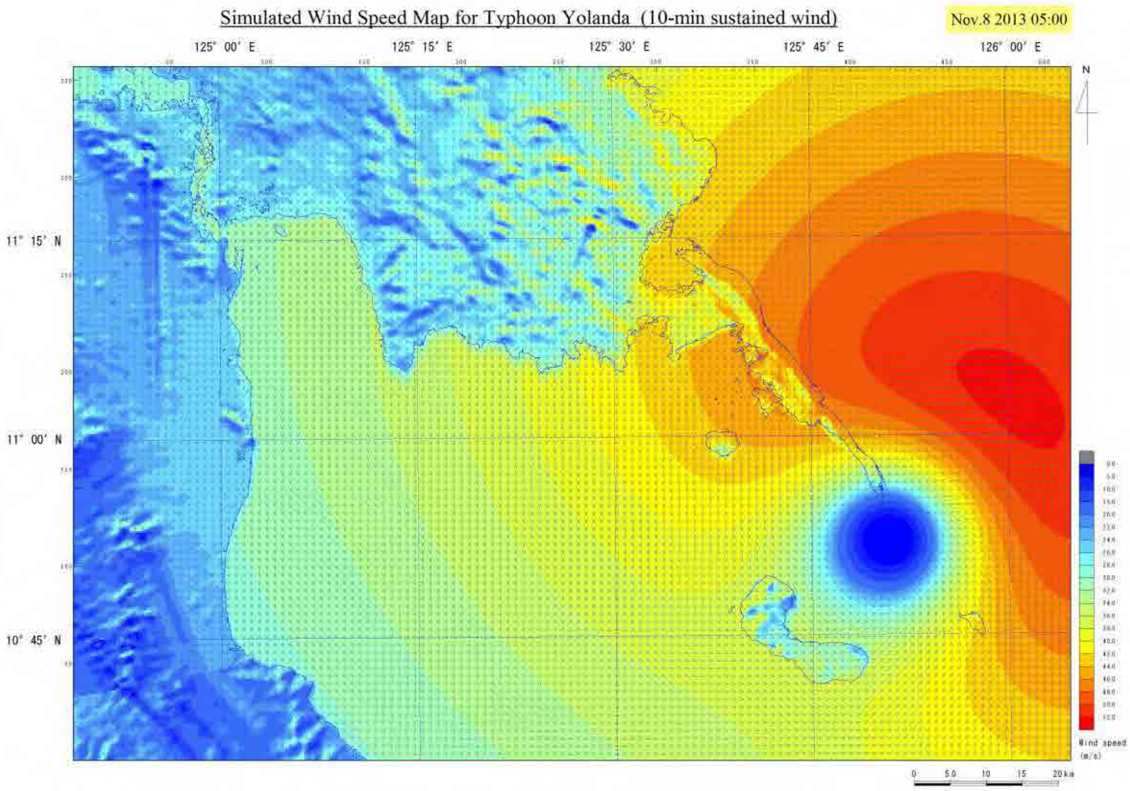
Source: JICA Study Team

Figure 5.3-12 Sustained wind speed map for Yolanda (Maximum Value)



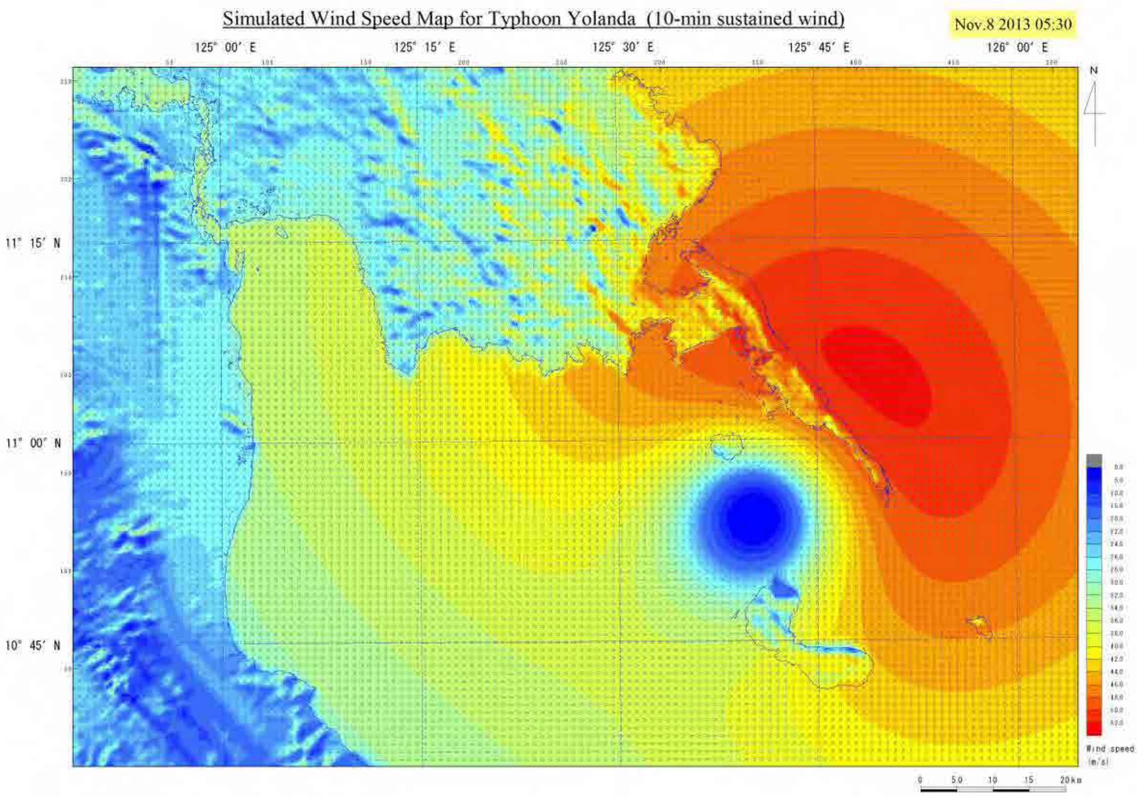
Source: JICA Study Team

Figure 5.3-13 Sustained wind speed map for Yolanda (4:30 am Nov.8 2013)



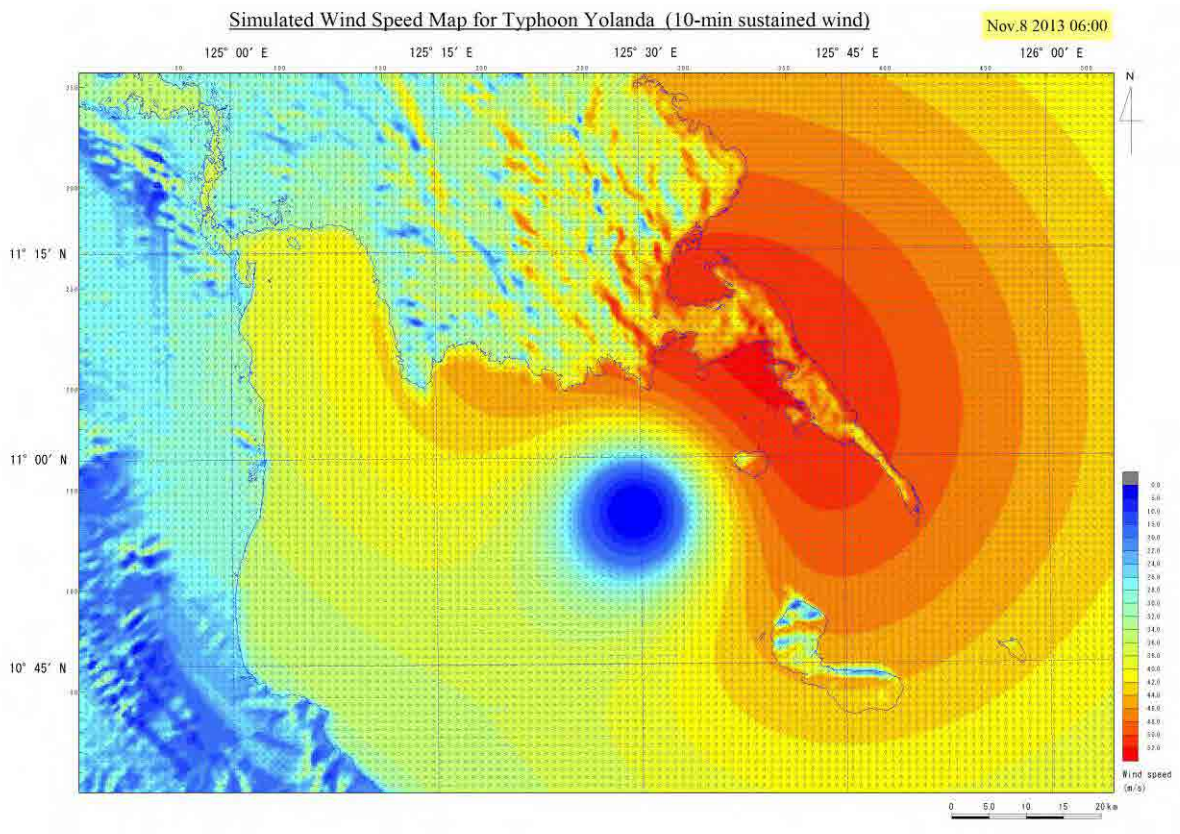
Source: JICA Study Team

Figure 5.3-14 Sustained wind speed map for Yolanda (5:00 am Nov.8 2013)



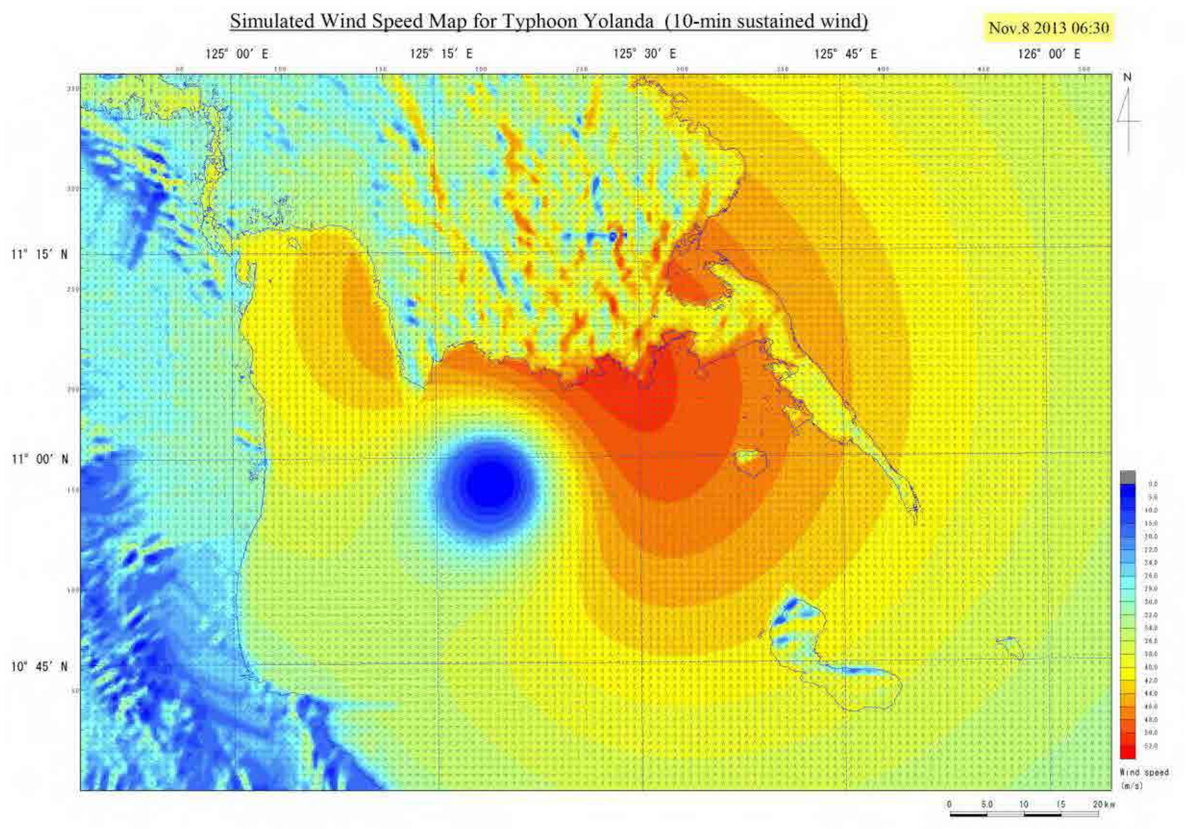
Source: JICA Study Team

Figure 5.3-15 Sustained wind speed map for Yolanda (5:30 am Nov.8 2013)



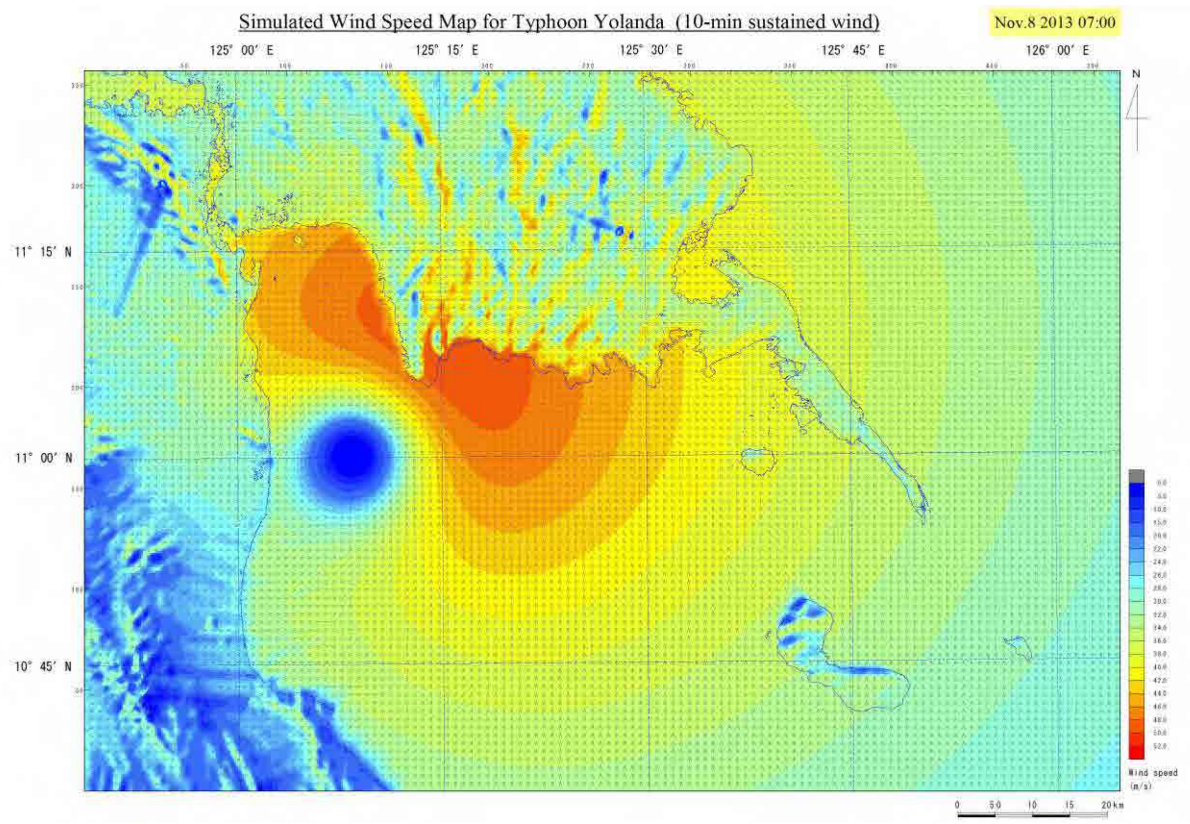
Source: JICA Study Team

Figure 5.3-16 Sustained wind speed map for Yolanda (6:00 am Nov.8 2013)



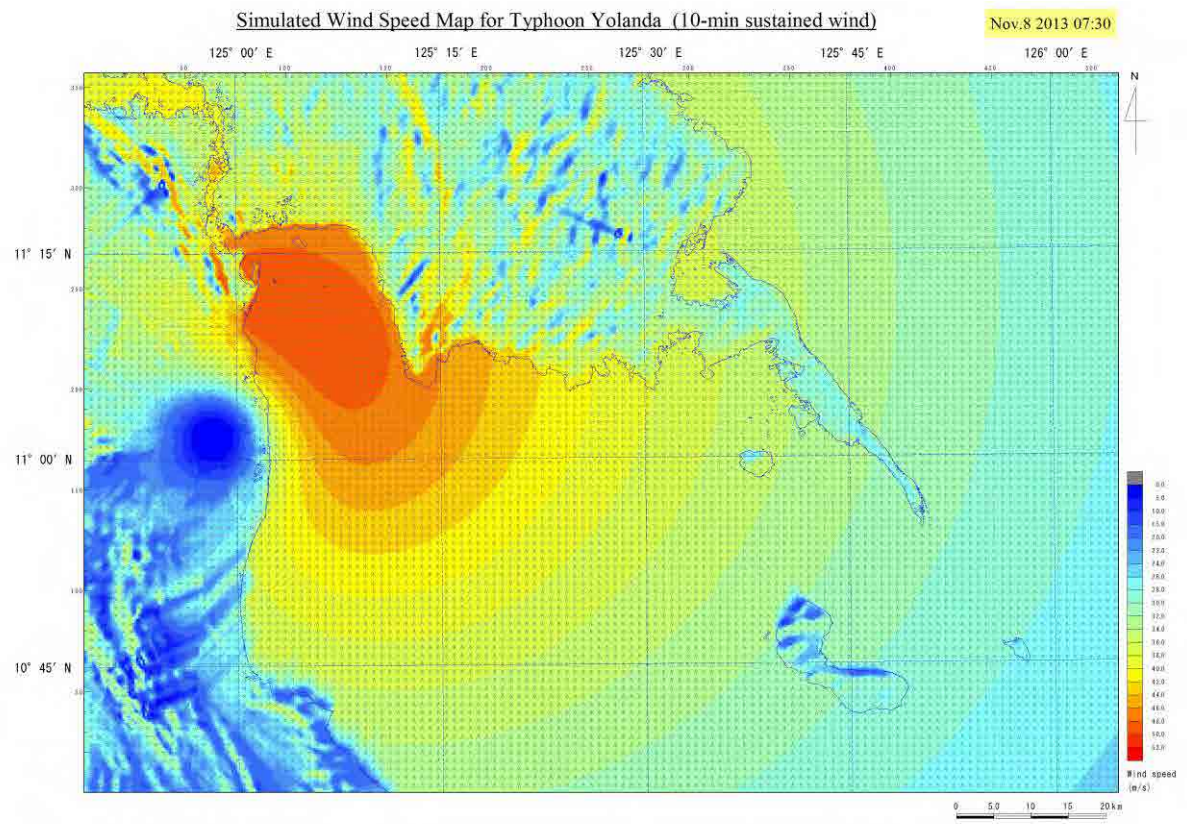
Source: JICA Study Team

Figure 5.3-17 Sustained wind speed map for Yolanda (6:30 am Nov.8 2013)



Source: JICA Study Team

Figure 5.3-18 Sustained wind speed map for Yolanda (7:00 am Nov.8 2013)



Source: JICA Study Team

Figure 5.3-19 Sustained wind speed map for Yolanda (7:30 am Nov.8 2013)

5.4 Flood Inundation Analysis

5.4.1 Objective and Output

(1) Objective

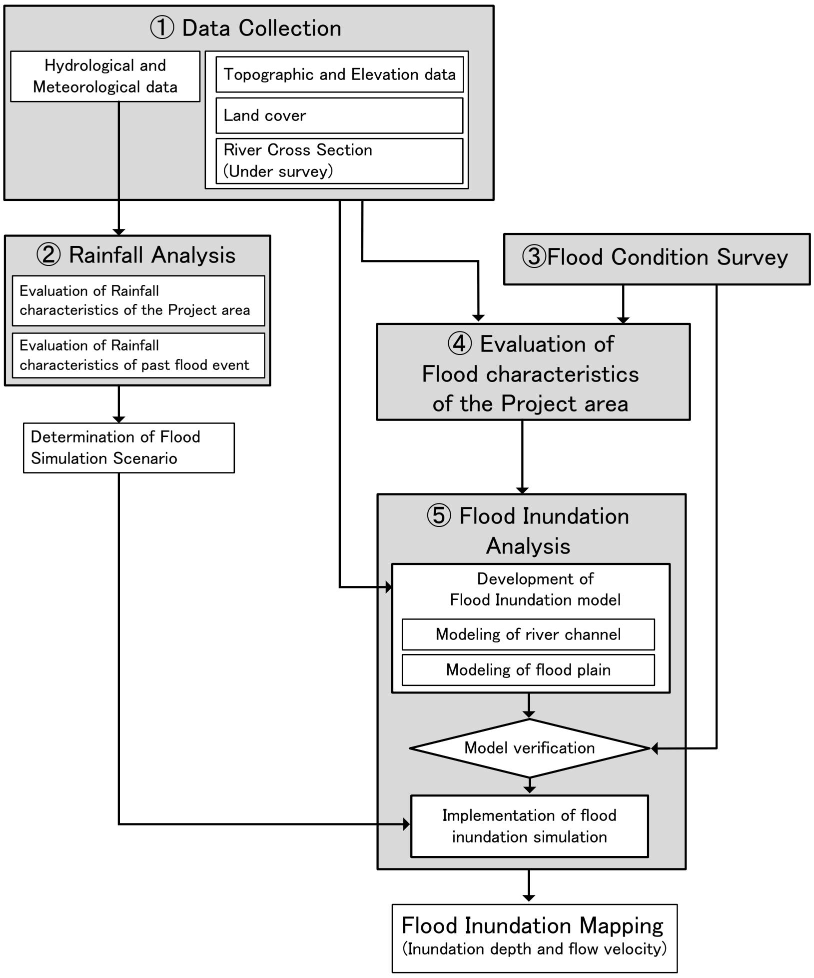
Objective of flood inundation analysis is evaluation of flood hazard as a part of multi-hazard analysis in the Project area, which is employed in the Policy and Plan for Rehabilitation and Recovery.

