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Acronyms and abbreviations

CAPRA	Central American Probabilistic Risk Assessment
DOST	Department of Science and Technology
DPWH	Department of Public Works and Highways
DRRMC	Disaster Risk Reduction and Management Office
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH
h	hour
HF	High Frequency
hPa	hecto Pascal
JRC	Joint Research Centre
km/h	kilometre per hour
LGU	Local Government Unit
MGB	Mines and Geoscience Bureau
Mph	miles per hour
NDRRMC	National Disaster Risk Reduction and Management Council
NIA	National Irrigation Agency
NOAH	National Organizational Assessment of Hazards
OCD	Office of Civil Defence
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Service Administration
PHIVOLCS	Philippine Institute of Volcanology and Seismology
PSTC	Philippine Science and Technology College
READY	Hazards Mapping and Assessment for Effective Community-Based Disaster Risk Management
SSS	Saffir Simpson Scale
TRMM	Tropical Rainfall Monitoring Mission
UNISDR	United Nations International Strategy for Disaster Reduction

1 Acknowledgement

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2

Executive Summary

Typhoon Haiyan/Yolanda was one of the strongest typhoons that made landfall ever recorded. The maximum windspeed in Tanauan/Palo was approximately 271 km/h with on-shore wind direction. The storm surge (sometimes wrongly referred to as a "tsunami" by locals) was highest in the Tanauan, Palo, and Tacloban areas, with estimates between 2.3 and 5 meters. Rains between 100-150 mm fell in the Central parts of Leyte.

The official storm surge hazard map underestimated the inundation area of the storm surge. The actual area was larger and close to the inundation area of the official tsunami hazard map. Furthermore, the official storm surge hazard map did not consider storm surges with a height of 7 meters (the forecasted height of PAGASA) and therefore it was not possible to relate this map to the predicted surge.

Though a spectrum of risk information was available, those in charge of risk management were partly unaware of the dimensions of the hazard and vulnerabilities and/or did not use the information appropriately. A safety check of evacuation centres in respect to the forecasted storm surge was either not done or the check was performed and did not result in appropriate actions. Some evacuation centres were located in storm surge areas and therefore flooded.

The forecast of the storm path and its strength was made very accurately by many agencies, including PAGASA, days before the landfall. The Joint Research Centre (JRC) of the European Union warned of a storm surge on 06.11.13, while PAGASA did this one day later at 12:00h. While PAGASA overestimated the storm surge height in its forecast, the JRC and the Project NOAH storm surge estimates were closer to the actual height for Tacloban.

The warnings from the government and media came days before the typhoon made landfall. Thus, there was enough time for preparations and evacuations before 8 November 2014. Government offices repeatedly asked residents near the coast to evacuate and, in a few cases, even used force to evacuate them. PAGASA/NDRRMC emphasized rain, flood and landslide warnings, but did not stress very strongly the storm surge to come. Warnings by many institutions, including OCD and LGUs, were apparently not serious enough to make people understand that their lives were in jeopardy if they do not evacuate. Many did not understand the term "storm surge". Accounts of residents suggest that a large part of the population in areas where there were storm surges did not evacuate. GIZ calculated that approximately 94% of the casualties in Tacloban, Palo and Tanauan were caused by the storm surge. Serious warnings and more effective evacuations along the coastline could have saved many lives.

3

Recommendations

Below are summaries of the most pertinent recommendations for each stakeholder (group). More detailed explanations are given in the main report.

For Scientific Institutions

- PAGASA's technical capacity should be improved to provide more accurate information for storm surge warnings and hazard maps.
- NOAH sensors should switch to HF radio or satellite phones for uninterrupted transmission of data.
- Storm surge hazard maps should be adjusted taking the recent experiences into consideration.

For OCD and DOST

- Warnings should use layman's language and clearly emphasise the seriousness of a particular hazard.
- A colour coded harmonized multi-hazard early warning system should be introduced.
- Storm surge should be included in the official warning system (similar to tsunami).

For Disaster Risk Reduction Offices/Committees

- Officials tasked with disaster management (e.g. OCD, rescuers, mayors) should not stay in high risk areas when an extreme hazard event is imminent. They may become victims themselves.
- Delineate identified danger zones (tsunami, storm surge) clearly with sign posts.
- Mark evacuation routes and evacuation centers with sign posts.
- Survey existing evacuation centers and identify those within danger zones.
- Assign evacuation centres depending on hazard.
- Reinforce evacuation centres depending on hazard.
- Consider strict enforcement of forced evacuation (example Albay).

For land use planners

- Assign new evacuation centres outside danger zones and clearly indicate which evacuation centers are off-limit for which particular hazards.
- Consider locally customized no-build zones in high risk areas.
- Consider conditional build zones (e.g. only buildings with special reinforcements; only business, but no residence, etc.)

4 Introduction and background

The storm Haiyan/Yolanda was the deadliest natural disaster in the Philippines since reliable records began. The typhoon made landfall in the early hours of 8 November 2013 in the South of Eastern Samar and proceeded West-North-West via Leyte, Northern Cebu, Northern Negros, Northern Panay and exited the Philippines via Coron/Busuanga in the North of Palawan, leaving destruction and death on its path.

The Philippines is regarded as a country with a well designed and solid disaster risk management system[1] featuring a specialized institution for disaster risk reduction and management (NDRRMC/OCD). UNISDR praised the advanced early warning systems[2]. However, it appeared that the Philippines was not fully prepared to meet this typhoon in terms of early warning, response, relief and rehabilitation.

Many Filipinos and observers asked whether the death toll of more than 6,000 confirmed dead would have been less if early warning systems had been more effective. This report seeks to contribute to answering this question and highlight areas that need improvement.

In recent Philippine history, two natural disasters are regarded by some observers to be failures of effective early warning. In 2011, severe tropical storm Washi/Sendong caught many inhabitants of Cagayan de Oro and Iligan unaware of flash floods, leaving more than a thousand dead[3].In the following year, 2012, a strong typhoon named Bopha/Pablo hit the Southeast of Mindanao and widely unprepared communities and some government offices apparently did not follow warnings. Again more than a thousand people perished. With these events in mind it was hoped that the early warnings to the local populationhad been improved when tropical cyclone Haiyan/Yolanda hit the Philippines.

This paper is meant to analyse the hazard event in terms of wind speeds, rain, storm surge, floods and landslides. The actual event is then compared with different general hazard information and then with forecasts to determine the accuracy of the predictions. It is assumed that accurate general hazard information (e.g. hazard maps) and precise forecasts (e.g. the track of the typhoon) would enable communities to prepare adequately. However, it is recognized that timely and detailed hazard information alone does not necessarily lead to adequate preparations. The timeliness, content and coverage of warning messages are essential for a successful evacuation and other preparations. Therefore information was gathered (mostly through interviews[4]) to understand the dissemination of the alerts and the reaction of residents in dangerous places. Last but not least, the connection between casualties and early warning is analysed to answer the question: would a better early warning system have saved lives?

This paper has to be treated as a preliminary assessment. Time constraints and other pressing tasks after the typhoon did not allow conducting a large scale survey with many respondents in the affected areas of Leyte. Many details (e.g. detailed account of causes of death in different locations, exact location of evacuation centres in relation to the inundation by storm surge) are still to be collected and may be subject to further investigations.

Furthermore, this report does not look into damages and losses caused by the typhoon. Those can hardly be avoided by early warnings, but advanced alerts are effective in saving lives and therefore this report concentrates on this aspect of disaster risk reduction.

Tropical cyclones, called typhoons in the Western Pacific, are one of the main causes of economic damages and human casualties caused by natural catastrophes in most of the affected countries Philippines, Vietnam, PR China, Taiwan, Korea and Japan.

Considerable effort has been invested in detecting, tracking and forecasting their path and characteristics. The data used for this are mostly generated by satellites and used by weather bureaus of all concerned countries. For any typhoon in the North-west Pacific there are several agencies predicting paths and wind speeds.

Haiyan/Yolanda caused the death of 6,111 persons with 1,779 still missing. 16 million persons were affected and 4 million persons were displaced. 1.14 million houses were damaged (550,928 totally, 589,404 partially)[5]. The overall economic losses are estimated at 571.1 billion Pesos (12.9 billion US$)[6]. The damage from typhoon Yolanda and the resulting loss in 2013 is estimated to be Php101.79 billion, representing 0.9 percent of Gross Domestic Product (GDP)[7].

Within about a month the Philippine government prepared an extensive recovery and rehabilitation strategy to respond to the event, called the Reconstruction Assistance on Yolanda (RAY) strategy, which also calls for deriving lessons from the disaster to be factored into policies, systems, and capacities[8].