(2) Output

As output of flood inundation analysis, flood inundation map is developed from the results of flood inundation simulation under certain scenarios and flood condition survey

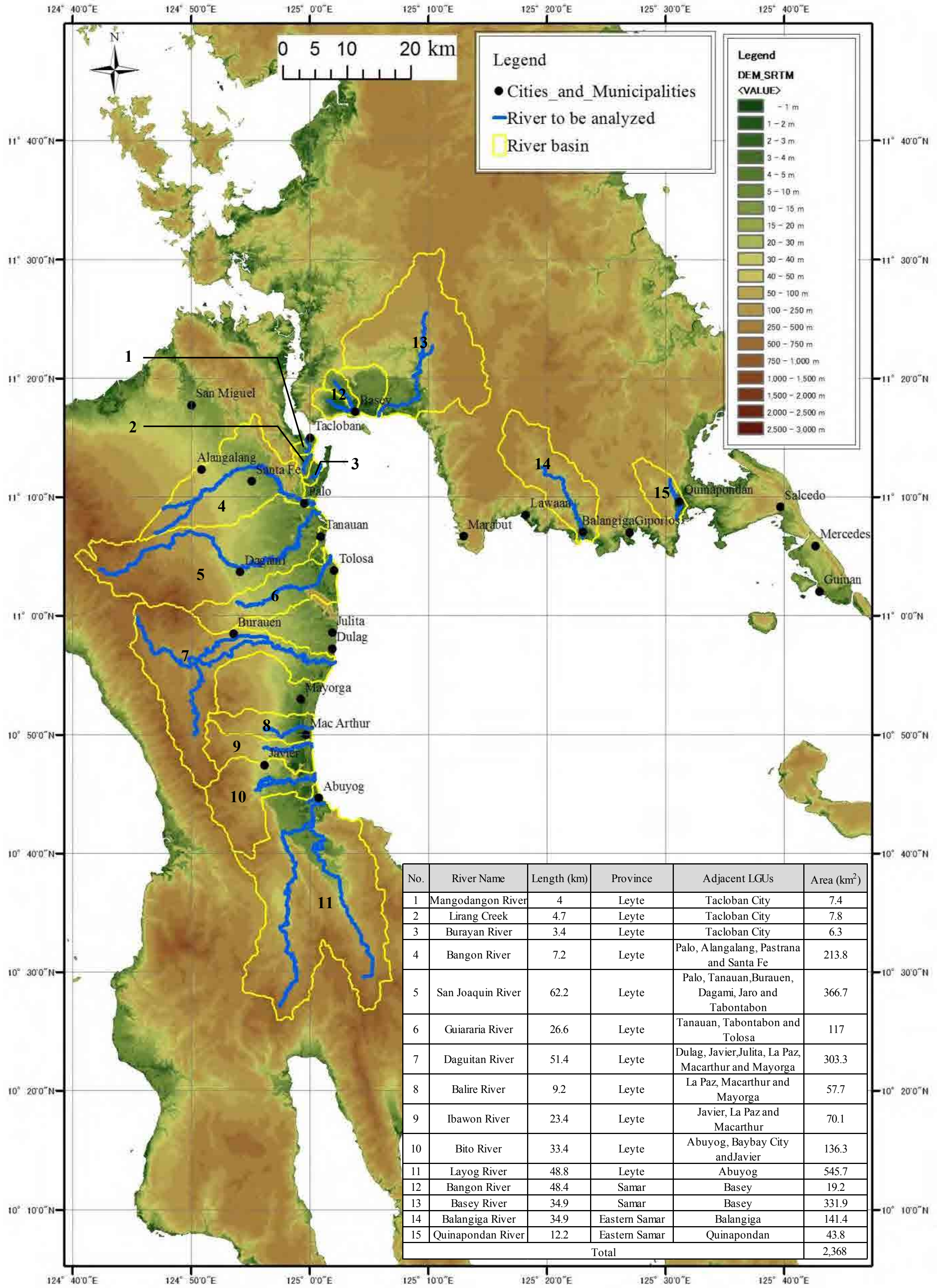
5.4.2 Work Flow

The work flow of this analysis is as follows. The target river basins for flood inundation analysis are shown in Figure 5.4-2.



Source: JICA Study Team

Figure 5.4- 1 Work Flow



No.	River Name	Length (km)	Province	Adjacent LGUs	Area (km^2)
1	Mangodangon River	4	Leyte	Tacloban City	7.4
2	Lirang Creek	4.7	Leyte	Tacloban City	7.8
3	Burayan River	3.4	Leyte	Tacloban City	6.3
4	Bangon River	7.2	Leyte	Palo, Alangalang, Pastrana and Santa Fe	213.8
5	San Joaquin River	62.2	Leyte	Palo, Tanauan,Burauen, Dagami, Jaro and Tabontabon	366.7
6	Guiararia River	26.6	Leyte	Tanauan, Tabontabon and Tolosa	117
7	Daguitan River	51.4	Leyte	Dulag, Javier,Julita, La Paz, Macarthur and Mayorga	303.3
8	Balire River	9.2	Leyte	La Paz, Macarthur and Mayorga	57.7
9	Ibawon River	23.4	Leyte	Javier, La Paz and Macarthur	70.1
10	Bito River	33.4	Leyte	Abuyog, Baybay City andJavier	136.3
11	Layog River	48.8	Leyte	Abuyog	545.7
12	Bangon River	48.4	Samar	Basey	19.2
13	Basey River	34.9	Samar	Basey	331.9
14	Balangiga River	34.9	Eastern Samar	Balangiga	141.4
15	Quinapondan River	12.2	Eastern Samar	Quinapondan	43.8
Total					2,368

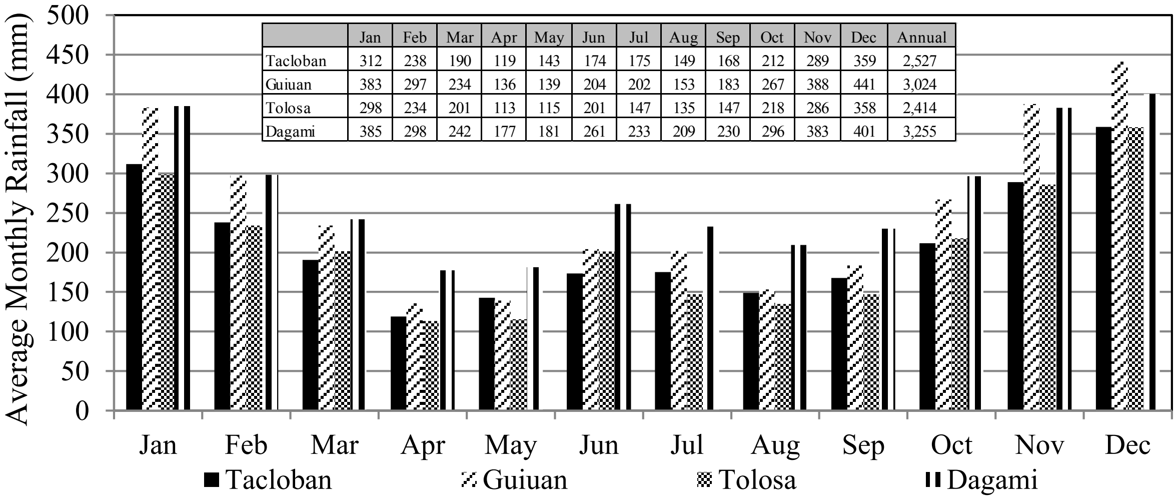
Source: JICA Study Team

Figure 5.4- 2 Target River Basins for Flood Inundation Analysis

5.4.3 Flood Characteristics the Project Area

(1) Rainfall Characteristics in the Project Area

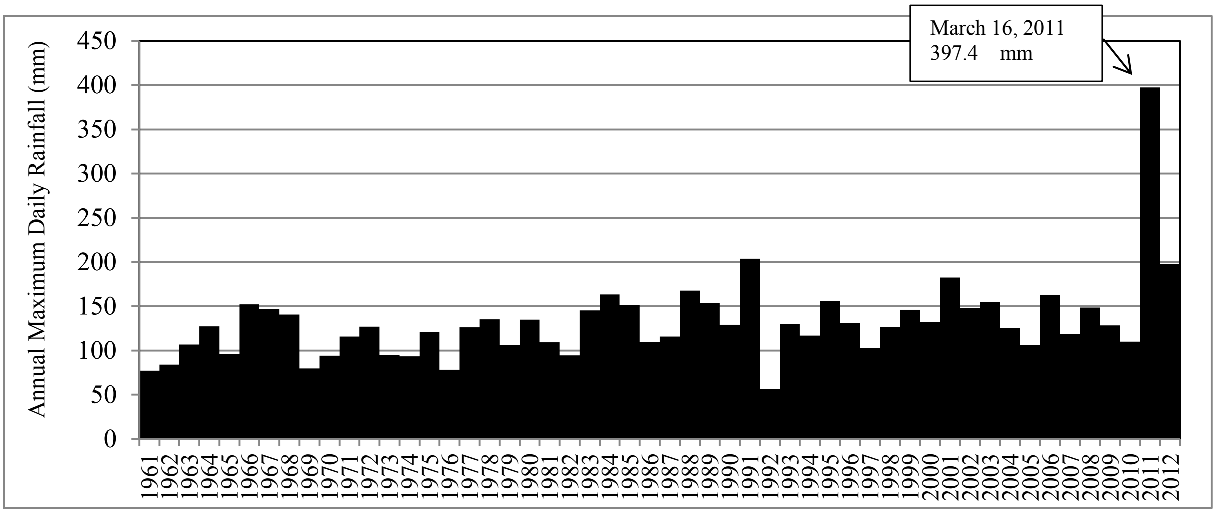
The Project area is classified into "Type2" and "Type4" in Philippines Climate Type, with unclear difference between dry and rainy seasons. Rainfall occurs through a year (as shown in Figure 5.4- 3), and increases between November to February. The biggest rainfall event in Tacloban is a continuous rainfall recorded on March 16, 2011, with daily rainfall of 397mm (as shown in Figure 5.4- 4). Its return period is beyond 400 years. According to LGUs Staff of Palo and Tanauan, it was the most serious flood occurred. On the other hand the amounts of typhoon-induced rainfall are not so significant as that of continuous rainfall. These return periods are within 5 years.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Tacloban	312	238	190	119	143	174	175	149	168	212	289	359	2,527
Guiuan	383	297	234	136	139	204	202	153	183	267	388	441	3,024
Tolosa	298	234	201	113	115	201	147	135	147	218	286	358	2,414
Dagami	385	298	242	177	181	261	233	209	230	296	383	401	3,255

Data Source: Daily and six(6) hourly Rainfall observed by PAGASA, organized in The Project

Figure 5.4- 3 Average Monthly Rainfall



Data Source: Daily and six(6) hourly Rainfall observed by PAGASA, organized in The Project

Figure 5.4- 4 Annual Maximum Daily Rainfall in Tacloban

(2) General Flood Characteristics in the Project Area

The rivers in the Project area, whose main basin areas are 300 - 550km^2, are classified into medium and small size river basins. There are different river basin characteristics between the rivers located at the Eastern Leyte and Southern Samar.

1) Eastern Leyte

The rivers located in the Eastern Leyte (e.g. Bangon, San Joaquin and Daguitan rivers), have three types of river characteristics based on topological conditions; a) alluvial area in the upper to middle reaches with steep slope, b) plain and irrigated area in the middle to lower reaches with moderate slope and c) intermixed area with lowland, swampy and residential in the lower reaches, where the river channel is meandering.

Judging from topographic condition and flood condition survey mentioned in Section 5.4.4. In the Project area, flood frequently occurs that was not as severe as people's lives lost. Flood occurred at which the river slope changes between the upper to middle reaches (e.g. Dagami and Burauen), and at lower reaches with low discharge capacity of river channel because of meandering (e.g. Palo, Tanauan, Tolosa, Dulag, MacAthur and Abuyog). As for the lower reaches rainfall inundation chronically occurs at lowland besides flood. Also it was testified that most serious hazard is flood at Abuyog.

2) Southern Samar

In the Southern Samar, the river basins have small plain areas located nearby seashore, where residential areas are also located. Besides the rivers shown in Figure 5.4-2, a lot of small creeks flow down into Leyte Gulf.

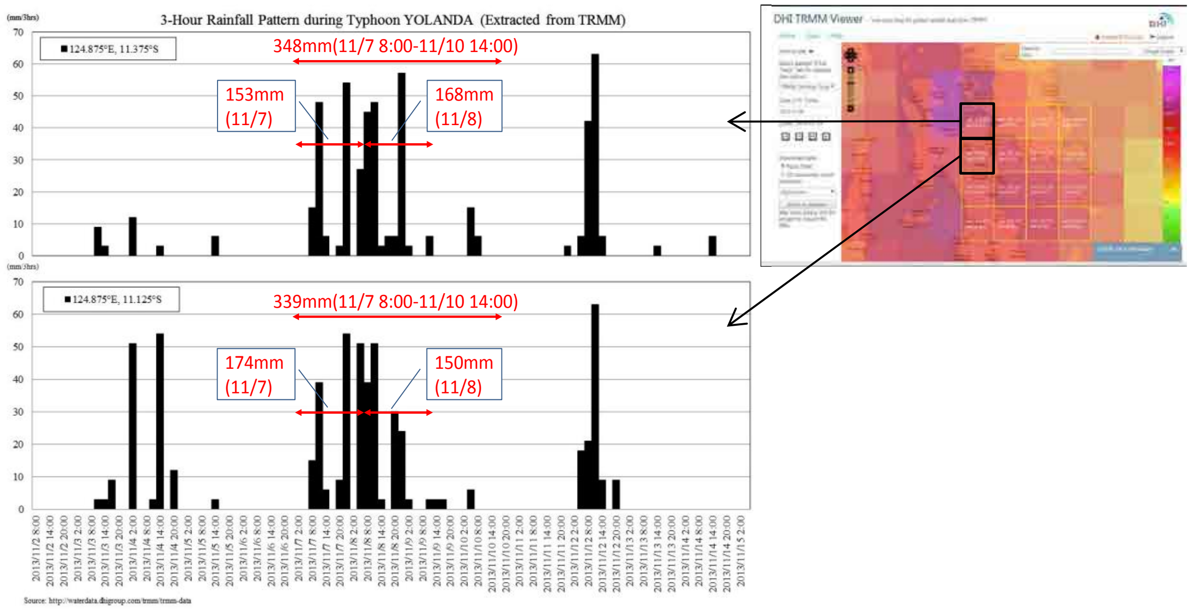
Flood occurs where their plain areas are relatively large and residential areas are also in the plain areas. Flood and rainfall inundation at lowland were testified in the flood condition survey at Southern Samar. Especially for Quinapondan river where flood has been complained by LGU Staff, who insisted that river improvement is the first priority.

(3) Flood during Typhoon YOLANDA

During Typhoon YOLANDA, unlike the devastated damage by storm surge and strong wind in the Project area, a few damage by flood have been reported in Dagami, Palo, Burauen, Dulag, etc., which are originally flood prone area.

According to TRMM (Tropical Rainfall Measurement Mission) rainfall data, which were collected from website of DHI (http://waterdata.dhigroup.com/trmm/trmm-data), it was assumed that daily rainfall is less than 200mm/day[1] (as shown in Figure 5.4- 5).

At Dulag, located adjacent to the river mouth of Daguitan River, it was testified that flood occurred due to storm surge at AM8:00 and its back water at AM11:00. As for Southern Samar, flood occurrence has been reported at Quinapondan.



Source: http://waterdata.dhigroup.com/trmm/trmm-data

Figure 5.4- 5 Three(3) Hour Rainfall Pattern around the Eastern Leyte during Typhoon YOLANDA (Extracted from TRMM)

[1] In the Project, TRMM rainfall data was not utilized for rainfall analysis, but for grasping rainfall trend as reference,

5.4.4 Flood Condition Survey

To this day, flood conditions have not been made clear in this area even for flood situation during YOLANDA and also for past flood events. Flood condition survey was conducted with questionnaire investigation covering the entire Project area. The survey is summarized in Table 5.4- 1.

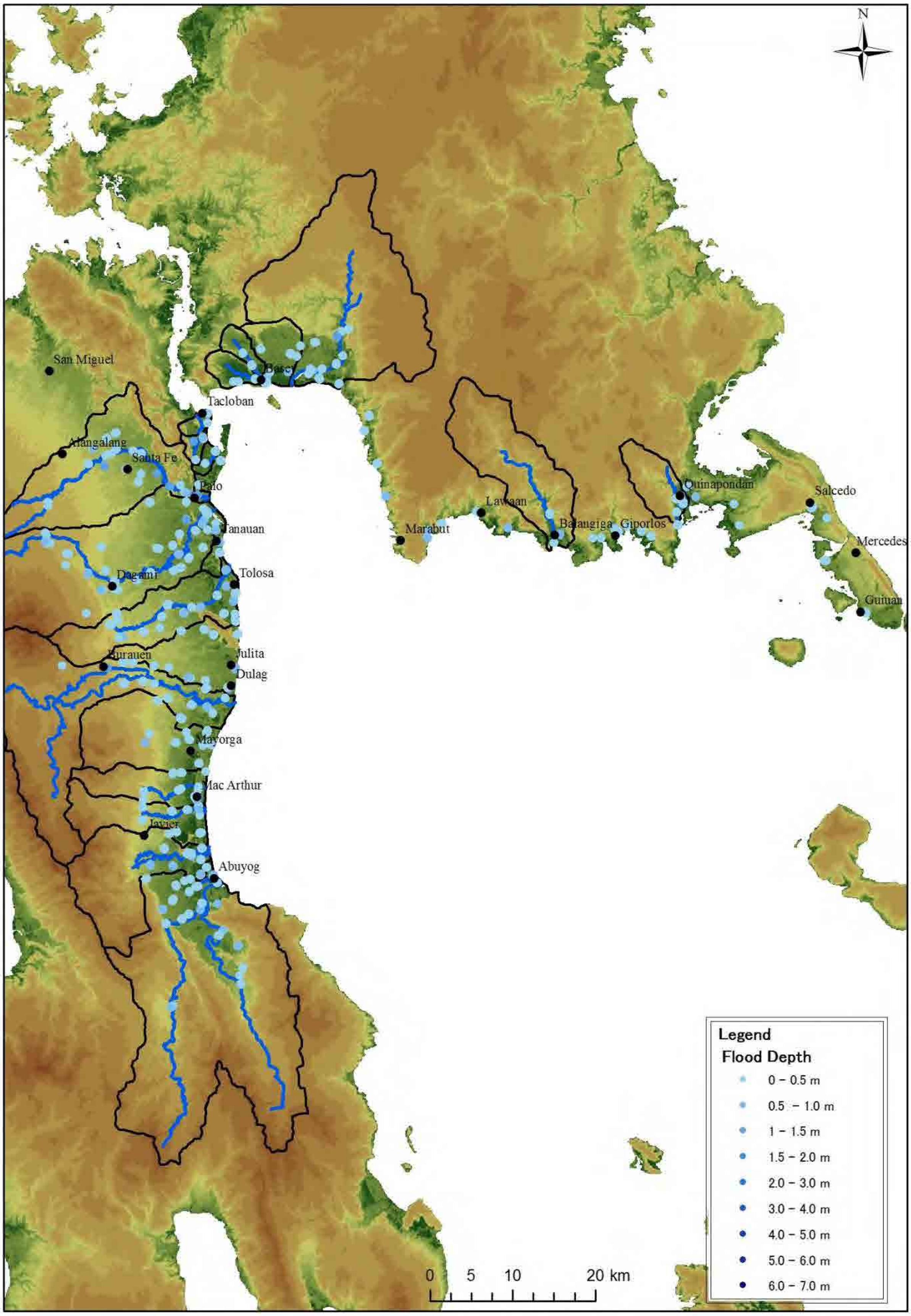
Table 5.4- 1 Summary of Flood Condition Survey

Item	Description
Survey type	Questionnaire survey
Survey Period	March to April of 2014
Target area	Entire Project area and its surrounding area
Sampling points	Approx. 800 points
Interview item	Inundation depth, Inundation duration, Flow direction, Evacuation during flood, Lost property during flood event, etc
Target flood event	1. During Typhoon YOLANDA, 2. Annual flood 3. On March 16-18, 2011 (for Bangon and San Joaquin river basins)

Source: JICA Study Team

As the survey results, flood depths for during Typhoon YOLADA, annual flood event and flood event on March 16-18 of 2011 are shown in Figure 5.4- 6, Figure 5.4- 7 and Figure 5.4- 9, respectively. It was found that there is chronically flood in the entire the Project area especially at plain area along rivers and alluvial area, which are attributes to overflow from river or rainfall inundation (as shown in Figure 5.4- 8). Also flood occurs at high populated areas such as Palo and Tanauan.

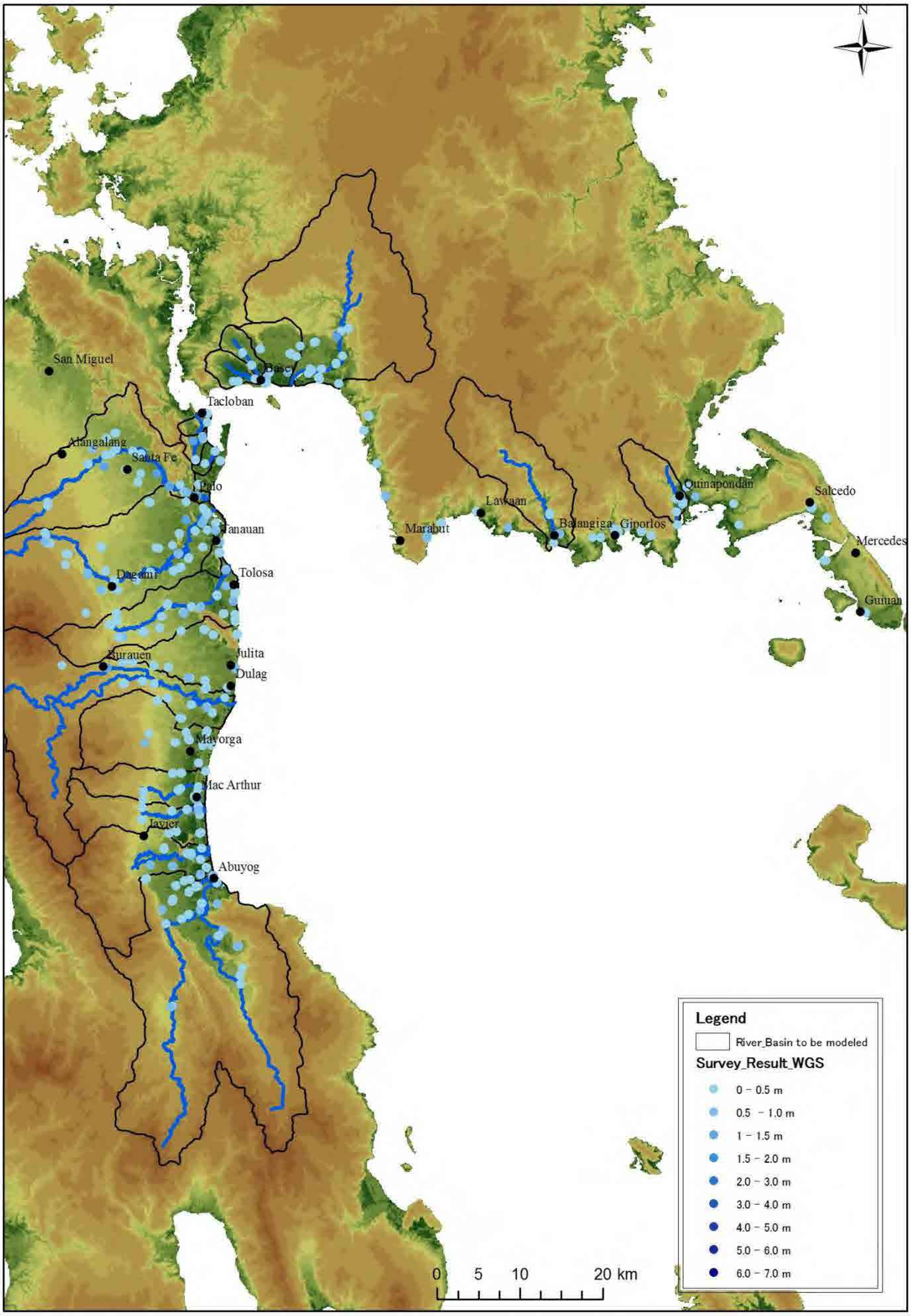
In the both cases during Typhoon YOLANDA and at annual flood event, occurrence of flood was confirmed with equivalent flood depth. As for the flood event at March 16-18 of 2013, residential area of Palo and Tanauan, flood depth exceeded 1m along the lower reaches of Bangon river and San Joaquin river.



*Surveyed points for storm surge were removed (Number of surveyed points for flood is 549).

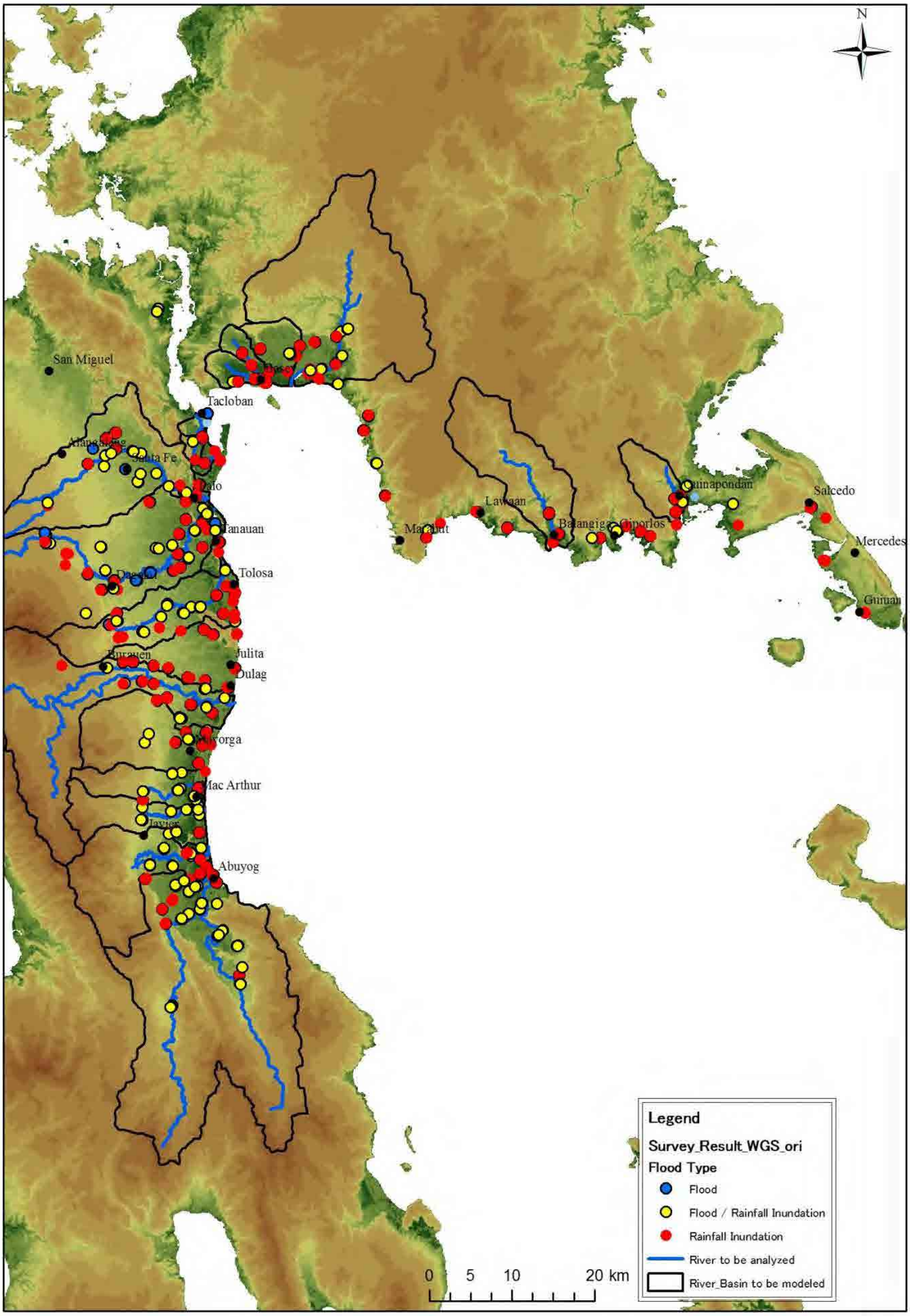
Source: JICA Study Team

Figure 5.4- 6 Survey Results (Flood Depth during Typhoon YOLANDA)



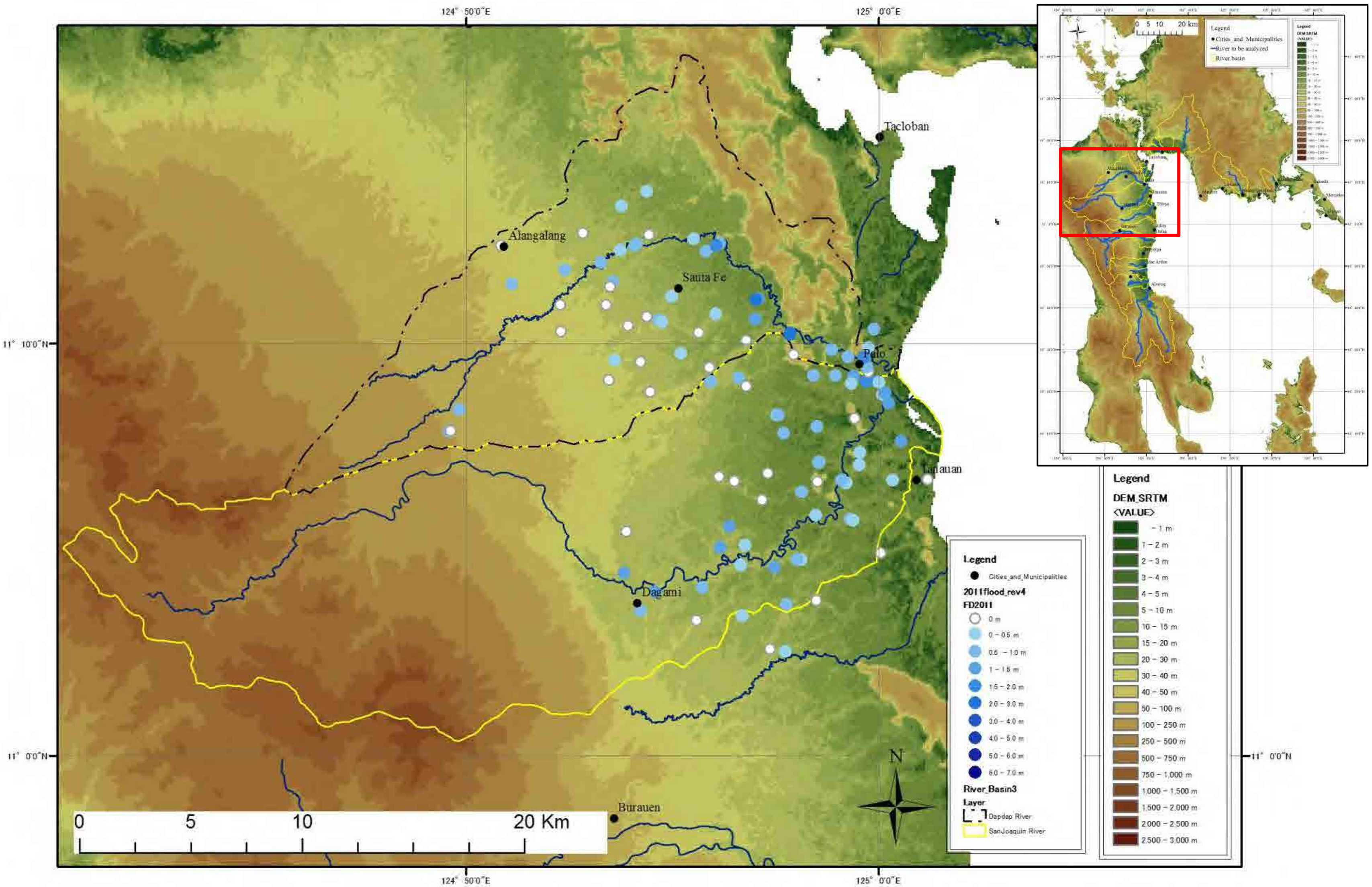
Source: JICA Study Team

Figure 5.4- 7 Survey Results (Flood Depth on Annual Flood)



Source: JICA Study Team

Figure 5.4- 8 Survey Results (Flood Type on Annual Flood)



*Number of surveyed points is 108.
Source: JICA Study Team

Figure 5.4- 9 Survey Results (Flood Depth on March 16-18, 2011 Flood)

5.4.5 Flood Inundation Simulation

Flood inundation model is developed with the considerations as summarized in Table 5.4- 2.

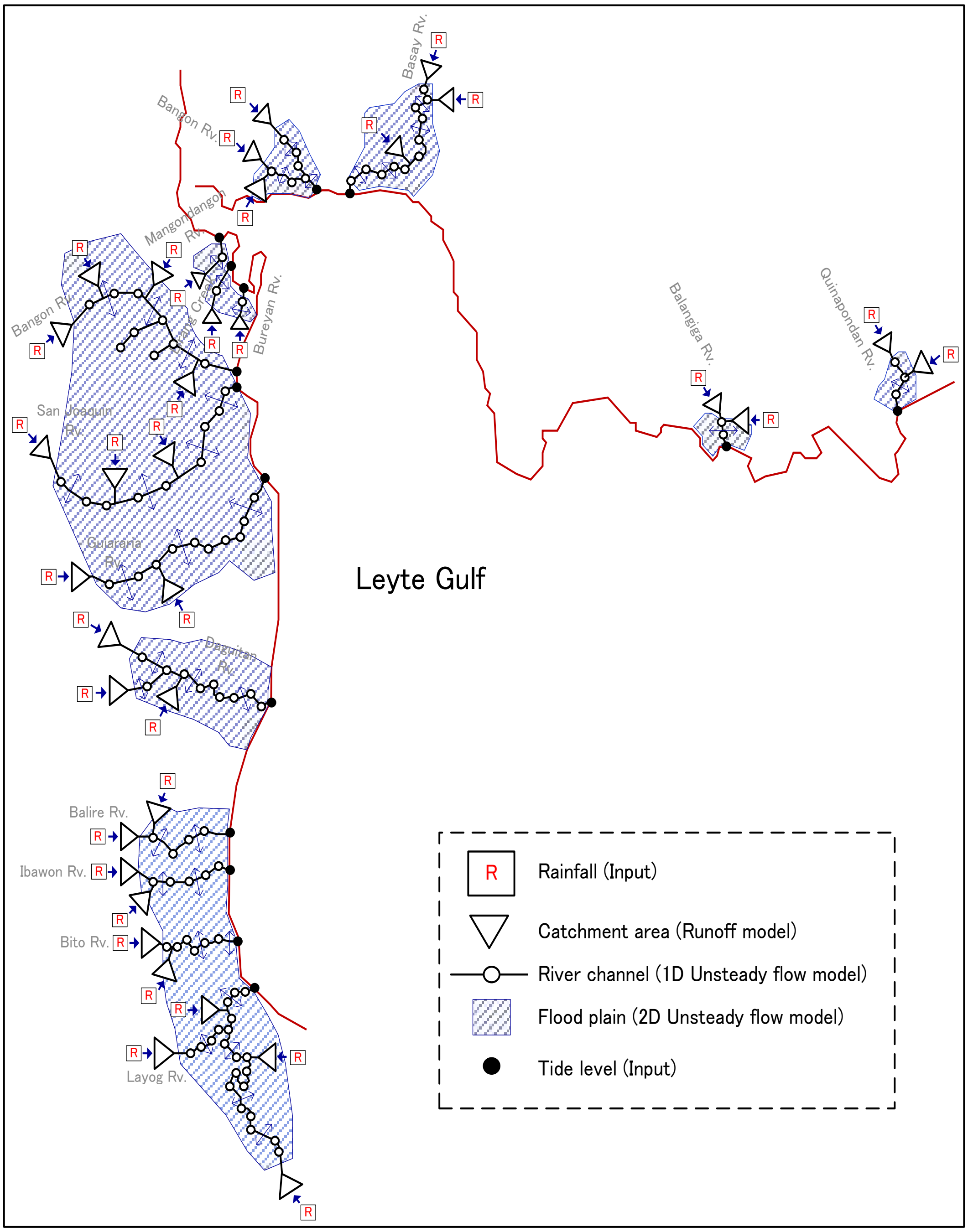
Table 5.4- 2 Summary of Flood Inundation Model

Item	Description
Modeled area	Selected 15 river basins, with Total area of approx. 2,400km^2
Mesh size	100 m
Rainfall-Runoff model	Soil Conservation Service Curve (SCS) Method
Hydraulic model	Unsteady flow model with One Dimension (River channel) and Two Dimension (Flood plain)
Model development	River channel: Surveyed river cross section Flood plain: Results of Airborne laser(LP) survey
Upstream boundary condition	River discharge, output of runoff calculation
Mid-Downstream	River discharge, lateral flow based on output of runoff calculation was given.
Downstream boundary condition	Water level (tide level), output of storm surge calculation

Source: JICA Study Team

(1) Development of Flood Inundation Model

The schematic diagram of flood inundation models is as shown in Figure 5.4-.10.Integrated hydrological and hydrodynamic models to simulate flooding conditions in the Project Area are developed in the course of the Project, which are hydrodynamic (HD) models with one-dimensional (1D) river channel network and two-dimensional (2D) flooding by overflow from the river to simulate flash flood condition for each target river basin in the Project Area. A rainfall-runoff models for short-term storm event are attached in the models.