5 The disaster event

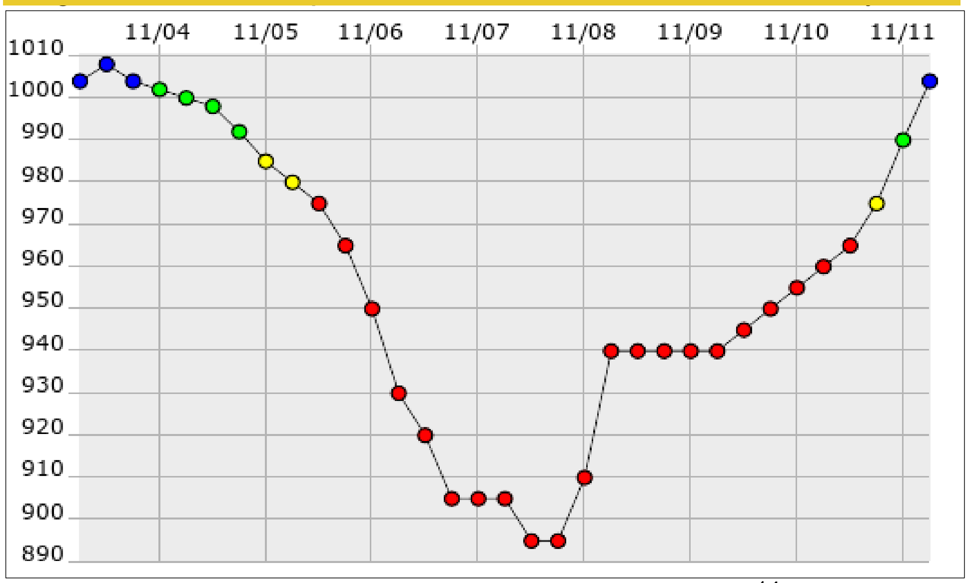
This chapter describes the natural extreme event that happened in Leyte on 8 November 2013. This is the reference for checking the quality of forecasts and warnings issued before Haiyan/Yolanda struck the Philippines.

5.1. Storm

Haiyan/Yolanda was first noticed as a weather disturbance with the potential of developing into a tropical storm on 3 November 2013. It continuously gained strength until 7 November and started weakening on 8 November and dissipated on 11 Nov. 2013 in the South of China[9]. Track data are available in from different agencies [10, 11, 12, 13].

Haiyan developed into a Saffir Simpson Category 5 typhoon with wind speeds of more than 251 km/h and continued to intensify as it travelled across the waters. On November 7, the Japan Meteorological Agency estimated the system's one-minute sustained winds were 315 km/h (195 mph). Several hours later, the eye of the cyclone made its first landfall in the Philippines at Guiuan, Eastern Samar, without losing any intensity. It gradually weakened, making landfall in Tolosa, Leyte at around 7 am on 8 November. While crossing Leyte, the structure of the cyclone was compromised and the eye filled with clouds, reducing its wind speed as as evidenced in the Doppler radar images. The central pressure of the eye was approximately 905 hPa when it hit Tolosa at 7:00 h local time.

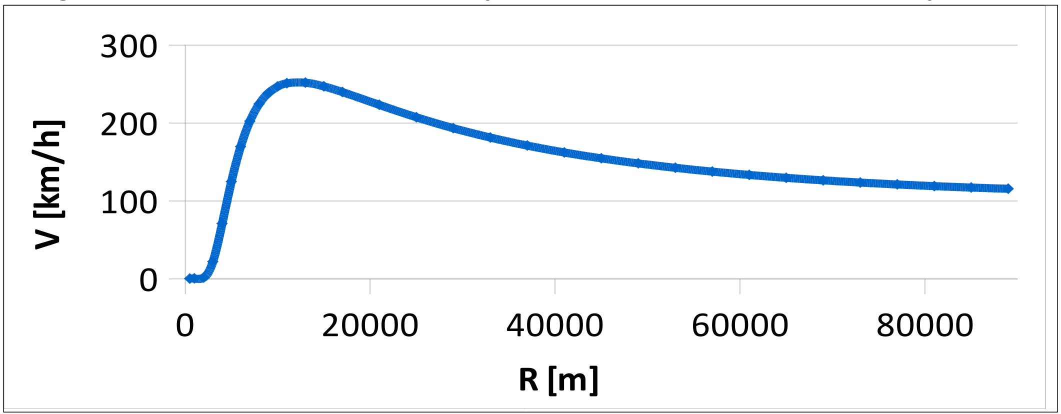
Diagram 1: Atmospheric Pressure in the Centre of Haiyan/Yolanda



Y: pressure in hPa, x: time in days. Time is UTC. [14]

With data on the maximum wind speed, central pressure and forward movement of the eye it is possible to calculate the wind profile of the cyclone (for the method see Neussner and Fuchs).

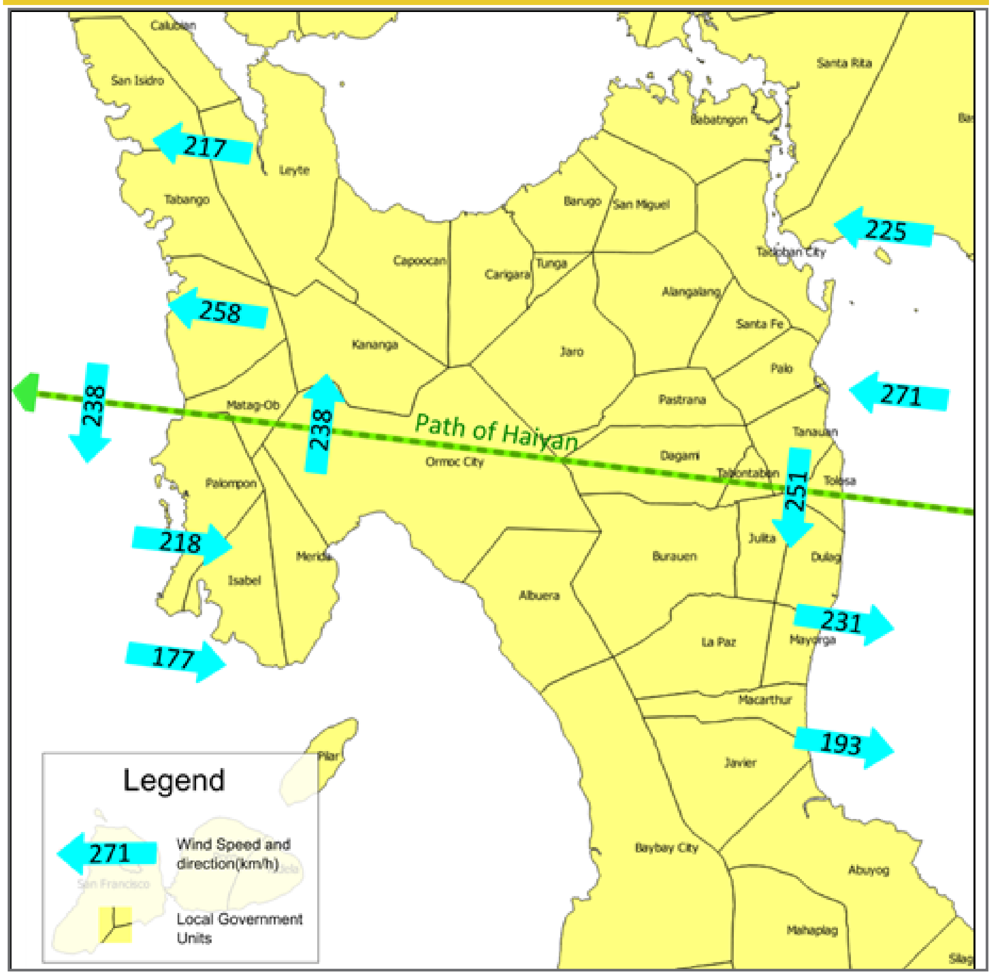
Diagram 2: Wind speed of Haiyan at landfall in Tolosa, Leyte



The radius R at Vmax was estimated from the Doppler radar image of 08.11.13

The calculated wind speeds show the maximum at Tolosa/Tanauan and gradually lesser winds towards the North and the South. It is noteworthy that the wind direction North of the eye was on-shore while South of the eye it was off-shore. This is important for the appearance of a high storm surge in the area of Tanauan, Palo and Tacloban, while the Southern areas experienced relatively little storm surge.

Map 1: Maximum wind speeds and directions of Haiyan/Yolanda in Leyte



Wind speed and direction on the Eastern side of Leyte at 7am, on the Western side at 9am.

Haiyan struck with a storm surge, strong enough to send cars and houses tumbling through neighbourhoods of Tacloban city.

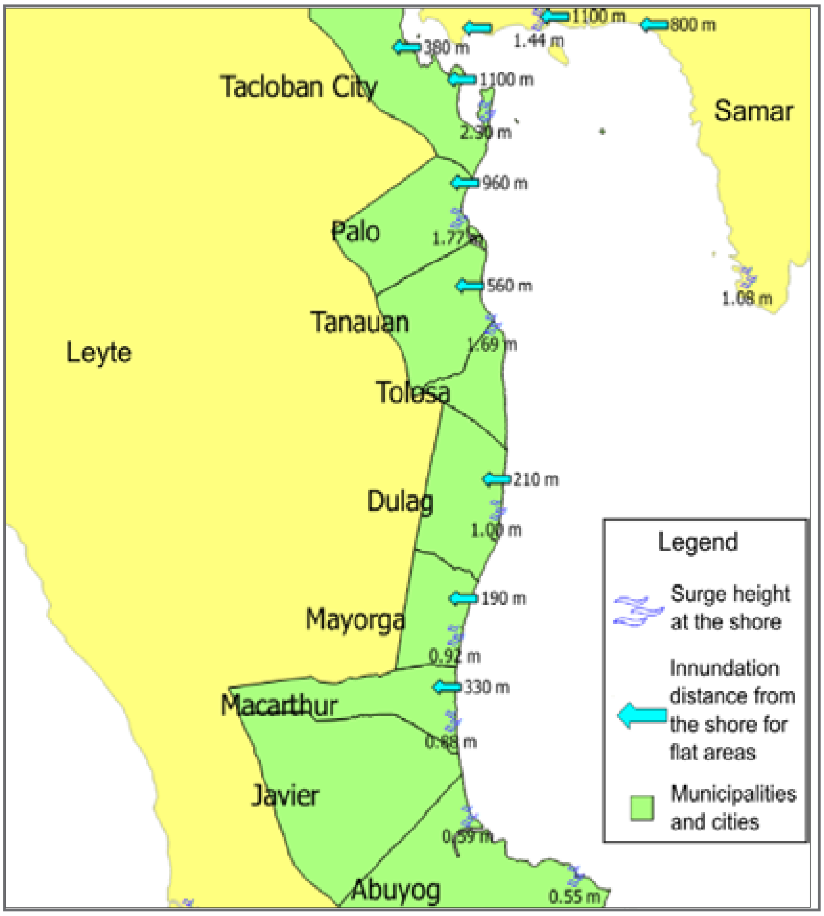
5.2. Storm surge

It is not known whether reliable ground based sea level data were collected during the event in Leyte. Therefore calculated data from simulations were utilized to describe the height of the water. It should be noted here that the tide was low in the Eastern coast of Leyte when the typhoon made its landfall. Some hours later the water level, and therefore also the storm surge would have been considerably higher.