Source: JICA Study Team

Figure 5.4- 10 Schematic Diagram of Flood Inundation Models in the Project Area

(2) Rainfall-Runoff Model

1) Catchment Area

The sub-basins covered by 1D-HD river network are further delineated as rainfall-runoff catchments. The delineated catchments are shown in Figure 5.4-11.

Basin Name	Area (km²)	Basin Name	Area (km²)
Mangondangon River	6.1	Bito River Up	66
Lirang Creek	6.8	Bito River Low	66.8
Bureygan River	6.1	Layog River UL	225.4
Bangon River Up	38.8	Layog River UR	173.5
Bangon River Up2	21.6	Layog River DL	69.3
Bangon River Mid	141.5	Layog River DR	54.5
Bangon River Low	21.8	Bangon(Basey) Up	18.1
SanJoaquin River Up	78.7	Bangon(Basey) Low	2.2
SanJoaquin River Mid	146.5	Concaran River	71.3
SanJoaquin River Low	115.7	Basey River Up	141.3
Guiararia River Up	21.1	Basey River UR	81
Guiararia River Low	73.2	Basey River Low	90.1
Daguitan River UL	142.4	Balangiga River Up	77.3
Daguitan River UR	94.3	Balangiga River Low	63.1
Daguitan River Low	51.4	Quinapondan River Up	26.3
Balire River Up	10.6	Quinapondan River Low	26.1
Balire River Low	46.4		
Ibawon River Up	10.2		
Ibawon River Low	53.9		

Source: JICA Study Team

Figure 5.4- 11 Delineation of Catchment Area

2) Loss Model

In the present study, the Soil Conservation Service (SCS) curve number method is employed as a loss model for rainfall-runoff process. The SCS method can reflect the effect of land cover and surface soil condition. The SCS curve number is calculated based on Table 5.4-.3 in the present study. The table is prepared referring to the National Engineering Handbook by Natural Resources Conservation Service, United States Department Of Agriculture (USDA).

Table 5.4- 3 SCS Curve Number Used

Land cover	Hydrological Soil Group			
	A	B	C	D
Annual Crop	61	70	77	80
Barren	77	86	91	94
Built-up Area	61	75	83	87
Fallow	74	83	88	90
Forest	25	55	70	77
Grassland	49	69	79	84
Mixed Vegetation	32	58	72	79
Shrubs	39	61	74	80
Water	100	100	100	100
Wet Area	61	70	77	80

Source: JICA Study Team

The soil condition in the study area is given by the soil map provided from Bureau of Soil and Water Management, Department of Agriculture (BSWM-DA). The soil condition by BSWM is categorized as the hydrologic soil group by applying the relationship shown in Table 5.4-4..

Table 5.4- 4 Hydrologic Soil Group

Hydrologic Soil Group	Soil Type
A	Gravel, Sand
B	Loamy sand, Sandy loam
C	Loam, Silt loam, Sandy clay loam, Clay loam, Silty clay loam
D	Clay

Source : Natural Resources Conservation Service, USDA: National Engineering Handbook, Part 630 Hydrology, Chapter 7, Hydrologic Soil Group, 20044).

The land cover data by National Mapping and Resource Information Authority (NAMRIA) (2003) is employed to estimate the SCS curve number. The category of landcover by NAMRIA is reclassified as shown in Table 5.4-5..

Table 5.4- 5 Reclassified Land cover

Category in the Preset Study	NAMRIA Category
Annual Crop	Other land, cultivated, annual crop
Barren	Other land, natural, barren land
Built-up Area	Other land, built-up area
Fallow	Other wooded land, fallow
Forest	Open forest, broadleaved
	Closed forest, broadleaved
	Forest Closed forest, mixed
	Bamboo/palm formation
Grassland	Other land, natural, grassland
Mixed Vegetation	Other wooded land, wooded grassland
	Other land, cultivated, perennial crop
Shrubs	Other wooded land, shrubs
Water	Inland water
Wet Area	Mangrove forest
	Other land, fishpond

Source: JICA Study Team

The SCS curve number is assigned for each category of land cover and hydrologic soil type. Then, the average SCS curve number for each rainfall-runoff catchment is computed. The estimated SCS curve number for each rainfall-runoff catchment is tabulated in Table 5.4-.8..

3) Model Validation

In order to validate the models developed, the calculation results and the observed data were compared at Bangon and San Joaquin River Basins.

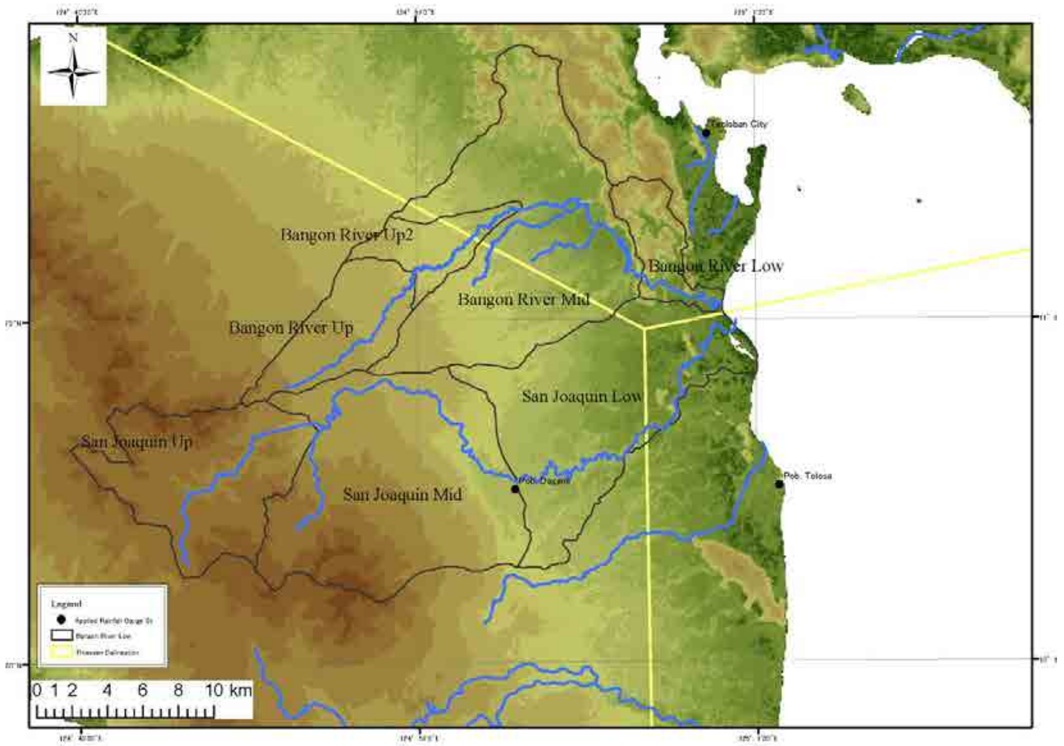
a) Boundary Condition

The rainfall event during the flood at 16Mar of 2011 was selected for validation of the model developed, when the maximum daily rainfall was observed, and which flood occurred along Bangon and San Joaquin River Basins, according to the result of flood condition survey. The given boundary conditions were summarized in Table 5.4-6.

Table 5.4- 6 Boundary Conditions

Item	Explanation	Remarks
Rainfall event	2011.3.16	- Basin average rainfall for each catchment area is calculated based on the daily rainfall observed at Tacloban、Tolosa and Dagami, Thiesen method was applied to calculate the average value.（as shown in Figure 5.4-.11 and Table 5.4-.7） - Rainfall patterns of the observed hourly rainfall at Tacloban, hourly rainfall extracted from GSMaP at Dagami and Tolosa were applied, respectively. As for Dagami and Tolosa, sum of hourly rainfall data were modified using observed daily rainfall data.
Upper Boundary condition	Calculated runoff discharge	Results of runoff calculation in the upper catchment areas.
Middle to Lower Boundary condition	Calculated runoff discharge	Results of runoff calculation in the middle and lower catchment areas. Lateral flows divided for the certain length of river channel were given.
Lower Boundary Condition	Calculated tide level during 2011.3.16 flood	Calculation results of storm surge analysis

Source: JICA Study Team



Source: JICA Study Team

Figure 5.4- 12 Thiesen Delineation

Table 5.4- 7 Thiesen Coefficients

	Area (km^2)				Tiessen Coeffcient		
	Dagami	Tacloban	Tolosa	Total	Dagami	Tacloban	Tolosa
Bangon River Low	0	21.91	0	21.91	0	1	0
Bangon River Mid	53.68	87.86	0	141.53	0.379	0.621	0
Bangon River Up2	17.14	4.49	0	21.62	0.793	0.207	0
Bangon River Up	38.78	0	0	38.78	1	0	0
SanJoaquin Low	85.08	5.97	24.93	115.98	0.734	0.051	0.215
SanJoaquin Mid	146.55	0	0	146.55	1	0	0
SanJoaquin Up	78.68	0	0	78.68	1	0	0

Source: JICA Study Team

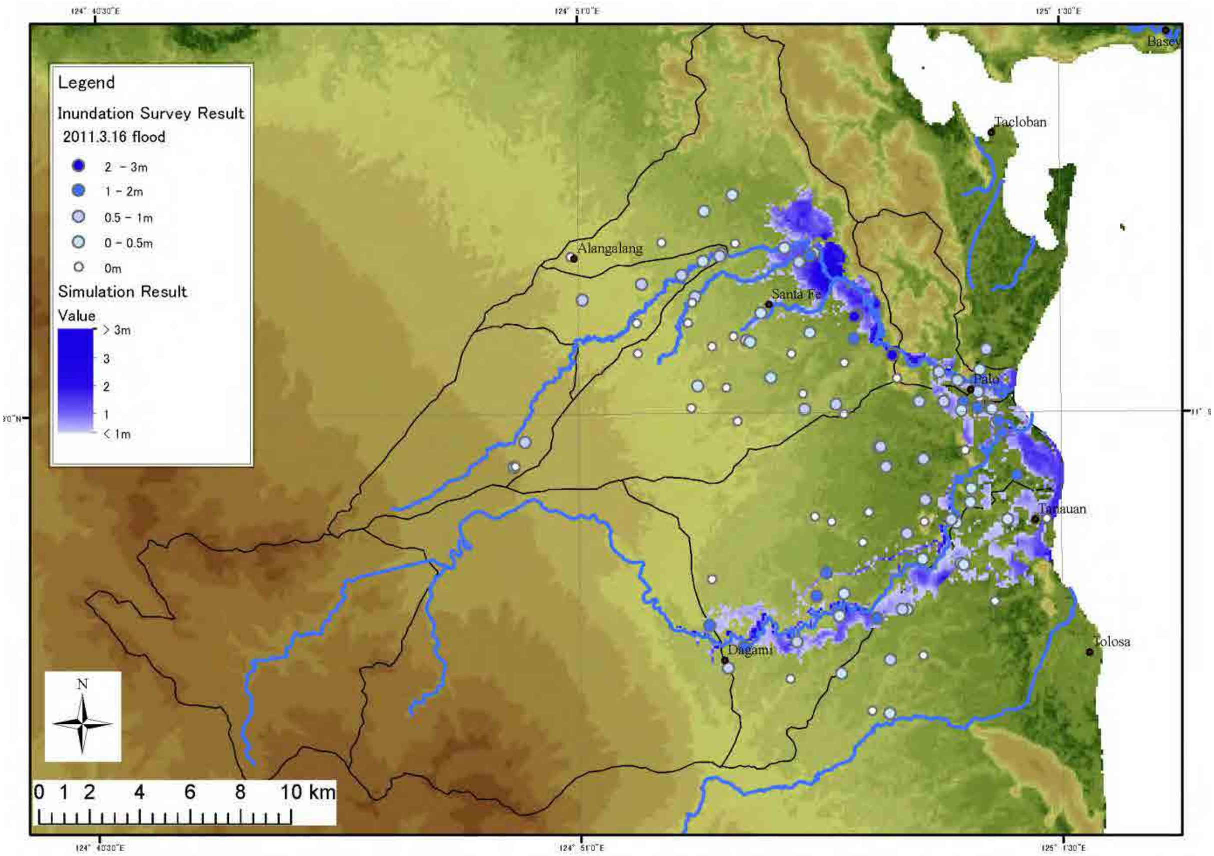
Table 5.4- 8 Parameters of SCS Model

	Area (km^2)	Flood Arrival Time (min)	SCS Curve No.	Impervious Ratio (%)
Mangondangon River	6.1	52	80	43.9
Lirang Creek	6.8	47	80	50.1
Bureygan River	6.1	47	79	60.4
Bangon River Up	38.8	82	70	0.8
Bangon River Up2	21.6	78	70	0.8
Bangon River Mid	141.5	117	74	0.8
Bangon River Low	21.8	109	77	8.3
SanJoaquin River Up	78.7	87	29	0.0
SanJoaquin River Mid	146.5	149	49	0.5
SanJoaquin River Low	115.7	189	73	1.6
Guiararia River Up	21.1	54	54	0.2
Guiararia River Low	73.2	189	67	3.1
Daguitan River UL	142.4	144	32	0.2
Daguitan River UR	94.3	173	32	0.0
Daguitan River Low	51.4	189	74	2.5
Balire River Up	10.6	59	33	0.0
Balire River Low	46.4	113	64	0.9
Ibawon River Up	10.2	44	36	0.0
Ibawon River Low	53.9	119	61	0.6
Bito River Up	66.0	78	32	0.0
Bito River Low	66.8	149	66	0.3
Layog River UL	225.4	173	37	0.1
Layog River UR	173.5	149	33	0.0
Layog River DL	69.3	149	66	1.9
Layog River DR	54.5	133	47	0.2
Bangon(Basey) Up	18.1	70	75	1.2
Bangon(Basey) Low	2.2	46	75	21.6
Concaran River	71.3	149	68	0.7
Basey River Up	141.3	135	52	0.1
Basey River UR	81.0	149	32	0.0
Basey River Low	90.1	149	68	0.6
Balangiga River Up	77.3	125	36	0.0
Balangiga River Low	63.1	109	77	1.0
Quinapondan River Up	26.3	59	79	0.1
Quinapondan River Low	26.1	213	78	1.1

Source: JICA Study Team

b) Result of Validation

Because of the limited availability of hourly-observed hydrological data such as river water level and river discharge in the Project Area (Observation by Project-NOAH started from March of 2013), which are utilized for model validation, the results of calculation results of the developed model and flood condition survey (flood depth and inundation area) were compared as shown in Figure 5.4-.12. The result shows that the developed model has a good expression of flood characteristics of the target area and has been adequately verified for flood characteristics in the target area. The developed model has been applied for the flood inundation simulation and determination of flood hazard area.



Source: JICA Study Team

Figure 5.4- 13 Comparison between Simulation Result and Flood Condition Survey

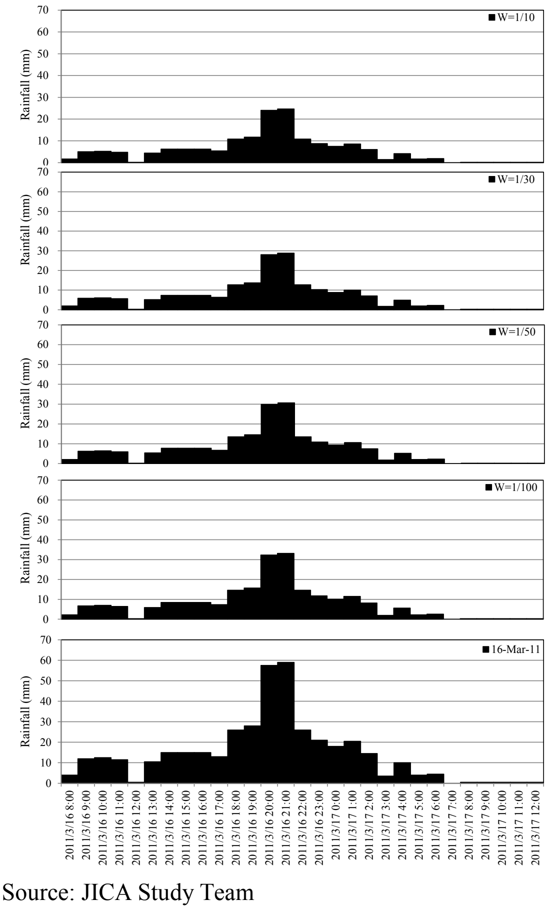
5.4.6 Simulation Scenario

Scenarios for flood inundation simulation are summarized at Table 5.4- 9. Five(5) scenarios are given to flood inundation model for input conditions.

Table 5.4- 9 Simulation Scenarios

Item	Description	Remarks
Rainfall patterns	Hyetographs are to be expanded using the following daily rainfall amounts* ➢ Rainfall events (Tacloban : 2011.3.16) ➢ Probable Rainfall with return periods of 10, 30, 50 and 100 years	Hyetograph applied to model will be based on past rainfall events (Tacloban: March 16, 2011)
Upper Boundary condition	Calculated runoff discharge	Results of runoff calculation in the upper catchment areas.
Middle to Lower Boundary condition	Calculated runoff discharge	Results of runoff calculation in the middle and lower catchment areas. Lateral flows divided for the certain length of river channel were given.
Lower Boundary Condition	Calculated tide level during 2011.3.16 flood	Calculation results of storm surge analysis

* Hyetograph of each rainfall event is illustrated in Figure 5.4-.14.
Source: JICA Study Team



Source: JICA Study Team

Figure 5.4- 14 Hyetograph of the Applied Rainfall Event

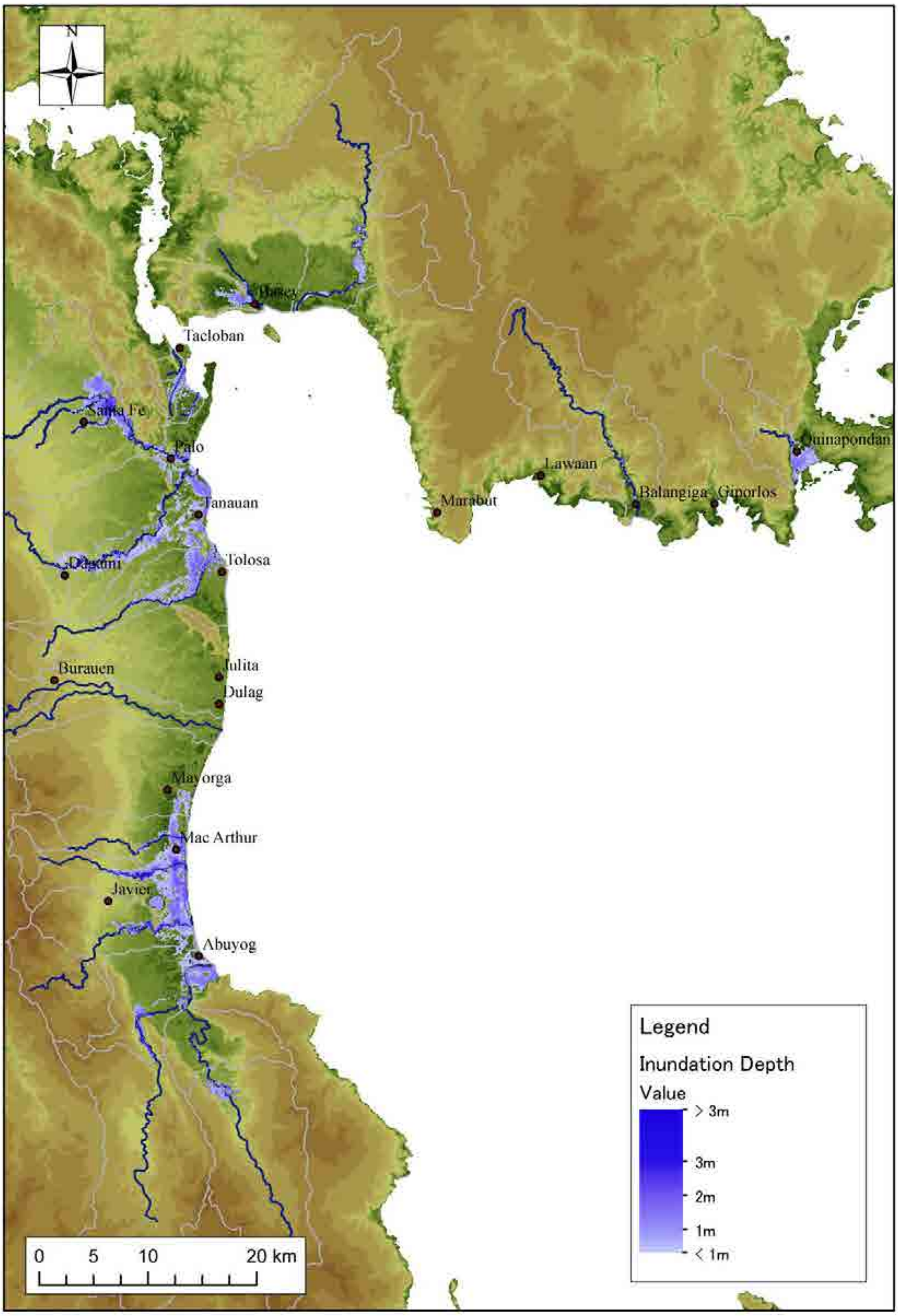
Table 5.4- 10 Summary of Probable Peak Discharge

No.	Basin Name	Area (km^2)	Probable Peak Discharge (m^3/s)				
			16Mar, 2011	W=100	W=50	W=30	W=10
1	Mangondagon	6.1	87	47	43	40	33
2	Lirang	6.8	99	54	49	46	38
3	Bureygan	6.1	90	49	45	42	35
4	Bangon Up	38.8	433	204	182	166	131
5	Bangon Up2	21.6	241	114	102	93	73
6	Bangon Mid	141.5	1517	729	654	597	475
7	Bangon Low	21.8	249	125	113	104	84
8	SanJoaquin Up	78.7	247	42	31	24	9
9	SanJoaquin Mid	146.5	961	322	270	234	162
10	SanJoaquin Low	115.7	1011	487	437	399	318
11	Guiararia Up	21.1	208	77	66	57	40
12	Guiararia Low	73.2	602	274	243	220	171
13	Daguitan UL	142.4	446	93	72	57	29
14	Daguitan UR	94.3	310	64	49	39	20
15	Daguitan Low	51.4	454	221	199	182	146
16	Balire Up	10.6	48	9	7	6	3
17	Balire Low	46.4	449	193	169	152	115
18	Ibawon Up	10.2	60	12	9	7	5
19	Ibawon Low	53.9	486	199	174	155	117
20	Bito Up	66	271	49	39	31	17
21	Bito Low	66.8	561	245	218	196	152
22	Layog UL	225.4	921	227	182	150	92
23	Layog UR	173.5	600	128	99	80	44
24	Layog DL	69.3	623	278	246	222	171
25	Layog DR	54.5	352	114	95	81	53
26	Bangon Basey Up	18.1	220	107	96	88	70
27	Bangon Basey Low	2.2	31	16	14	13	11
28	Concaran Up	71.3	655	298	264	239	186
29	Basey Up	141.3	1025	371	316	274	191
30	Basey R	81	265	54	42	33	17
31	Basey Low	90.1	827	376	334	302	235
32	Balangiga Up	77.3	339	75	61	51	30
33	Balangiga Low	63.1	715	355	320	294	237
34	Quinapondan Up	26.3	350	177	160	148	120
35	Quinapondan Low	26.1	230	115	103	95	77

Source: JICA Study Team

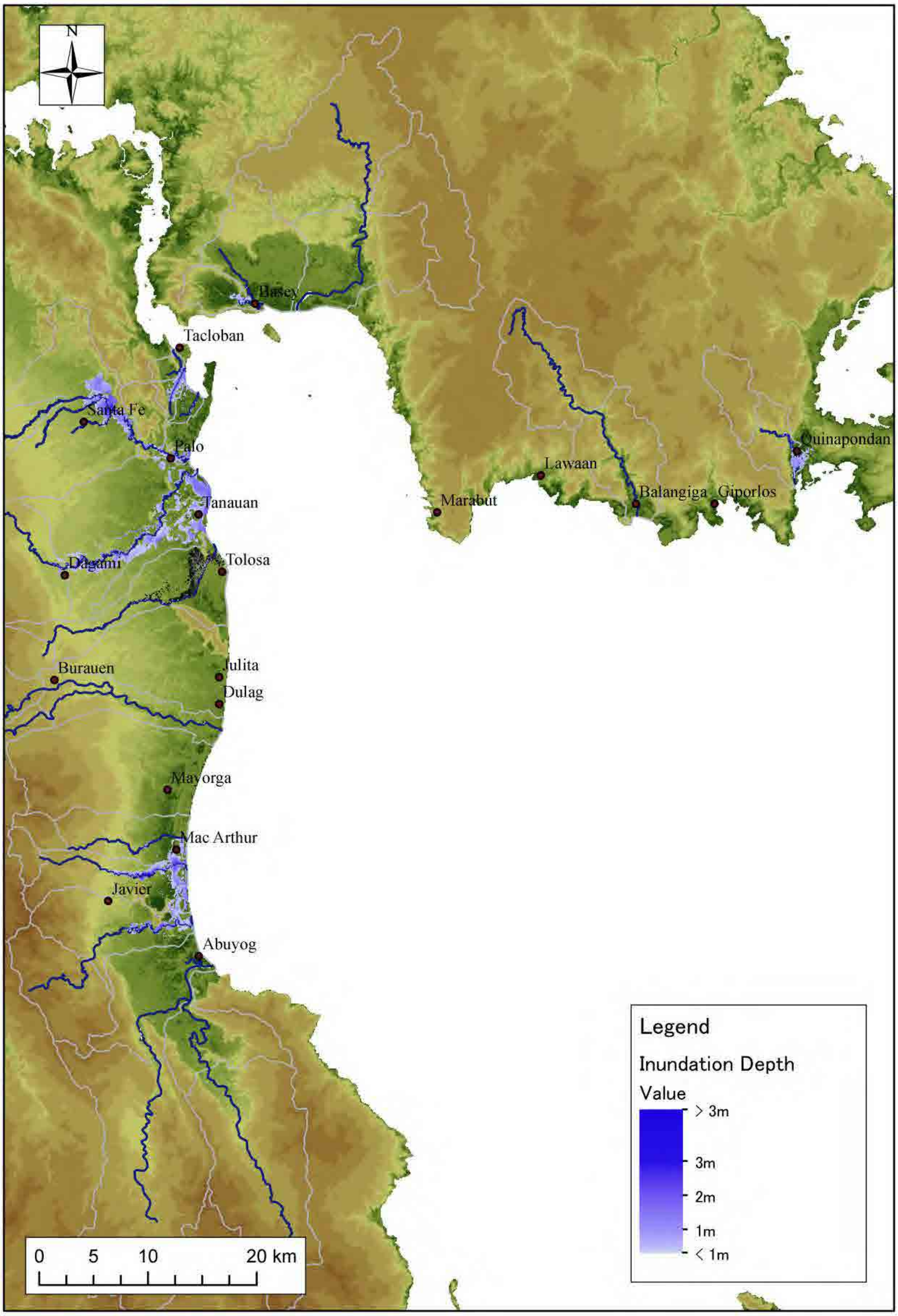
5.4.7 Simulation Results

Simulation result for each scenario described in 5.4-.6 is as shown in Figure 5.4- 15 to Figure 5.4-19.



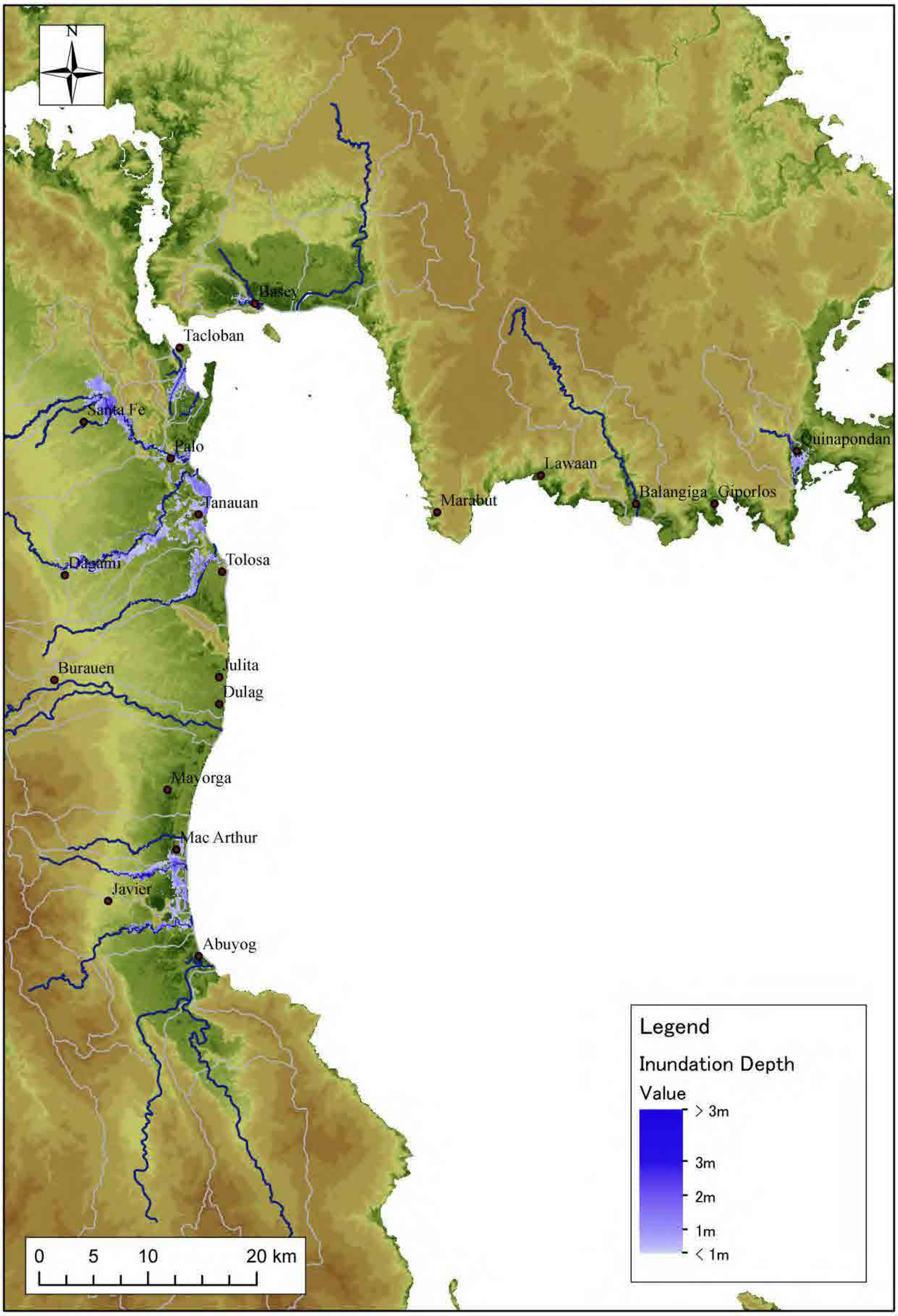
Source: JICA Study Team

Figure 5.4- 15 Simulation Result (Rainfall Event on March16, 2011 at Tacloban)



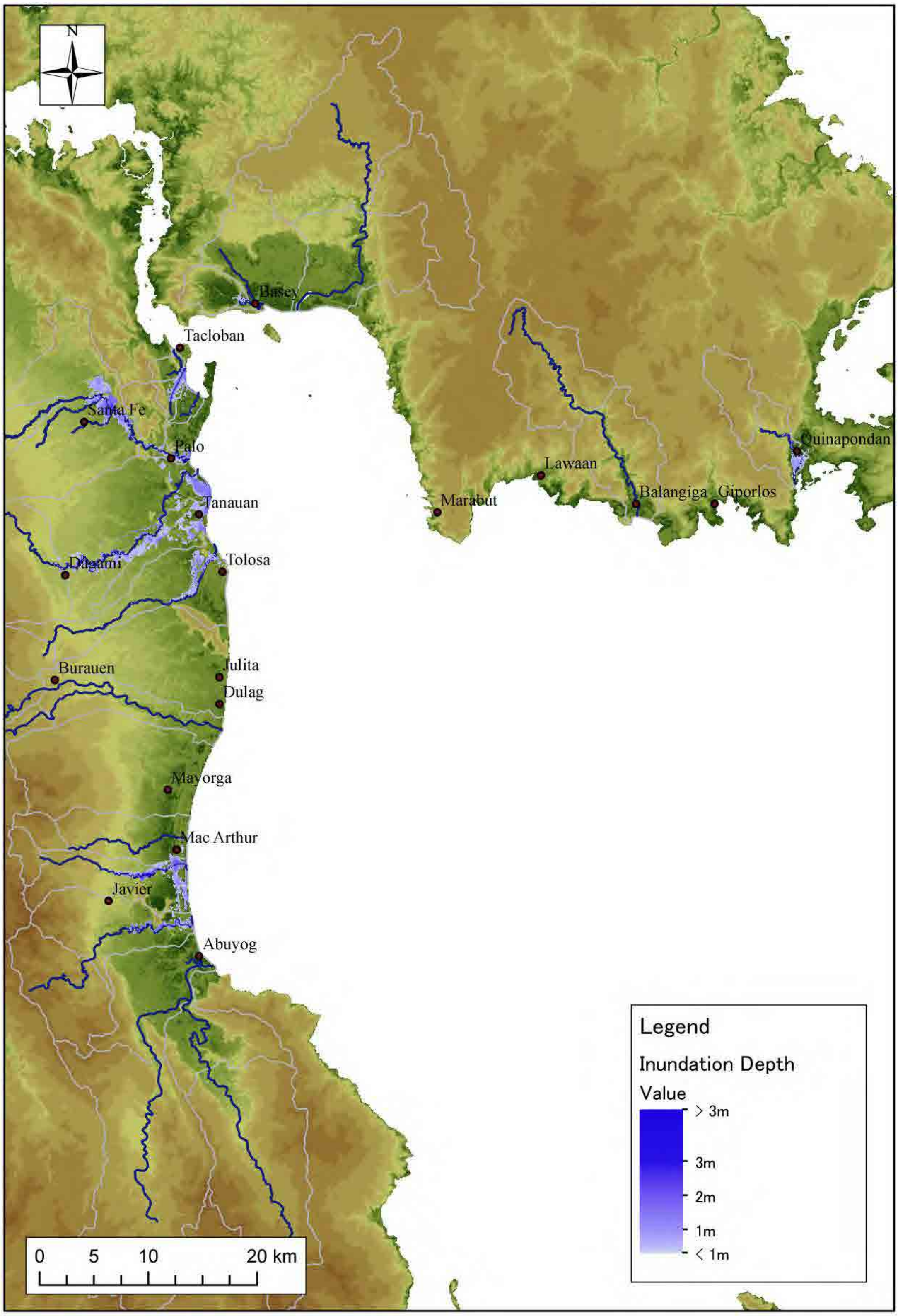
Source: JICA Study Team

Figure 5.4- 16 Simulation Result (Return Period of 100 Year)



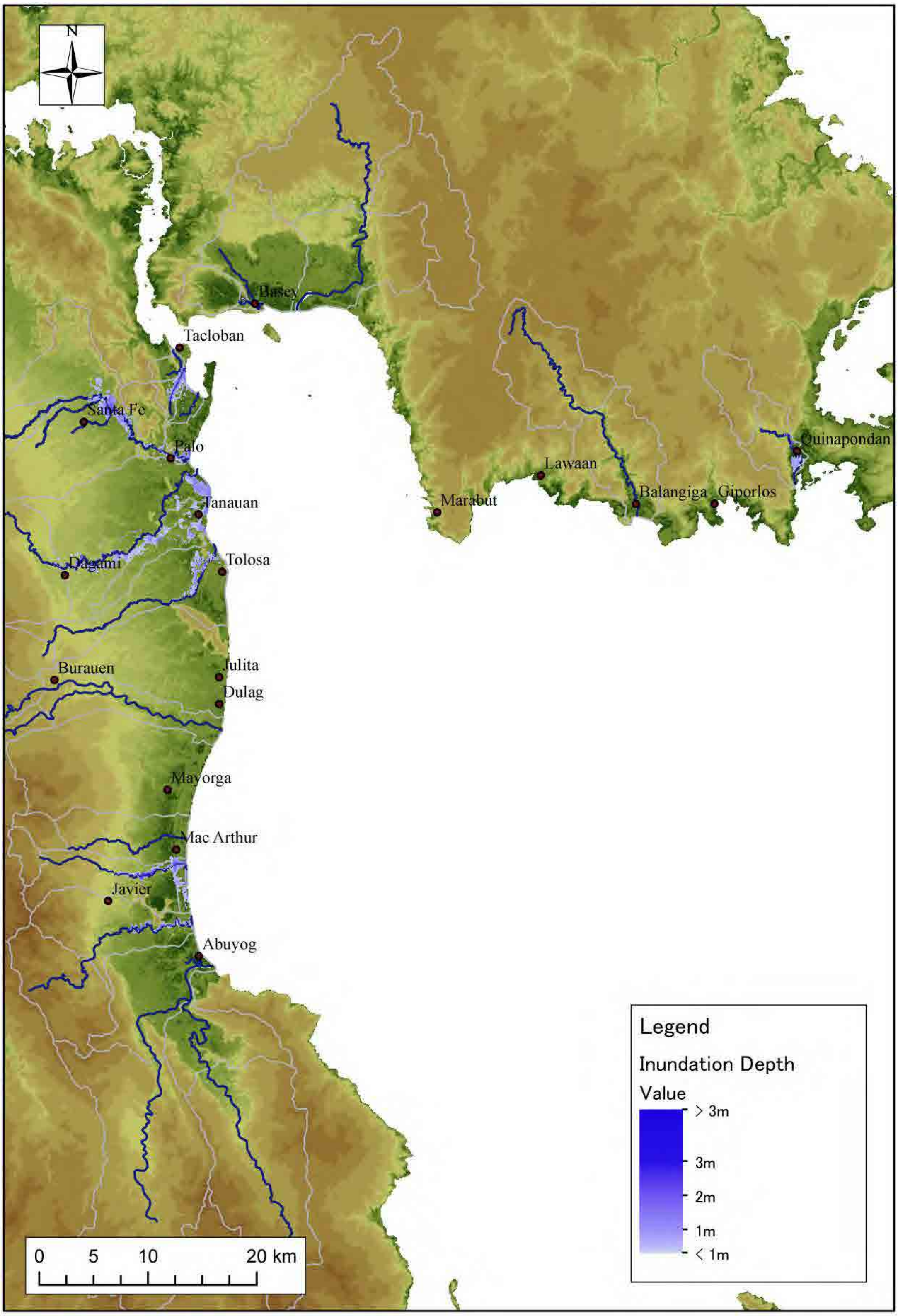
Source: JICA Study Team

Figure 5.4- 17 Simulation Result (Return Period of 50 Year)



Source: JICA Study Team

Figure 5.4- 18 Simulation Result (Return Period of 30 Year)



Source: JICA Study Team

Figure 5.4- 19 Simulation Result (Return Period of 10 Year)

5.5 Earthquake and Tsunami

5.5.1 Objective and Output

Seismic and tsunami hazard analysis will not be conducted in this project and the existing hazard map will be referred to instead. The seismic and tsunami hazard maps, which will be used in the project, are those developed by Philippine Institute of Volcanology and Seismology (PHIVOLCS), Department of Science and Technology, under the framework of READY project (Hazards Mapping and Assessment for Effective Community-Based Disaster Risk Management) implemented by a multi-agency participation (PHIVOLCS, PAGASA, MGB, NAMRIA and OCD, chaired by OCD) and financed by United Nations Development Programme (UNDP) and Australian Agency for International Development (AusAID). The READY project has prepared a set of multi-hazard maps covering (1) earthquake-related hazards (ground rupture, ground shaking, liquefaction, earthquake-induced landslide and tsunami) and (2) hydro-meteorological hazards, such as rain-induced landslide, floods/flashfloods and storm surge. The READY project has finished hazard mapping for 27 provinces, including Leyte and Eastern Samar. But Samar is not on the list. The available hazard maps for the project area are shown in Table 5.4-1.