There are numerous eye witness accounts, photos and videos of many areas giving indications of the extent of inundation as well as the water height. These accounts are quite consistent with the tsunami hazard map produced by PHIVOLCS in the context of the READY Project (see chapter “Risk Knowledge”).

Map 2: Storm Surge Water Height at Coast and Inundation Distance

Calculated storm surge data from JRC[17]

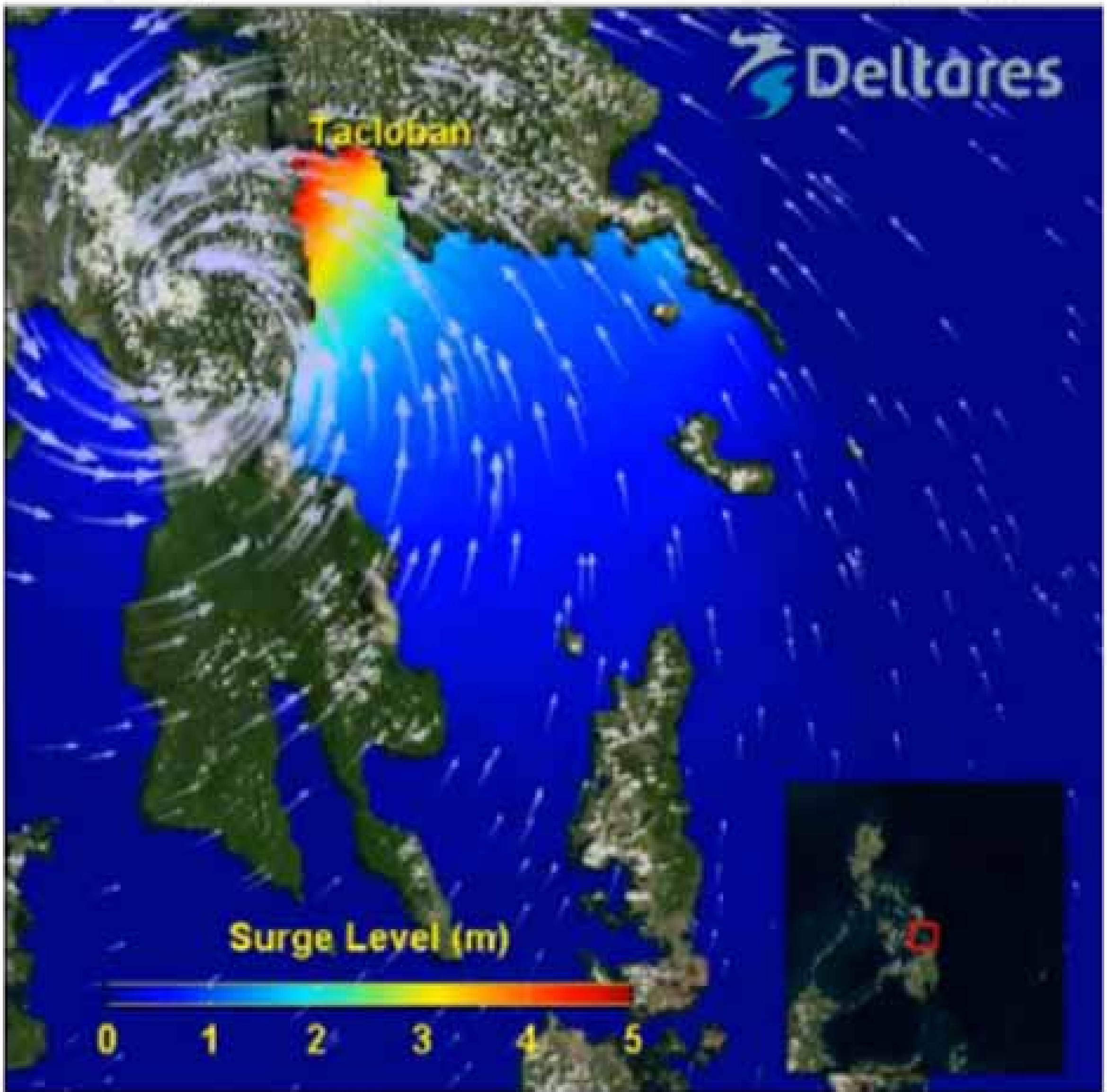


A fire engulfed one of the buildings after a storm surge swept Tacloban city.

Map 3 below shows that Deltares created a storm surge animation that shows computed storm surge levels for Super Typhoon Haiyan, which generated a devastating storm surge in the Philippines.

Map 3: Storm Surge Simulation by Deltares

"Super Typhoon Haiyan making landfall near Tacloban, Philippines"



Source: Deltares [18]

The data from JRC and Deltares were not completely consistent. The JRC data indicated a storm surge South of the eye of the typhoon while Deltares saw this only North of the typhoon. This seemed to be more realistic than JRC's calculations. Both are in agreement that the storm surge was highest in the Tacloban area although the wind speeds were higher in Tolosa and Palo. The Deltares map seemed to indicate 5 meter storm surge while JRC indicated about half of this (2.3 meter).

The NOAH project published data from a second computer simulation in March 2014. The maximum water height was 3.76m. The computed inundation area may be close to the actual inundation in many places, but some areas known to be covered are not included (e.g. the Provincial Capitol). **Map 4** shows the area calculated by NOAH together with the tsunami inundation with calculated water heights . The tsunami inundation map is regarded to be close to reality by many residents. This is supported by numerous photos and videos from different places. However, the actual storm surge area was larger in a number of places than the tsunami hazard map, but by and large reports about inundation extent and water height is surprisingly consistent with the PHIVOLCS map with water heights calculated by GIZ.

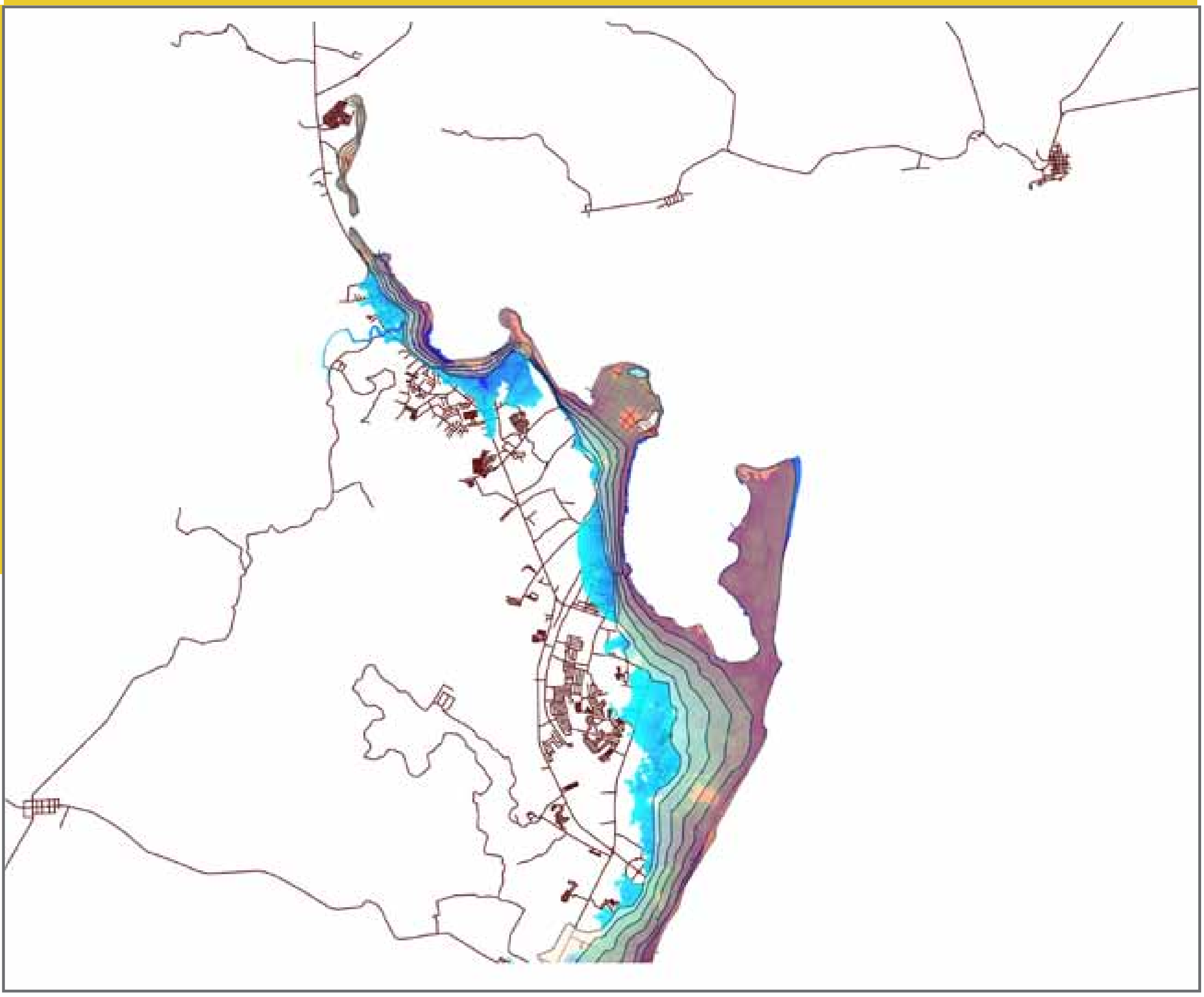
Map 4: Storm Surge Inundation Area in Southern Tacloban City

Tsunami Hazard Map modified by GIZ and NOAH Simulation map

Shades of red: GIZ modified tsunami hazard map (dark: 5m, light: 0m);

blue: NOAH simulation (dark: 4m, light: 0m);

dark red: roads from Open Street Map.



5.3. Rain and river floods

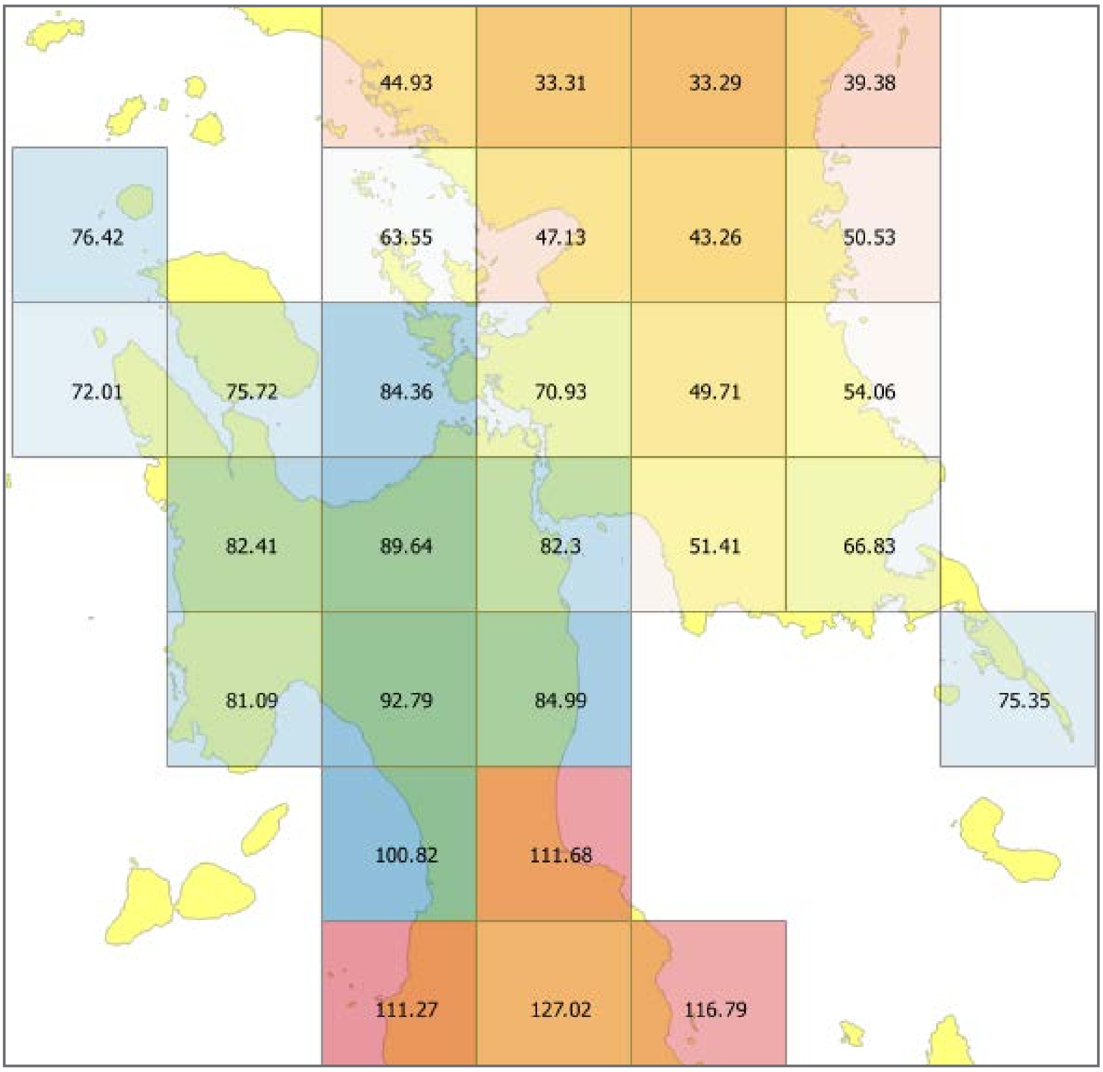
Compared to the major impact of high wind speeds and storm surge, rain and resulting extreme events like floods or landslides played a minor role in this disaster. Since the storm and storm surges rendered most observation instruments useless by either direct damage or destruction or by cutting off communication lines, relatively little on the ground data were collected. Other methods (Doppler radar and remote sensing) were tilized to estimate the amount of rain that fell in connection with the typhoon.

The PAGASA - Tacloban station, recorded rain until 08:00 in the morning[21] and most NOAH rain gauges stopped transmitting data between 6 and 8 am[22]. Rain gauges of the Province of Leyte (GIZ supported) gave up at the same time.

© Photo by Ruth Cabangangan on November 8, 2013

Residents brave a chest-deep floodwater around the municipality of Dagami.

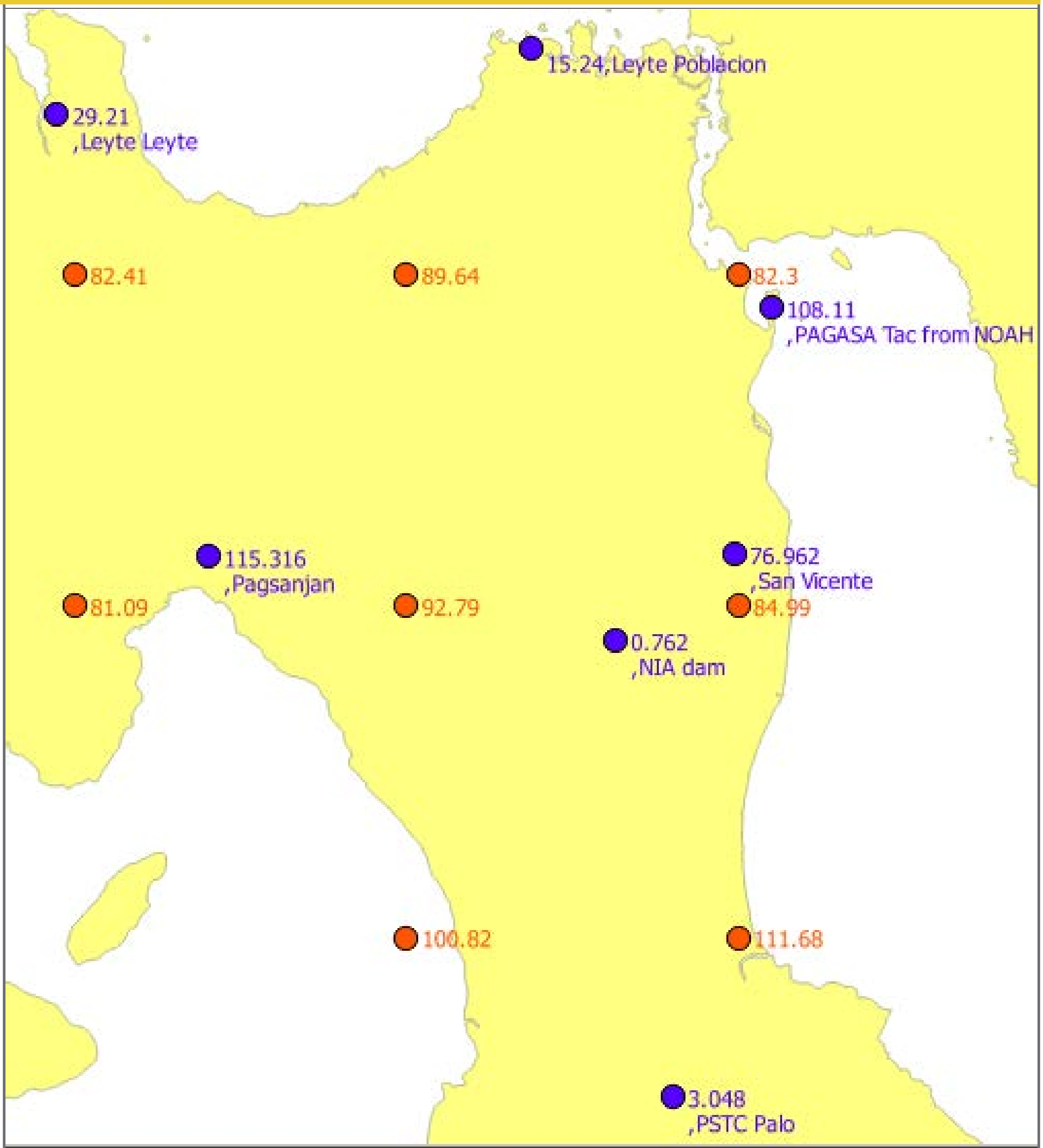
Map 5: Rain in Leyte and Samar from 07.11, 02:00h, to 08.11.2013, 17:00h from TRMM



Numbers in squares are mm rain . Background: map of the coastline of parts of Leyte and Samar.