Seismic ground shaking hazard and tsunami hazard will be considered in the process of making the recovery and rehabilitation plan. However, it has to be noted that, besides the READY hazard map, the seismic hazard map specified in the National Structural Code will also be considered since it has to be followed in building construction. The field of application of the hazard is shown in Table 5.5-2.

For the ground shaking hazard of Samar, where the READY project doesn't cover, the earthquake environment will be investigated and the strength of ground shaking near the southern Samar lineament will be estimated. It should be pointed out that the seismic hazard from READY project, which was derived from several scenario earthquakes, cannot be used directly for seismic design and the hazard map from National Structural Code should be applied serves as the lowest limit. The tsunami inundation hazard of Samar, not available from READY project, will be estimated with a simple way by making use of the tsunami height at coast line, which will be evaluated by considering the height of READY project at the neighboring coast line as well as that of the maximum height in the history, and the elevation data of land.

Table 5.5-1 Availability of Hazard Maps from READY Project for the Project Area

Hazard map	Leyte	Eastern Samar	Samar
Seismic hazard	Ground shaking map	Ground shaking map	-
Tsunami hazard	Inundation map	Inundation map	-
Earthquake-induced landslide	Susceptibility map	Susceptibility map	-
Rain-induced landslide	Susceptibility map	Susceptibility map	-

Source: JICA Study Team

Table 5.5-2 The application of seismic and tsunami hazard

Hazard	Application
Ground shaking hazard	✧ Land use planning ✧ Seismic risk assessment ✧ Seismic design and seismic strengthening ✧ Public awareness
Tsunami inundation hazard	✧ Land use planning ✧ Construction of tide embankment ✧ Determination of evacuation facilities and evacuation routes ✧ Public awareness

Source: JICA Study Team

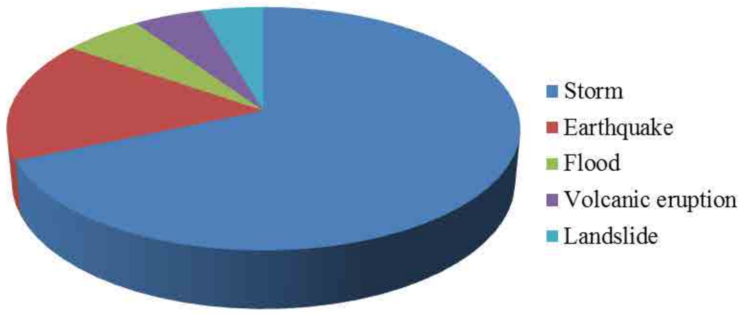
5.5.2 Earthquake Hazard

(1) Earthquake Environment and Historical Earthquakes

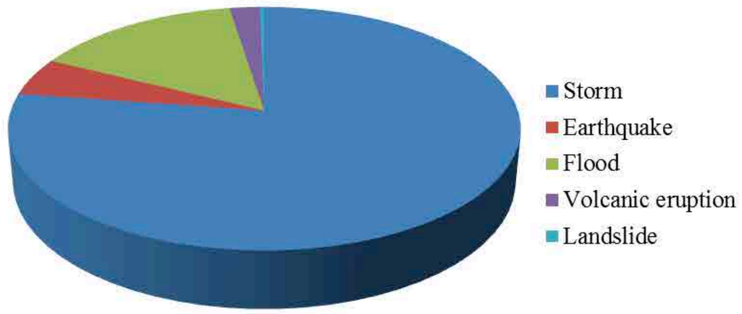
The Philippines, like Japan, lies along the Pacific Ring of Fire, having high seismicity and frequent volcanic activity. The Philippines is a disaster prone country, which suffered not only earthquake and volcanic eruption but also the storm, flood as well as landslide. The life loss and economic loss of the Philippines from 1900 to 2013 is shown in Figure 5.5-1. The storm caused the most damage in terms of both life and economic loss, while the earthquake comes to the second for life loss and the third in economic loss.

The plate tectonics in the Philippines is complex with Philippine Plate in the east and Eurasian Plate in the west and several micro-plates between the two convergent plate margins. The active faults of Philippines are shown in Figure 5.5-2 and the active faults in Region VIII (the project area and the vicinity) are shown in Figure 5.5-3. A major tectonic feature of the Philippines is the 1,200km long Philippine fault zone (PFZ) that transects the whole Philippine archipelago from northwestern Luzon to southeastern Mindanao. This arc-parallel, left-lateral strike slip fault is divided into several segments and has been the source of several past large earthquakes. The Philippine fault zone passes through the Leyte Island from north to south. The distance from the fault to the east cost of Leyte is about 10 to 50 km. There are three active faults in the southern of Samar. The Eastern Samar is facing to the Philippine Trench and could be affected by the large earthquakes in the trench zone. All of these faults characterize the project area facing a high seismic hazard.

There were a number of earthquakes in the history around the project area. Earthquakes with magnitude larger than 3 occurred in Central Visayas during 1900 to 2013 are shown in Table 5.5-3, from which it can be observed the earthquakes are mainly distributed along the Philippine fault zone and Philippine Trench. The destructive earthquakes after 1900 are listed in Table 5.5-3. There are 28 quakes, which caused the damages, in about a period of 110 years. There was an earthquake occurred in 31 August 2012 in Guiuan (Eastern Samar), which caused 1 death and affected about 28,879 people. For the earthquakes around the project area before 1900, there are two on the list of the National Geophysical Data Center archives of National Oceanic and Atmospheric Administration (NOAA), USA. One of them was in 1743 in Leyte and another was 1890 in Leyte and Samar, but no more detail information.



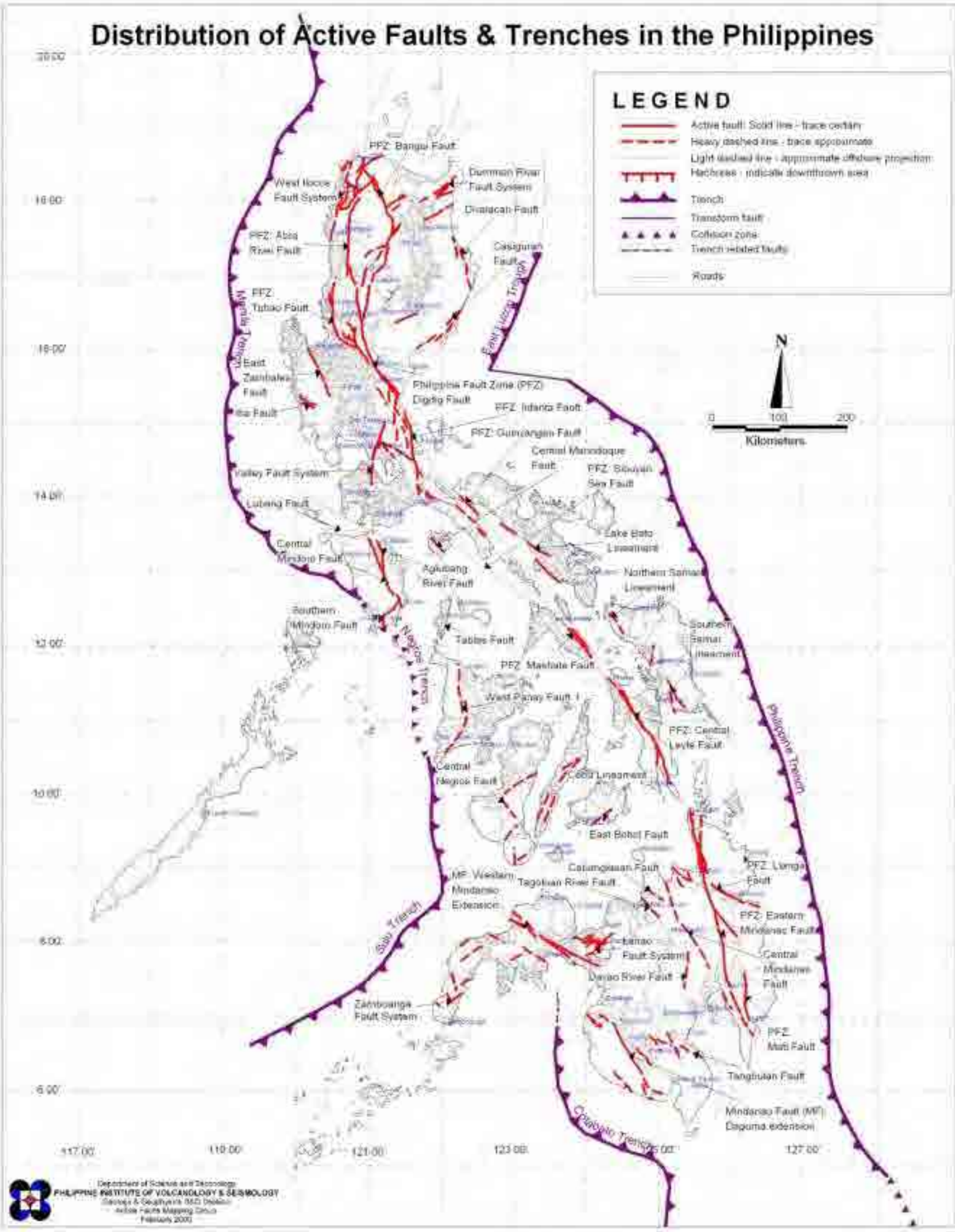
(a) Life Loss



(b) Economic Loss

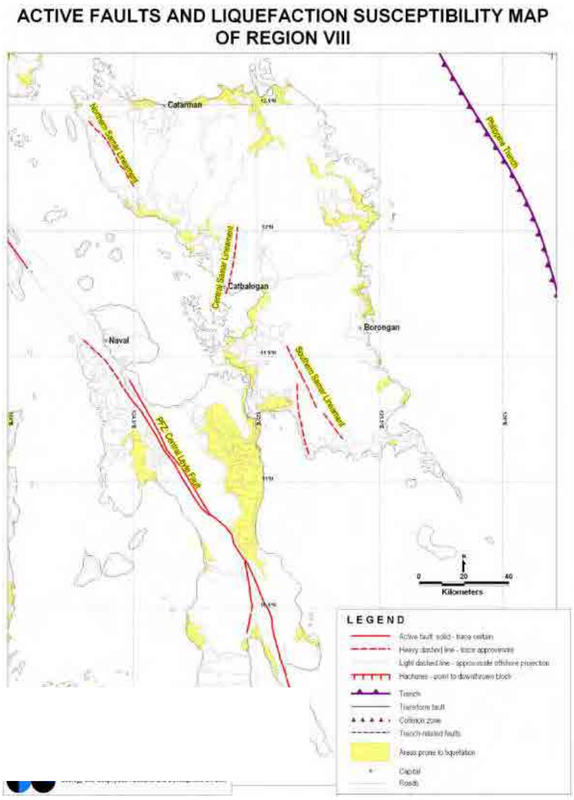
Sourse: EM-DAT, CRED

Figure 5.5-1 Life and Economic Loss by Natural Disasters during 1900 to 2013



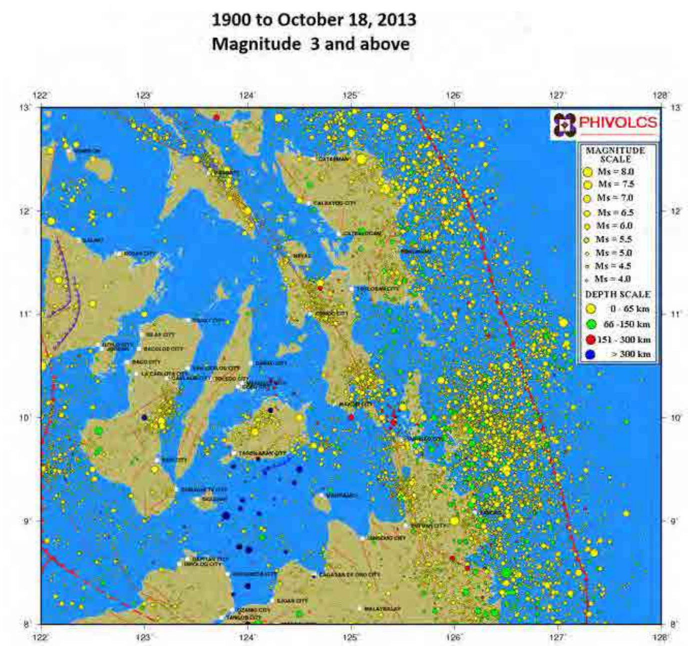
Source: PHIVOLCS

Figure 5.5-2 Distribution of Active Faults and Trenches of Philippines



Source: PHIVOLCS

Figure 5.5-3 Distribution of Active Faults of Region VIII



Source: PHIVOLCS

Figure 5.5-4 Distribution of Earthquakes in Central Visayas

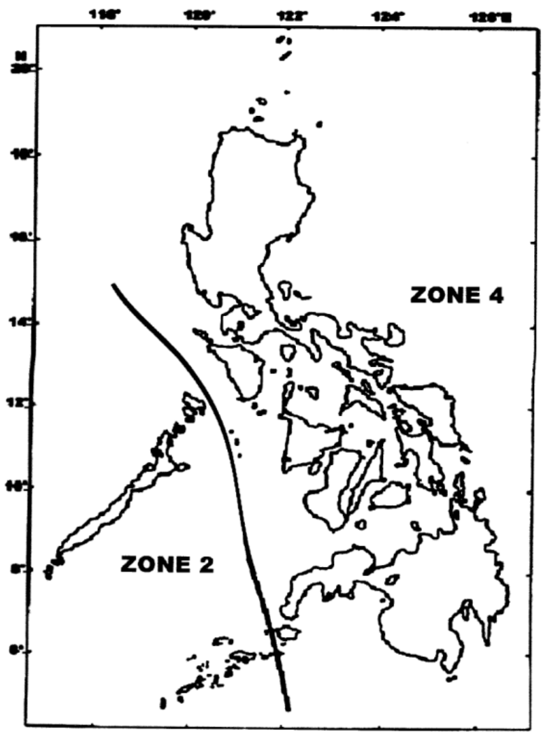
Table 5.5-3 Destructive Earthquakes in Philippines after 1900

Date	Location	Killed	Total Affected	Damage (US$ Mil)
15/10/2013	Bohol	200		50
31/08/2012	Guiuan (Eastern Samar)	1	28,879	3
04/09/2012	Valencia, Maramag		4,001	
06/02/2012	Tayasan	113	320,277	9
07/11/2011	Valencia		28	
18/09/2009	Pablacion, Norala, Panay		392	0
06/03/2002	General Santo city	15	73,451	2
12/12/1999	Luzon (Manila Region)	6	190	2
21/04/1995	near Dolores (Samar Isl.)			
13/05/1994	Oro area (Mindanao)		218	
15/11/1994	Mindoro, Luzon	81	270,866	4
16/07/1990	Cabanatuan, Baguio	2,412	1,597,553	370
14/06/1990	Cualasi area (Near Panay)	4	15	
08/02/1990	Bohol, Cebu	1	34,504	1
18/03/1985	Mindanao	2	175	
18/08/1983	Ilocos Norte	19	1,901	2
11/01/1982	Catanduanes (Luzon Isl.)			
19/03/1977	Cagayan (N.E. Luzon)	1	60,030	0
16/08/1976	Gulf of Moro, Sulu	6,000	181,348	134
17/03/1973	Luzon, Tablas Is.	14	64	0
07/04/1970	Luzon	14	200	
02/08/1968	Luzon Is., Manila	271	261	5
00/08/1967	Manilla	200		
22/05/1960	Nationwide	32		
01/04/1955	Mindanao, Lanao	400	2,000	
02/07/1954	Luzon, Sorsogon, Bacon	13	101	
25/01/1948	Panay, Iloilo city	27		
15/08/1918	Mindanao, South Cotabato	100		

Source: EM-DAT, CRED

(2) Earthquake Hazard in the Project Area

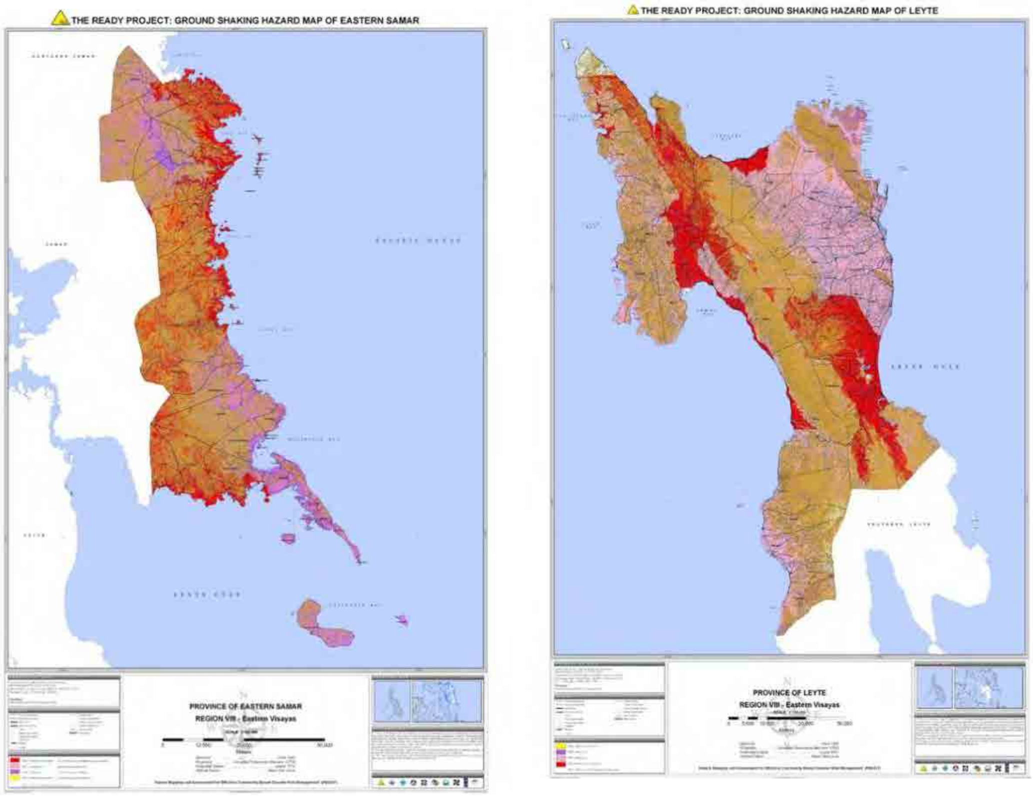
There are different ways to represent the earthquake hazard, which could be based on a probabilistic concept or by a deterministic approach. The hazard could be in terms of intensity, peak ground acceleration or other ground motion characteristics. It may be necessary to consider different types of hazard for different purposes. The earthquake hazard which has to be followed for structure design is the hazard specified in the National Structural Code of the Philippines. The earthquake hazard from the code, sixth edition (2010), is shown in Figure 5.5-5, which is the peak ground acceleration (PGA) with the exceedance probability of 10% in 50 years. According to the code, the project area belongs to Zone 4 and the zone factor is 0.4, which means 0.4g.