The TRMM data usually underestimate extreme rain events and therefore it is likely that the actual amount of rain was higher than the displayed data. However, the error of TRMM is normally not more than 50%. This means the rain in connection to Haiyan/Yolanda was not very heavy in comparison to many other tropical cyclones making landfall in the Philippines in the past. In Leyte only one place reported rain-induced flooding. The Poblacion of the town of Dagami experienced flooding in the morning of 8 November. The water emerged quickly and reached more than 1m height. No suspicious water level changes were recorded upstream in Tingib, Pastrana. The PDRRMC concluded that the water must have come from the Southwest of Dagami (Guinaronga) and not from the main Binahaan River.

Map 5: Rain in Leyte and Samar from 07.11, 02:00h, to 08.11.2013, 17:00h from TRMM

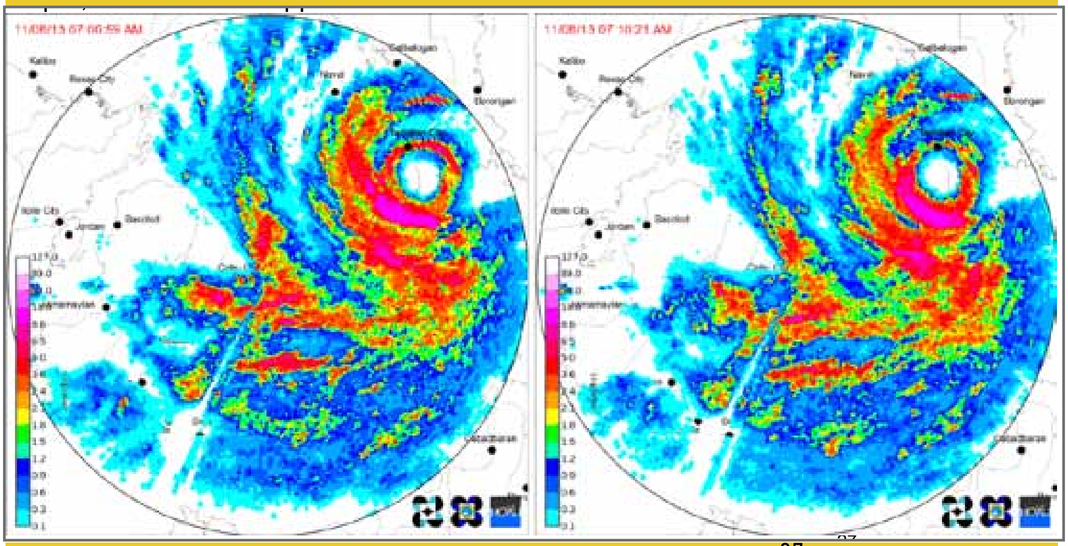


Rain in mm (07.11.13, 02:00 – 08.11.13, 08:00) with data from NOAH (blue dots and numbers with location names)[24] and TRMM (07.11.13, 02:00 – 08.11.13, 17:00) for reference (orange dots and numbers)[25]

The NOAH rain data[26] were partly consistent with the TRMM data, but “PSTC Palo” and “NIA dam” exhibited much lower values than expected and it was suspected that these devices did not function properly. Furthermore “Leyte Leyte” and “Leyte Poblacion” also recorded much lower than expected data and might not have recorded precipitation correctly. The stations “Pagsanjan”, “PAGASA Tac”, and “San Vicente” recorded data in the same range as TRMM.

Doppler radar data from Mactan, Cebu, showed that the heaviest rainfall in Leyte during Haiyan/Yolanda happened in South of the eye of the storm after 07:00h. It appears that the high rain intensity would have been sufficient to create widespread serious flooding if it would have been sustained.

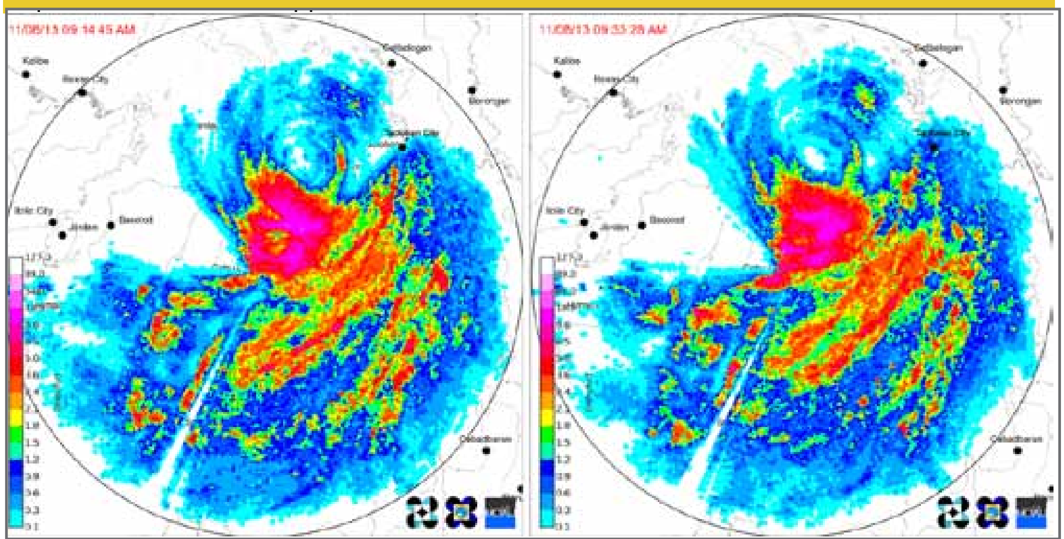
Map 7, 8: Rain from Doppler Radar at 7:00h and 7:10h on 08.11.13



Doppler radar images from PAGASA/NOAH. Date and time on top left. [27]

The typhoon moved quickly Westward and after 09:00 there were only sporadic showers in Leyte were Haiyan/Yolanda made landfall.

Map 9, 10: Rain from Doppler Radar at 9:14h and 9:33h on 08.11.13



Doppler radar images from PAGASA/NOAH. Date and time on top left. Source as above.

The Doppler radar was not yet properly calibrated and the amount of rain indicated with colours are only estimates and not suitable for quantitative calculations of rain.

Considering PAGASA/NOAH, TRMM and Doppler radar data it appeared that there was100-150mm of rain in the central Southern part of Leyte and less than 100mm in the Northern part of the island on 7/8 Nov. 2013. These amounts of rain were small for a typhoon the size of Haiyan/Yolanda and in Leyte such amounts usually do not cause floods. Only one localized flood was reported and this flood caused only little damages.

5.4. Landslide

A few landslides were observed in municipalities in Eastern Leyte. They appeared to be relatively small in size and there are no reports of casualties from landslides or major damages. None of the officials interviewed by GIZ reported landslides.

5.5. Summary concerning the event

At the time of writing this report most, but not all aspects of the natural extreme event that happened in Leyte on 8 November 2014 could be described in detail. The following facts appear to be certain:

A. At 07:00 h on 08.11.2013 the eye of the typhoon arrived in the Tolosa area heading West.

B. The maximum sustained windspeed at this time in Tanauan/Palo was approximately 271 km/h with on-shore wind direction. This is worldwide and historically one of the highest windspeeds of typhoons ever making landfall.

C. The maximum wind speed slowed down to 258 km/h at around 09:00h when the eye of Haiyan/Yolanda left Leyte to the West.

D. South of Tolosa the maximum wind speed was 231km/h and the direction was off shore.

E. The storm surge was highest in the Tanauan, Palo, Tacloban area, but the actual height has not been measured and estimations are between 2.3 and 5m.

F. Rains of 100-150mm fell in the central parts of Leyte, but in the Northern parts of Leyte it was less than 100mm. This is unusually low for a strong typhoon.

G. Only one river flooding event is known (in Dagami) and no significant landslides were recorded.

6 Risk knowledge

Professionals dealing with risks connected to natural hazards can access an array of sources of information describing hazards, vulnerabilities and to some extent risks. Apparently not all persons tasked with disaster risk management in a professional way are aware of all information available or if they are they seem to utilize such information only to a limited degree.

Some information about risks, like the 1:50,000 hazard maps of the READY project, were provided to LGUs, specifically the Disaster Risk Reduction and Management Officers. However, for other information, the persons in charge would have to actively search for it from different sources inside and outside of the Philippines. It seems that only few DRRMOs do that and, as such, relatively small part of relevant information available is known to them.

Obviously some political decision makers were not fully aware of different natural hazards. For example, one Councilor said "It was not a storm surge; it was definitely a tsunami."[28] Even if information was present (e.g. READY hazard maps) some officials tasked with disaster management did not utilize it [29, 30]. The same applies to some members of the national government who awaited the typhoon in Tacloban and became initially victims themselves without any means of communication [31].

Because risk knowledge was limited, the utilization of such knowledge was naturally also limited. This lead to inadequate (or no) actions by responsible disaster managers. Only parts of the people in the storm surge area were evacuated and many of those who remained in their homes died. Even evacuation centres became into death traps as they were located in the inundation area [32,33].

Citizens are not expected to do their own research into sources of information about hazards. They have to rely on what government officials and media tell them. However, the most reliable source of knowledge for many citizens is apparently their own experience. They are able to relate to frequently occurring hazard events like river floods or average type of typhoons but not so much to rarely happening events with return periods far beyond normal expected lifetime. For those rare events media or official information must play a crucial role. This is apparent for tsunamis. No significant tsunami hit the Eastern coast of Leyte within living memory but the media coverage of the tsunamis in the Indian Ocean in 2003 and in Japan in 2011 raised the awareness of the dangers of a tsunami considerably.

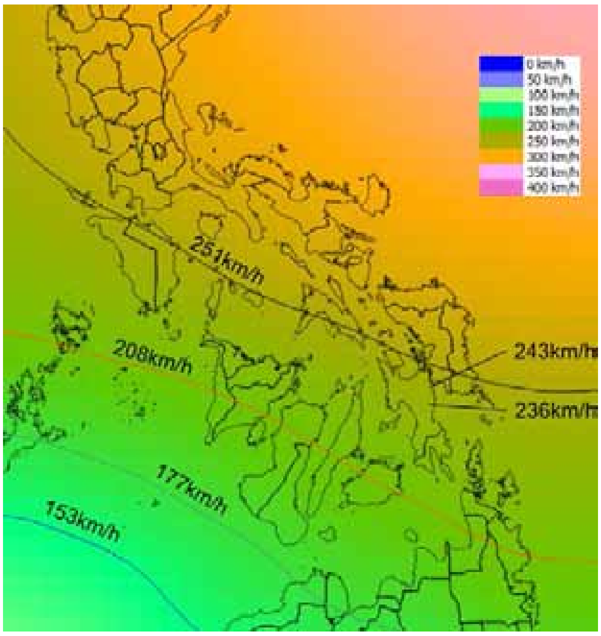
6.1. Storm

PAGASA did not publish a wind/ storm hazard map for Region 8 of the Philippines yet, but there are a number of other sources of information available.

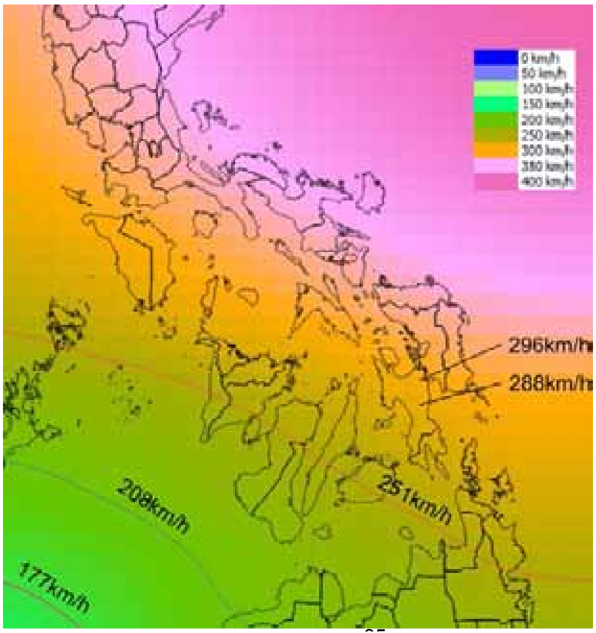
CAPRA (Central American Probabilistic Risk Assessment) published a worldwide Wind / Storm Hazard map in GIS format[34]. GIZ converted this to printable maps. Examples covering Leyte are shown in **Maps 11, 12** for 100 and 250 years return periods.

Commercial buildings such as the Metro Supermarket were destroyed after Super Typhoon Haiyan battered Tacloban city.

Map 11, 12: Storm Hazard from CAPRA



Return Period of 100 years
Isolines of wind speed calculated by GIZ.



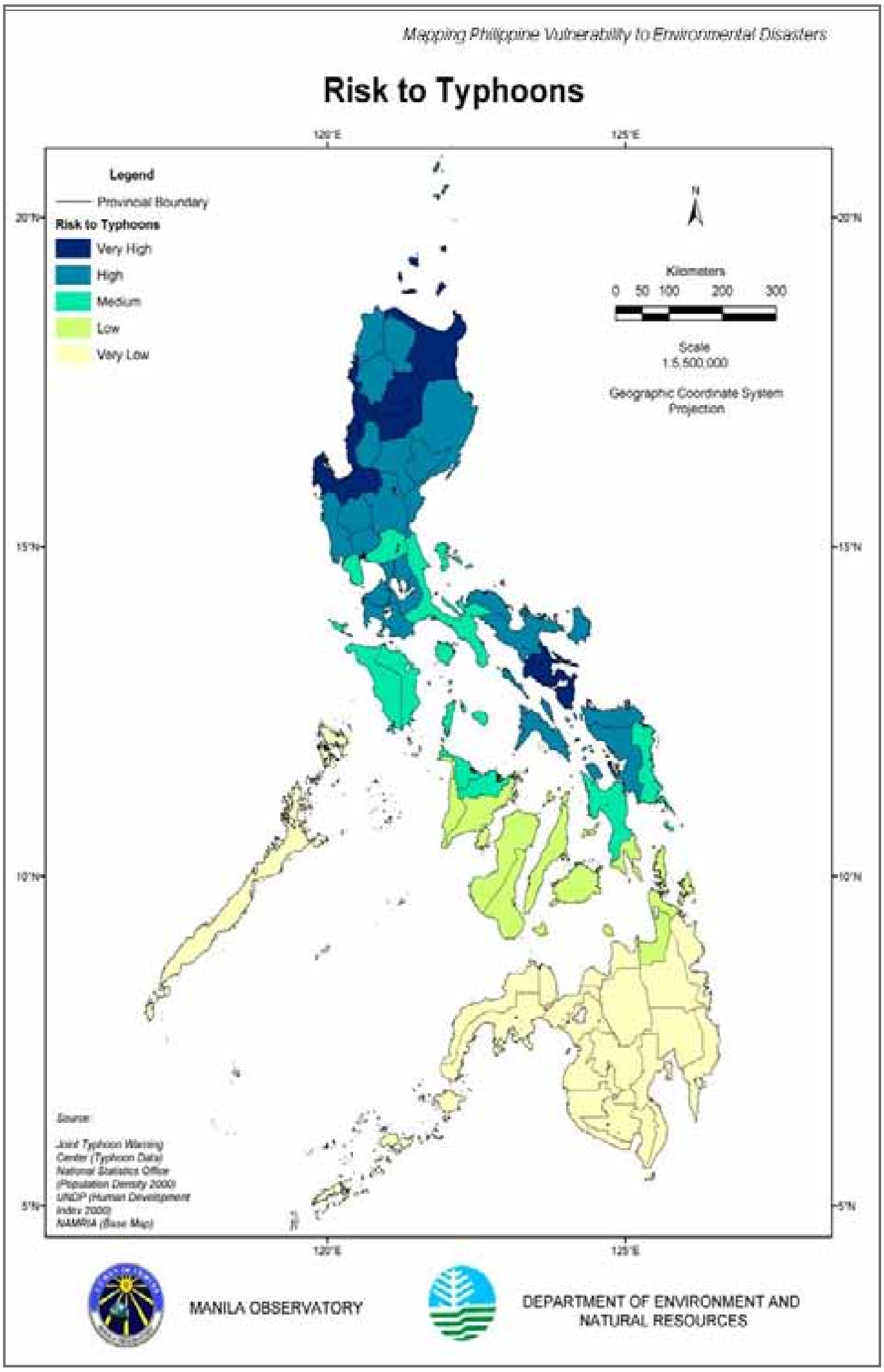
Return Period of 250 years [35]

The CAPRA maps show that the Eastern coast of Leyte lies in the area of a 100 years return period of Saffir Simpson Category 4 and in the 250 years return period of a Category 5 storm. This means a tropical cyclone like Haiyan/Yolanda is statistically expected once in 250 years. However, the calculated speeds for Eastern Leyte suggest a return period closer to 200 years.

Manila Observatory published a typhoon risk map. It is a qualitative map comparing the risk of different provinces but it does not provide indications of probabilities or categories of typhoons.