Source: Structural code, 2010

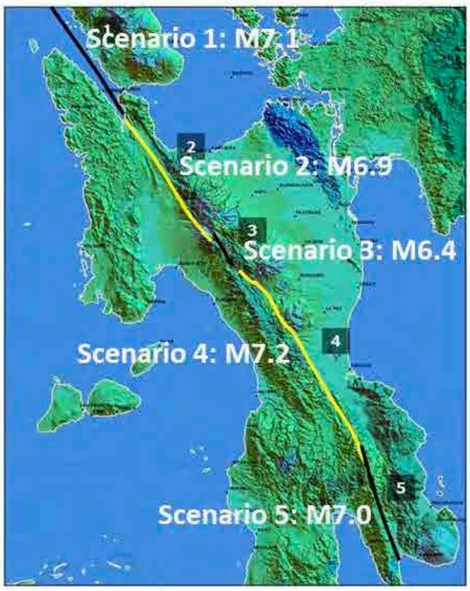
Figure 5.5-5 Seismic Hazard Map of the Philippines

The seismic hazard map of the READY project for Leyte and Eastern Samar is shown in Figure 5.5-6. The hazard is represented by PEIS (PHIVOLCS earthquake intensity scale). The project area has the intensity of VI, VII and VIII depending on the location. The hazard map was created by a deterministic approach with the magnitude of the earthquake and an attenuation equation. Five earthquake scenarios were considered for Leyte, which is shown in Figure 5.5-7.



Source: PHIVOLCS

Figure 5.5-6 Seismic Hazard Map (left: Leyte, right: Eastern Samar)

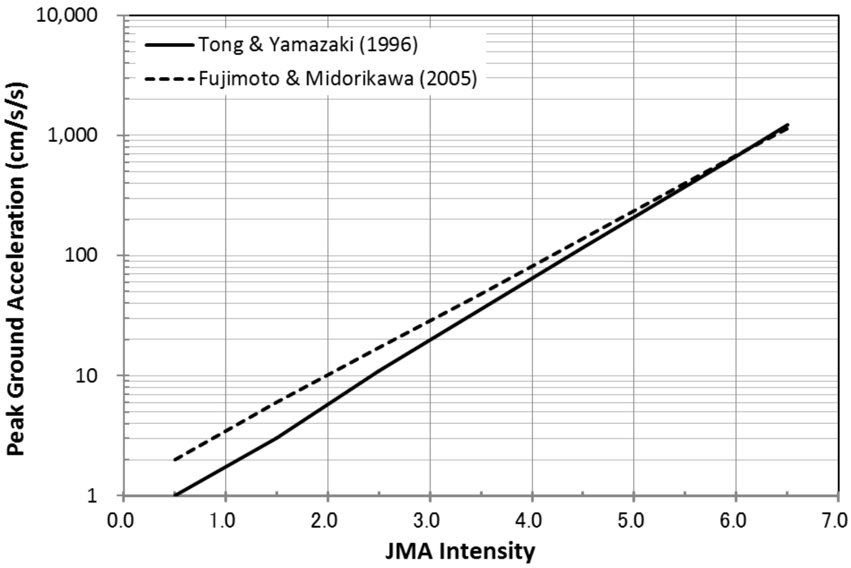


Source: PHIVOLCS

Figure 5.5-7 Scenario Earthquakes Used for Seismic Hazard of Leyte

Although the READY seismic hazard and that in National Construction Code were not based on the same approach, they were compared here serving as a reference. For the purpose of comparison the PEIS was first converted to peak ground acceleration (PGA). Since the intensity cannot be described by a single ground motion characteristic, it is difficult to give a one-to-one relationship between intensity and PGA. In order to compare the READY hazard map with the seismic hazard of the structural code, the relationship of PEIS and PGA is estimated through (1) the relationship between PEIS and the Japan Meteorological Agency (JMA) intensity and (2) the relationship between the JMA intensity and PGA.

It is found the PEIS VI, VII and VIII are generally corresponded to the JMA intensity of 5-lower, 5 and 6-lower according to their definitions. There are several researches on the relationship between JMA intensity and PGA. The researches by Tong and Yamazaki (1996) and Fujimoto and Midorikawa (2005) are applied here. The results are shown in Figure 5.5-8, from which it is found the two researches shown a close results. Then, the relationship between PEIS and PGA was obtained and is shown in Table 5.5-4. It is found the PEIS VI and VII have a PGA less than the structural code (0.4g), while the PEIS VIII has a larger PGA than the structural code.



Source: JICA Study Team

Figure 5.5-8 Relationship between JMA Intensity and PGA

Table 5.5-4 The Relationship among PEIS, JMA Intensity and PGA

PEIS	VI	VII	VIII
JMA intensity	5-lower	5	6-upper
PGA (Tong, cm/s/s)	116 – 209	210 – 376	377 – 676
PGA (Fujimoto, cm/s/s)	139 – 236	237 – 400	401 – 679
Average (cm/s/s)	175	305	533

Source: JICA Study Team

The active fault, called southern Samar lineament, and historical earthquakes in and around Samar are shown in Figure 5.5-9. The ground shaking of Samar could be considered from the Philippine Fault Zone, Philippine Trench and the southern Samar lineament. From the seismic hazard map of Leyte and Eastern Samar, the effect of Philippine Fault Zone and Philippine Trench would not exceed PEIS VIII. Since the southern Samar lineament is located within the area of Samar, its effect was considered here. Because the return period and last movement of the fault was not clear, its occurrence probability in the near future was not assessed.

There are three segments in southern Samar lineament. According to the GIS fault data provided by PHIVOLCS, the three segments have the length of about 31km, 21km and 32km individually (see Figure 5.5-9). Based on the relationship between fault length and JMA magnitude M_J (Matsuda, 1975):

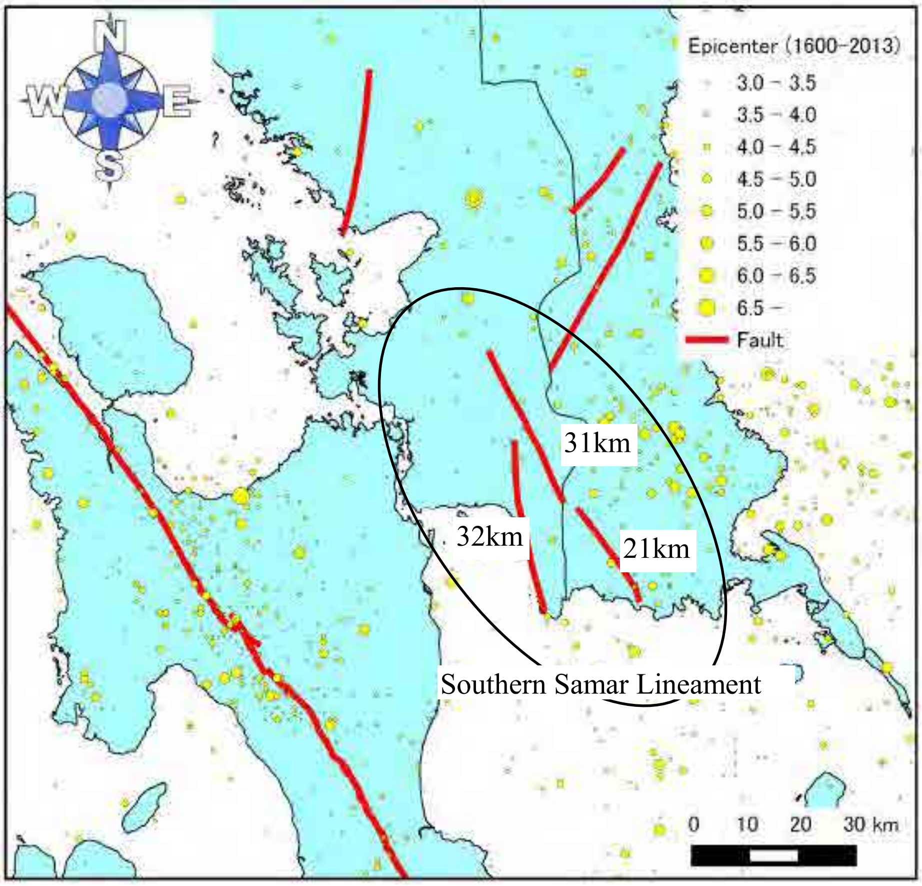
$$\log L = 0.6M_J - 2.9$$

and the relationship between M_J and moment magnitude M_w (Central Disaster Prevention Council, 2004):

$$M_w = 0.88M_J + 0.54$$

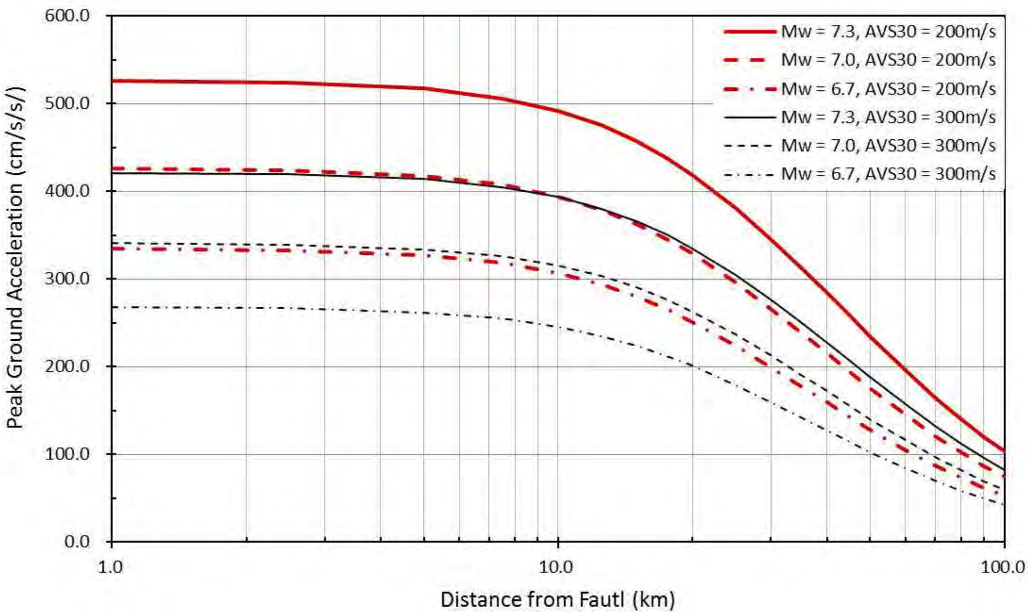
the possible moment magnitude of the active faults were estimated as M_w=6.7 for 21km and M_w=7.0 for 31km and 32km. It is also noted that the segment of the two segments of 31km and 21km is located almost along a straight line and about 2.5km separated. According to Matsuda (1990) who pointed out that the fault segments within a 5km separation could be possibly interacted and ruptured together, these two segments would have the possibility to consider as an integrated fault. In this case, the length of the fault is about 55km and the moment magnitude is estimated M_w=7.3.

The ground shaking in terms of PGA was estimated for the southern Samar lineament. The attenuation proposed by Kanno et. al. (2006) was used because the relationship covered the acceleration records near the fault from Japan, USA and Turkey and, at the time, could consider the site effect. The source depth was assumed to be 20km based on the distribution of the historical hypocenters. The acceleration was estimated for two kinds of site, one is its average shear wave velocity at the top 30m (AVS30) being 300m/s (corresponding to engineering bedrock) and another is AVS30=200m/s. The acceleration against the distance from fault is shown in Figure 5.5-10. It is found that in the case of M_w=7.3 and M_w=7.0, AVS30=200m/s the acceleration within a distance of 9km from fault is larger than 400cm/s/s, which corresponds to PEIS VIII (see Table 5.5-5). It should be noted that the ground shaking doesn’t represent that at real site. The ground shaking could be smaller or larger depending on the ground condition of the site. In general, considering the ground shaking of READY hazard map of Eastern Samar (Figure 5.5-6), where the ground shaking at the area near Samar boarder is PEIS VIII, the results could be considered consistent with the READY results.



Source: Created by JICA Study Team based on PHIVOLCS data

Figure 5.5-9 Active Fault and Historical Earthquakes around Samar



Source: JICA Study Team

Figure 5.5-10 Peak Ground Acceleration for Southern Samar Lineament

(3) Lessons from Bohol earthquake

A strong earthquake of Mw 7.2 struck Bohol Island on October 15, 2013 with the epicenter near the boundary of Sagbayan and Catigbian (Figure 5.5-11). According to the National Disaster Risk Reduction and Management Council (NDRRMC), there were 222 dead and 976 injured. More than 73,000 structures were damaged, of which more than 14,500 were totally destroyed. The intensity distribution is given in Table 5.5-5. There were no strong ground motion records from the earthquake.

A two-day site survey was carried out in March, about 5 months after the quake. The survey targeted the intensity VIII and VII areas. Although most of the debris has been cleared, a number of damaged buildings still remained. The major building structure type, similar to that in this project area, is concrete hollow block (CHB) and wooden structures. The roof is generally thin metal plate. Both structural and non-structural damages were observed. The features of the damage could be summarized as (1) the 1-story buildings were damaged less than the 2- or more-story buildings, (2) the wooden structures were damaged less than CHB structures, (3) there were several cases in which the damage was concentrated on the first floor and (4) the non-structural damage especially occurred in the CHB walls.

Example of the first floor damage of CHB structures is similar to the damages experienced in piloti structures. The causes of the damage could be attributed to (1) not enough strength in the first floor and (2) the CHB wall makes the second floor heavy which increased the seismic load. In order to avoid this kind of damage, it is necessary to reduce the seismic load by using light-material walls and/or strengthen the first floor by not only columns but also application of shear wall.

Non-structural damage was observed in the walls, and ceilings as well as architectural decorations. No damage to the columns or beams can be found but the CHB wall was severely damaged or completely removed in one of them. The collapse of a CHB wall could increase injury or cause death because of its weight. For safety reasons, it is suggested to use a light-material wall instead of CHB or increase the reinforce bars in CHB walls to increase their integrity.

A structure which utilizes the local materials and was considered earthquake resistant, was found during the survey. The lower part of the wall is CHB but the upper part is a double layer wall with one of bamboo woven stuff and another is plywood. The wall is light and, at the same time provides thermal insulation.

Table 5.5-5 Intensity Distribution of Bohol Earthquake

PEIS	City, Town and Municipality
VIII	Sagbayan, Catigbian, Loon, Maribojoc, San Isidro, Antequera, Cortes, Clarin, Buenavista
VII	Tagbilaran City, Cebu City, Lapu-Lapu City, Mandaue City, Toledo City, Carcar City, Naga City, Danao, Carmen Bilar, Loboc, Loay, Baclayon, Albuquerque And Dauis
VI	Hinigaran, Negros Occidental, Dumaguete City, Siquijor Island, Lila, Dimiao, Valencia, Garcia-Hernandez, Jagna, Duero, Guindulman, Candijay
V	Iloilo City, La Carlota City, Guimaras Island, Camiguin Island, Abuyog, Ozamis City, Sibulan, Negros Oriental, Gingoog, Misamis Oriental, Cagayan De Oro City
IV	Roxas City, Masbate City, Tacloban City, Bulusan, Sorsogon, Tabon, San Pablo, Bato, Dipolog City, Bacolod City, Naval, Biliran, Bayawan City, Hinunangan, Baybay, Butuan City

Source: JICA Study Team

Source: PHIVOLCS

Figure 5.5-11 Epicenter and Intensity Distribution of Bohol Earthquake

5.5.3 Tsunami Hazard

(1) Tsunami Hazard in the Project Area

The tsunami hazard map of the READY project for Leyte and Eastern Samar gives the tsunami inundation area and tsunami wave height at coastline. The tsunami hazard of Leyte was estimated from scenario earthquakes located at the Philippine trench. The tsunami was calculated based on empirical equations without numerical simulation. The tsunami at the Leyte coastline of the project area is 4 to 5 meters high. The tsunami hazard of Eastern Samar was estimated with the same approach as that used for Leyte. The tsunami at the Eastern Samar coastline of the project area is 2 to 5 meters.

The READY tsunami hazard was estimated by empirical equations, which cannot consider the effect of the shape of sea bed, coast line and topography correctly. It could be appropriated for the purpose of community-based tsunami awareness. For urban planning, where the relocation of residential area, construction of seawall and determination of tsunami evacuation facilities and evacuation route could be the major concern, a tsunami hazard based on the numerical simulation is preferred.

In this project, a part of Leyte was surveyed by LiDAR and a new DEM was created. It had been used for storm surge simulation. Making use of this new DEM, the tsunami inundation under the condition of READY tsunami height at coast line was evaluated by a simple method.proposed by Non-Life Insurance Rating Organization of Japan (NLIRO, 2008). The method is called energy conservation method, which calculates the water level from a known mesh to the next mesh with considering the difference of elevation as well as the fiction of land. The concept of the method is illustrated in Figure 5.5-14. In this method, the only required initial condition for the calculation is water level at coast line. It should be pointed out that the run-up of tsunami was affected by the topography of land, resistance (friction) of structures, trees and plants of ground as well as tsunami period, etc.. This method is a simple method, which can take into account the topography and friction but not for the characteristics of tsunami like period.