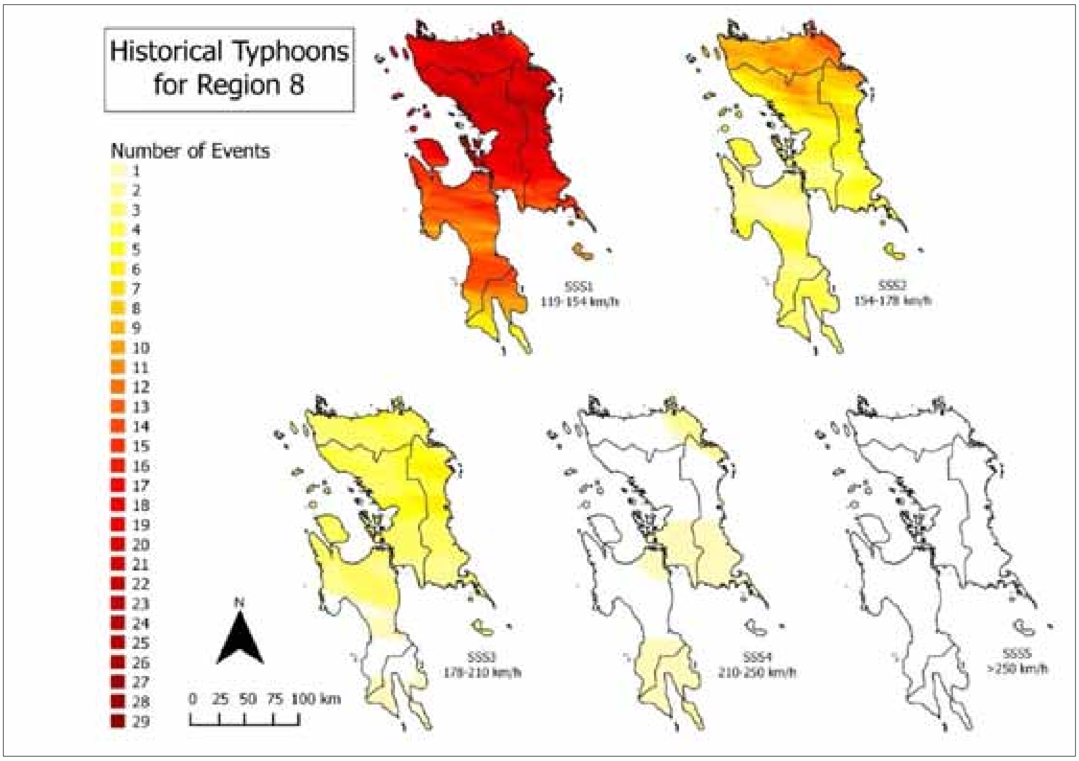
A cargo ship washed ashore after super Typhoon Haiyan hit Anibong town, Tacloban city.

Map 13: Typhoon Risk Map by Manila Observatory



GIZ analysed historical typhoons in Region 8 by calculating wind speeds and counting the times the same wind speed hit an area. Reference period was the last 60 years. It is noteworthy that no tropical cyclone of Saffir Simpson Category 5 hit the Eastern Visayas during these 60 Years. Therefore the map displaying SSS5 is blank (**Map 14**).

Map 14: Historical Wind Speeds in Region 8 by GIZ



SSS: Saffir Simpson Scale

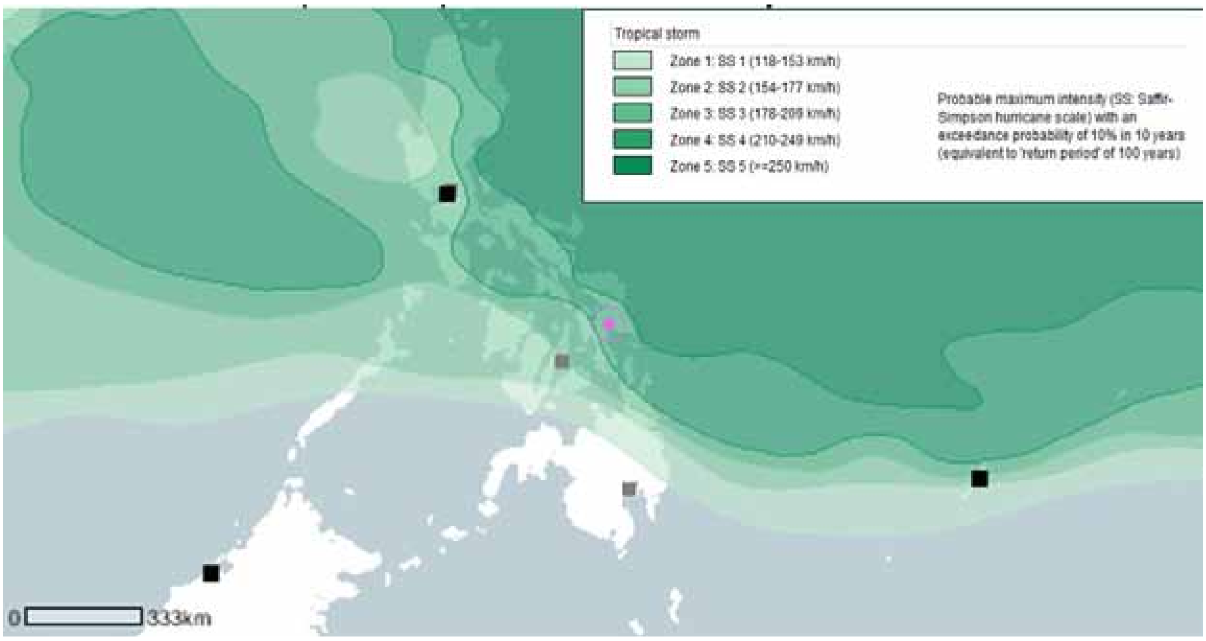
The GIZ-generated map is a historic map and not a hazard map displaying future probabilities. However, in hazard mapping it is generally accepted that historic maps can serve as probability maps for the same future time period as the analysed period. This means a similar wind speed distribution could be expected for the next 60 years. The non-occurrence of SSS5 in 120 years does not contradict the CAPRA maps. The 200 year return period of CAPRA is consistent with GIZ's findings.

The reinsurance company MunichRe published a tropical storm hazard map for typhoons with a return period of 100 years (**Map 15**). The Pacific coast of Leyte is in Zone 4. This means a storm of SSS5 is expected to be less frequent than once in 100 years.

People driven to desperation looted business establishments for food in Tacloban city.

© Photo by Brenda Samson on November 9, 2013

Map 15: Tropical Storm Hazard by MunichRe



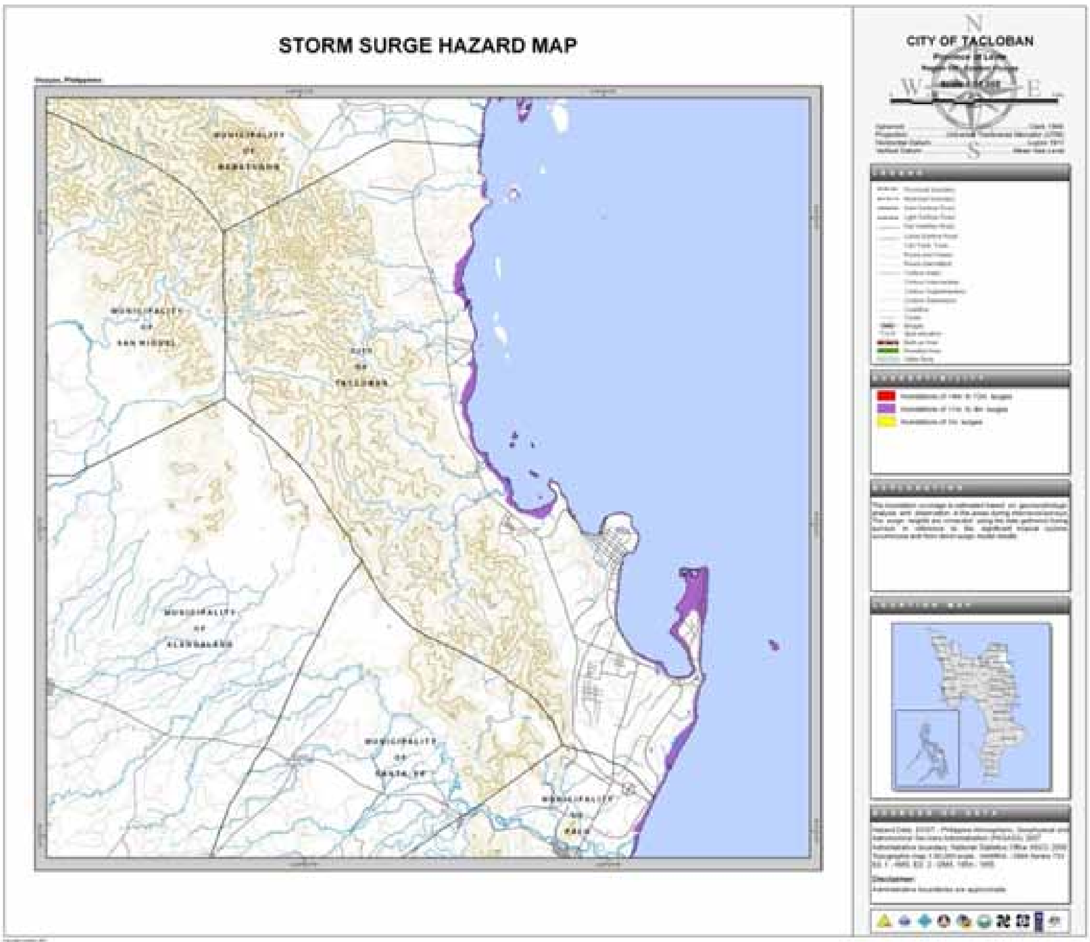
All four sources are consistent in seeing Leyte to be less likely to be hit by strong storms than more Northern provinces. From the CAPRA and MunichRe maps it may be concluded that the return period for storms with wind speeds as Haiyan/Yolanda have a return period of about 200 years in Eastern Leyte.