Now suppose the water flow from right mesh to left mesh and the water level at right mash is known as Z_1 (see Figure 5.5-14). Then the water level of the left mash Z_2 can be calculated as below with considering the energy conservation.

$$E_1 = E_2 + E_f \quad \text{..........} (1)$$

in which

E_1 : Energy of the water, higher than the elevation of left mesh, in the right mesh

＝potential energy + pressure energy + kinetic energy

$$E_1 = \int_{H_2}^{Z_1} \rho g z dz + \int_{H_2}^{Z_1} \rho g (Z_1 - z) dz + \int_{H_2}^{Z_1} \frac{\rho {V_1}^2}{2} dz$$

$$= \frac{\rho g}{2}(Z_1 - H_1)(Z_1 - H_2) + \rho g Z_1 (Z_1 - H_2) \quad \text{..........} (2)$$

E_2 : Energy of the water in the left mesh

＝potential energy + pressure energy + kinetic energy

$$E_2 = \int_{H_2}^{Z_2} \rho g z dz + \int_{H_2}^{Z_2} \rho g (Z_2 - z) dz + \int_{H_2}^{Z_2} \frac{\rho {V_2}^2}{2} dz$$

$$= \frac{\rho g}{2}(Z_2 - H_2)^2 + \rho g Z_2 (Z_2 - H_2) \quad \text{..........} (3)$$

E_f : Energy due to fiction (based on Manning formula)

$$E_f = \frac{\rho n^2 g^2}{(Z_1 - H_1)^{1/3}} \times r \quad \text{..........} (4)$$

From equations (1) – (4)、a quadratic equation of Z_2 (equation 5) can be derived. Solving the equation and Z_2 can be obtained.

$$3Z_2^2 - 4H_2 Z_2 + (H_2^2 - E_1' + E_f') = 0 \quad \text{..........} (5)$$

where

$E_1' = (Z_1 - H_1)(Z_1 - H_2) + 2Z_1(Z_1 - H_2)$

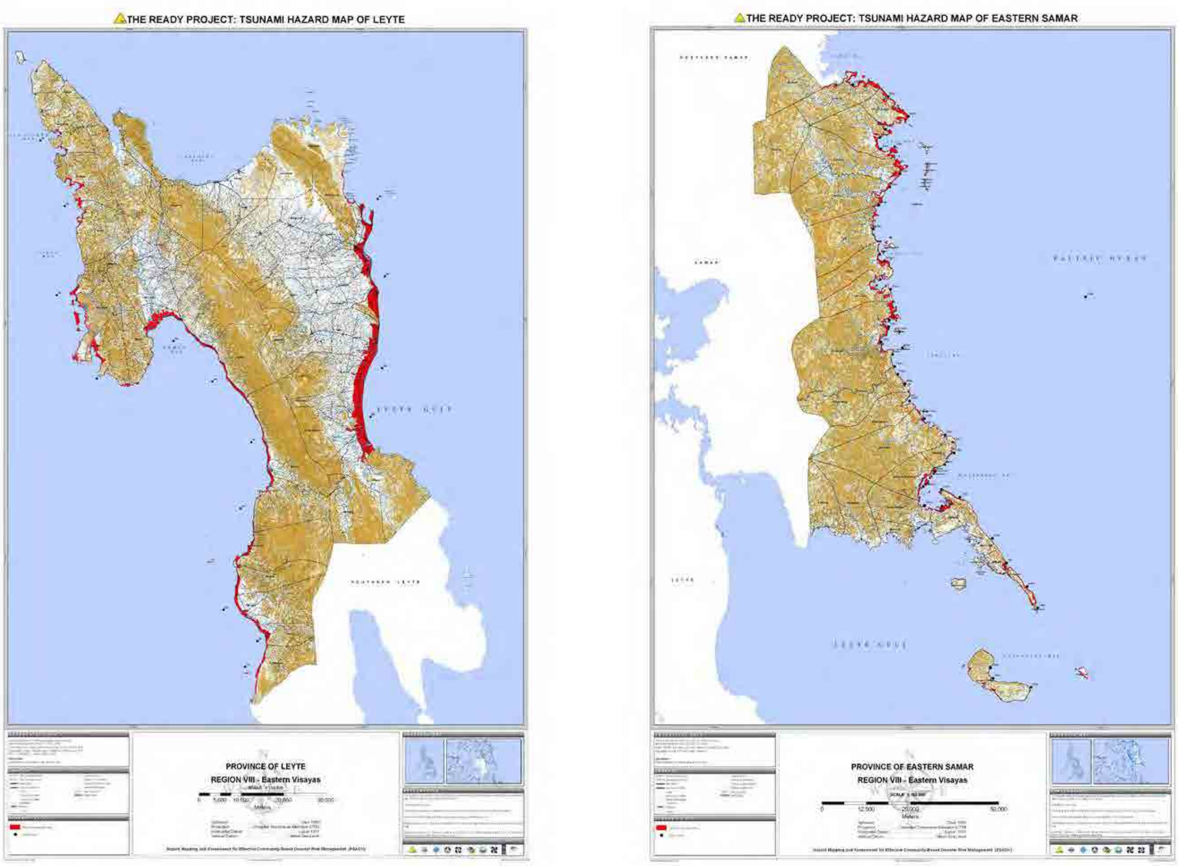
$E_f' = \frac{2n^2 g}{(Z_1 - H_1)^{1/3}} \times r$

n: roughness coefficient (=0.03)

g: Gravity (=9.8m/s/s)

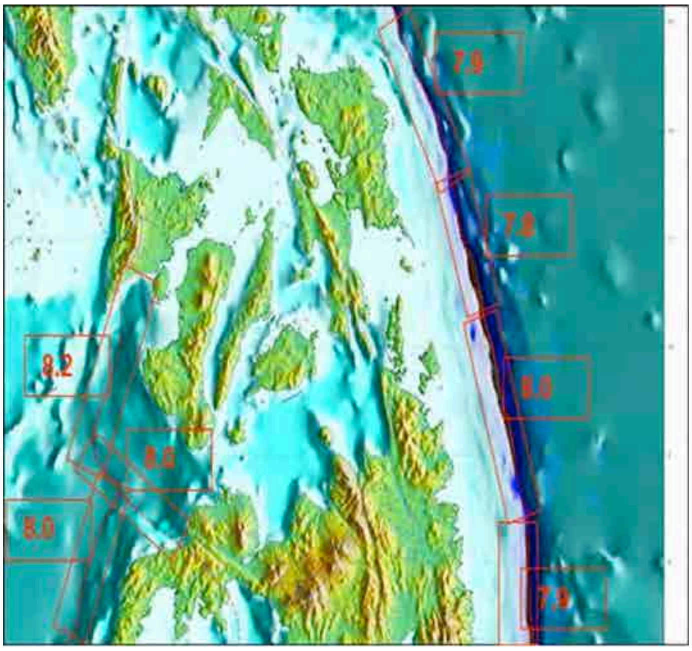
r: Mesh dimension

The calculation was conducted for the east coast of Leyte where the new DEM was available. The calculation area was divided into 30m mesh. The tsunami height at the coast line by READY project was adopted as initial condition (Figure 5.5-15). The result of tsunami inundation is shown in Figure 5.5-16. Comparing with the tsunami hazard of READY project, this result provides not only inundation area but also inundation depth. The inundation area of this project is generally smaller than that of READY project. It could be attributed to the consideration of the effect of topography and friction. On the other hand, since the method is a simplified way to estimate the tsunami inundation, this result may have the difference with that from the tsunami propagation and run-up simulation.



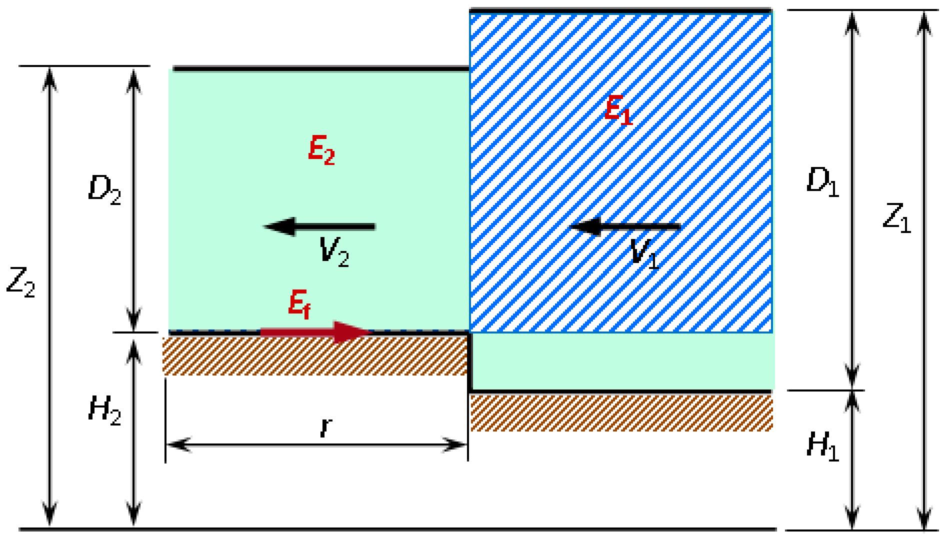
Source: PHIVOLCS

Figure 5.5-12 Tsunami Hazard (left: Leyte, right: Eastern Samar)



Source: PHIVOLCS

Figure 5.5-13 Scenario Earthquakes for Tsunami Hazard



E_1, E_2 : Energy of water

E_f: Energy due to friction

V_1, V_2 : Water flow velocity、 $(V = \sqrt{gD})$

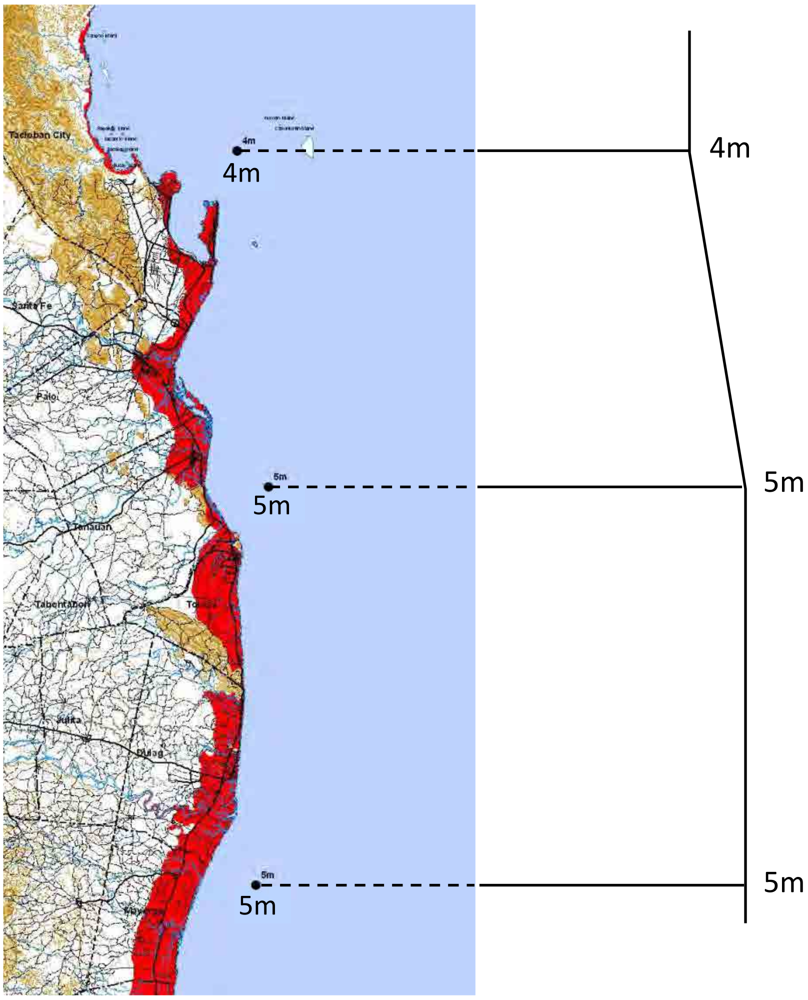
Z_1, Z_2 : Maximum water level

H_1, H_2 : Elevation

D_1, D_2 : Water depth

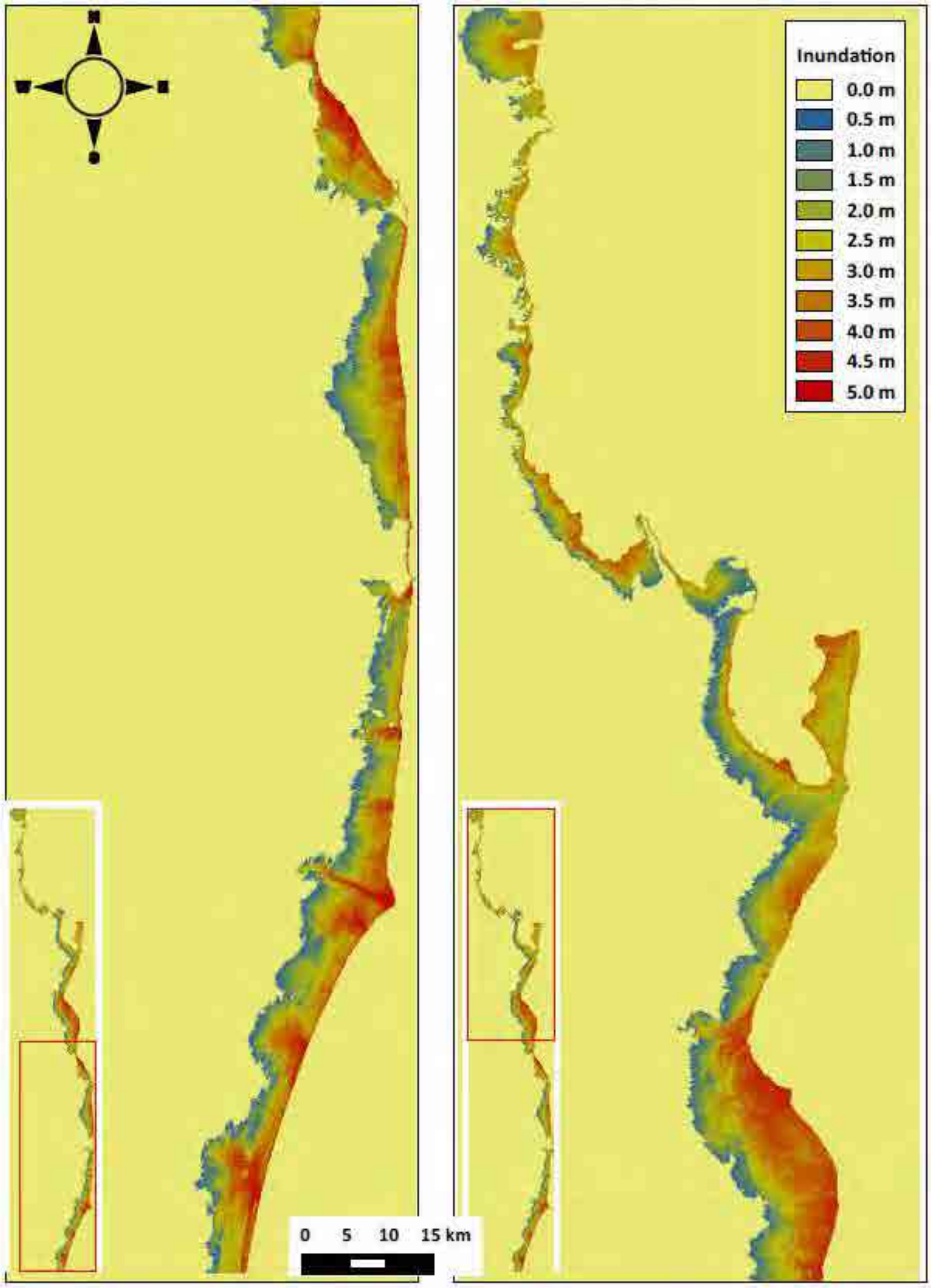
Source: Project Team

Figure 5.5-14 Illustration of Energy Conservation Method for Tsunami Inundation



Source: PHIVOLCS

Figure 5.5-15 Initial Tsunami Height along the Coast Line of Leyte

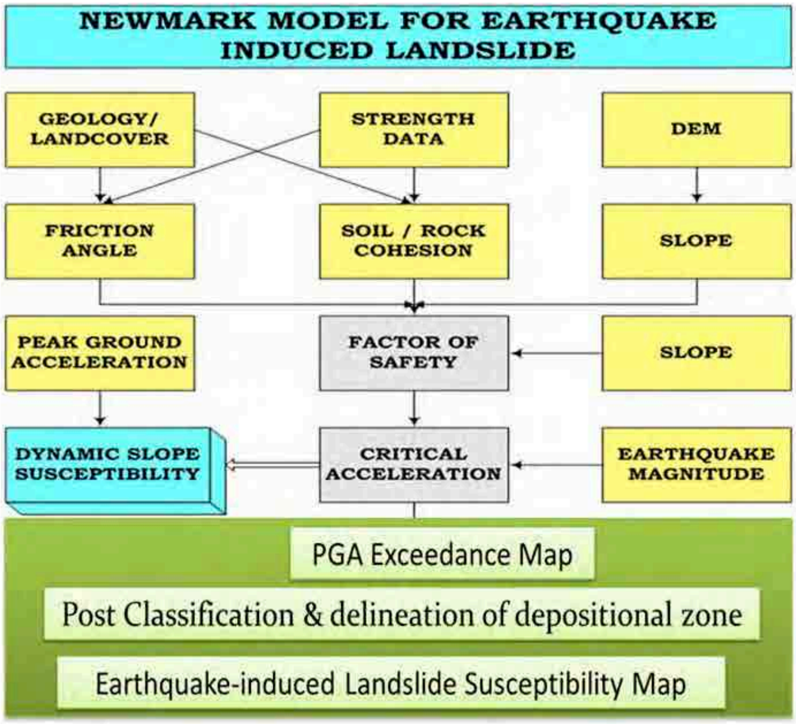


Source: JICA Study Team

Figure 5.5-16 Tsunami Inundation of Leyte

5.6 Landslide

Two kinds of landslide hazard maps were created in the READY project, i.e. earthquake-induced landslide and rain-induced landslide. The hazard of earthquake-induced landslide was estimated with the Newmark model, the flowchart of which is shown Figure 5.6-1. The hazard of landslide is represented by the susceptibility of landslide, which is classified into high, moderate, low and no susceptibility. Figure 5.6-2 and Figure 5.6-3 shows the landslide hazards for Leyte and Eastern Samar, respectively. The landslide hazard map is useful for land use planning, observation and early warning as well as public awareness.

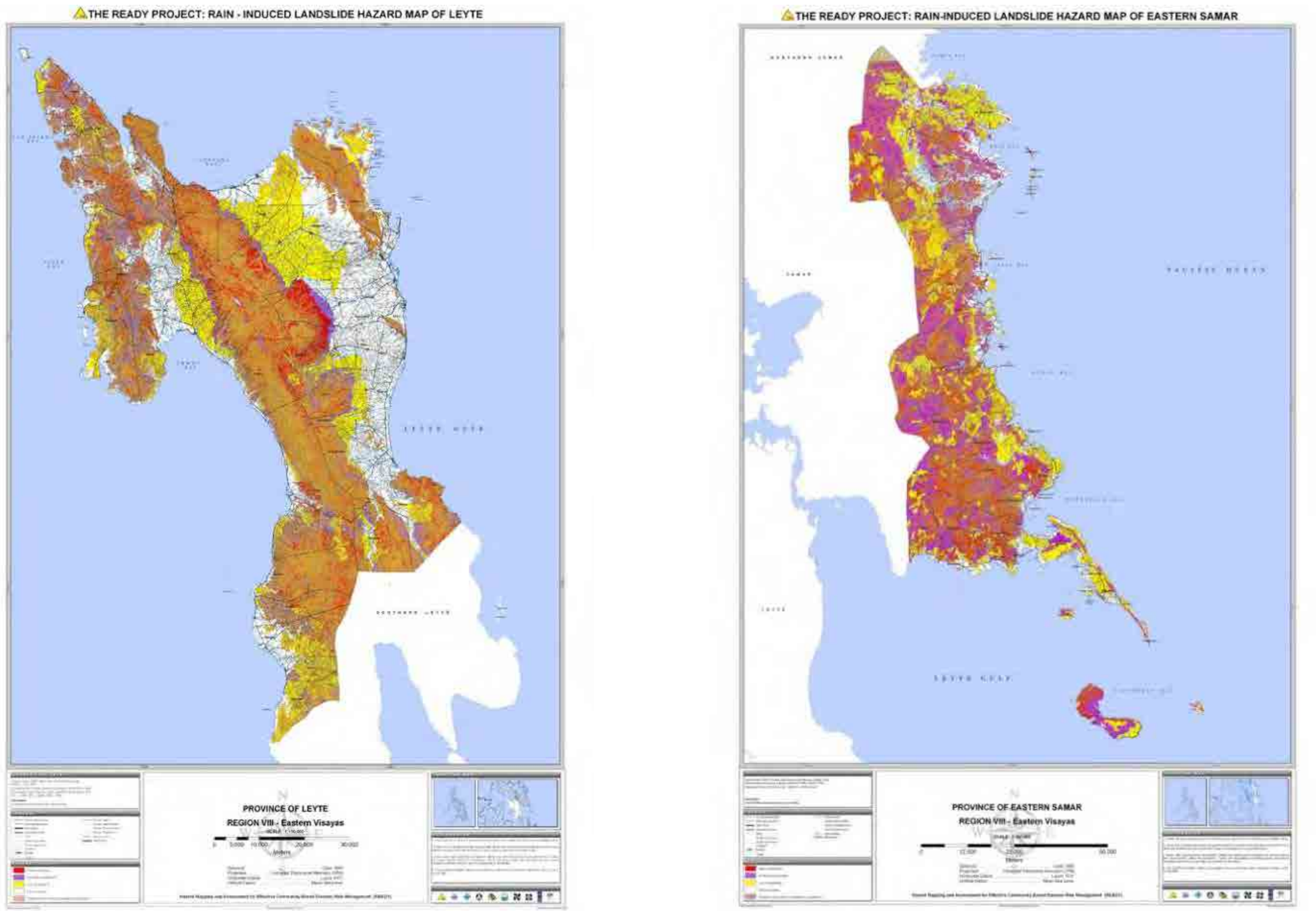


Source: PHIVOLCS

Figure 5.6-1 Flowchart of Newmark Model for Earthquake-induced Landslide Hazard

Source: PHIVOLCS

Figure 5.6-2 Earthquake-induced Landslide Hazard (left: Leyte, right: Eastern Samar)



Source: PHIVOLCS

Figure 5.6-3 Rain-induced Landslide Hazard (left: Leyte, right: Eastern Samar)