6.2. Storm surge

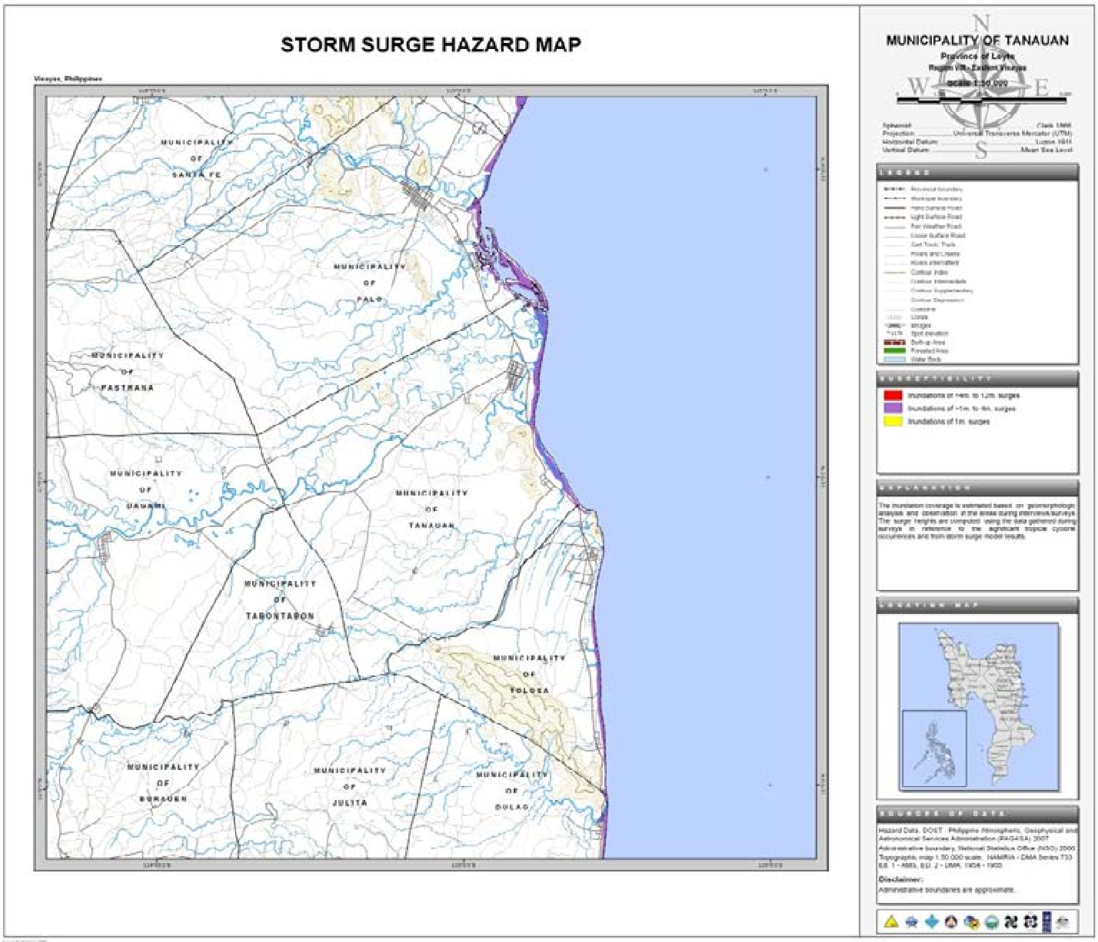
Only one source of storm surge hazard maps is known. This scarcity probably indicates that this hazard was underestimated in the past. In the context of the READY project PAGASA published storm surge hazard maps (**Maps 16, 17**).

The city was turned into a "ghost-town" after Typhoon Haiyan has broken downtown Tacloban and its people.

Map 16: Storm Surge Hazard Map for Tacloban



Map 17: Strom Surge Hazard Map covering Palo, Tanauan, Tolosa

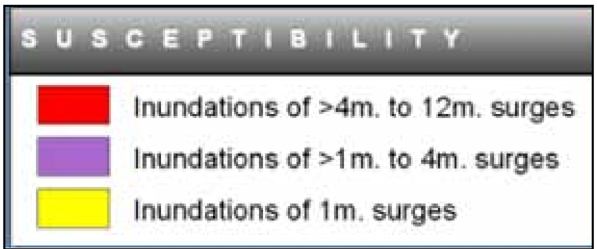


Interestingly the storm surge hazard maps by PAGASA only display inundation areas for 1-4 meter surges, but not for lower and higher surges although these are indicated in the legend of the map (enlarged inset). For a reader of the map it might be difficult to judge whether the lack of 4-12 meter inundations on the actual map mean that this is not expected to happen in this area or whether it was omitted for some other reason. According to JRC, NOAH and Deltares (see chapter The Disaster Event) the water height during the Haiyan storm surge was in the range of 2.3 -5 meter. With this it appears that the hazard map of PAGASA underestimated the possible inundation area for a surge of this magnitude.

The PAGASA maps only included up to 4 meter water heights, but the forecast of PAGASA for the Haiyan surge height was 7 meter. Therefore it would appear to be reasonable consulting the hazard maps for a similar hazard, the tsunami, where higher wave heights (4-5 meter) were used as a basis for the inundation area.

PHIVOLCS contributed tsunami hazard maps for the Eastern coast of Leyte (**Maps 18, 19**). The maps do not display the height of the water in the inundated area but there are points in the ocean indicating wave heights in a certain area. In the area of interest the height is 4-5 meter. This happens to be comparable to the height of the storm surge caused by Haiyan/Yolanda.

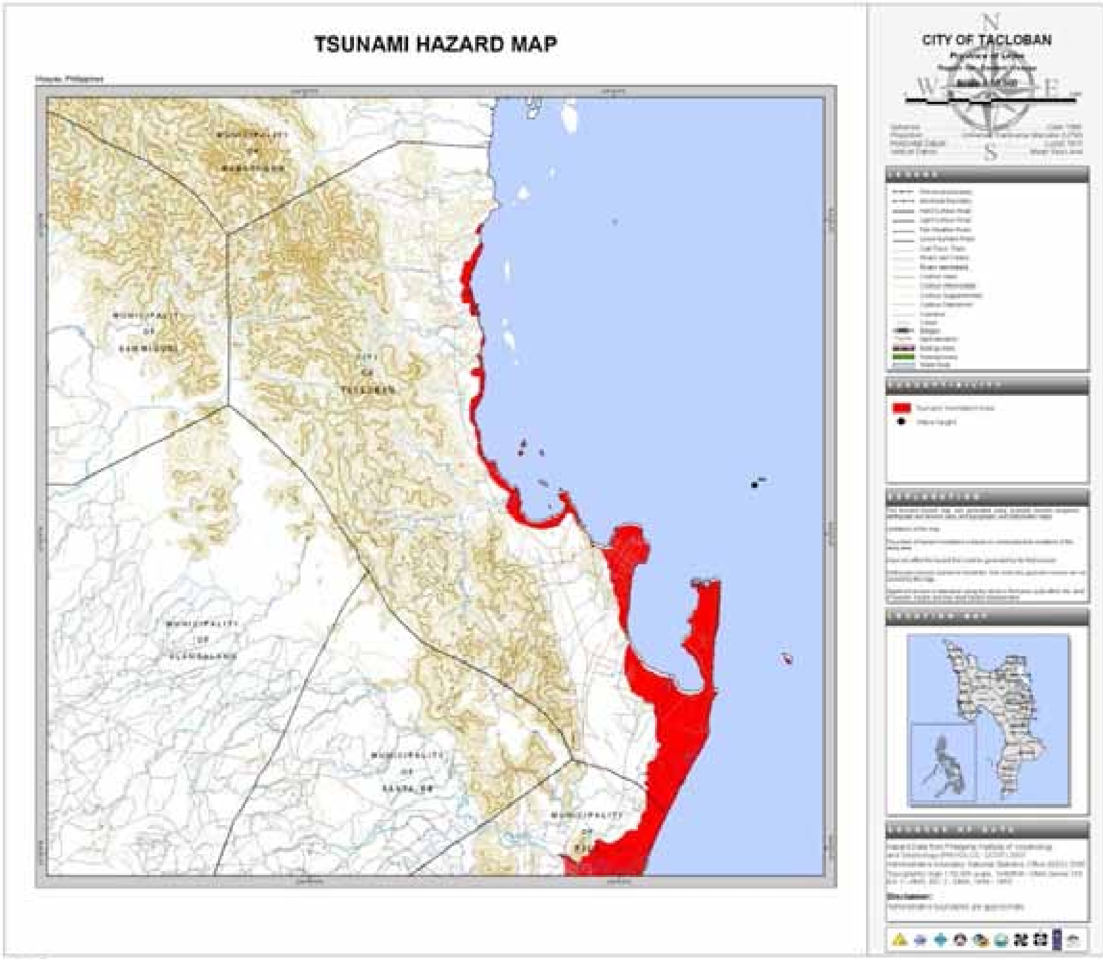
Map 17, enlarged detail



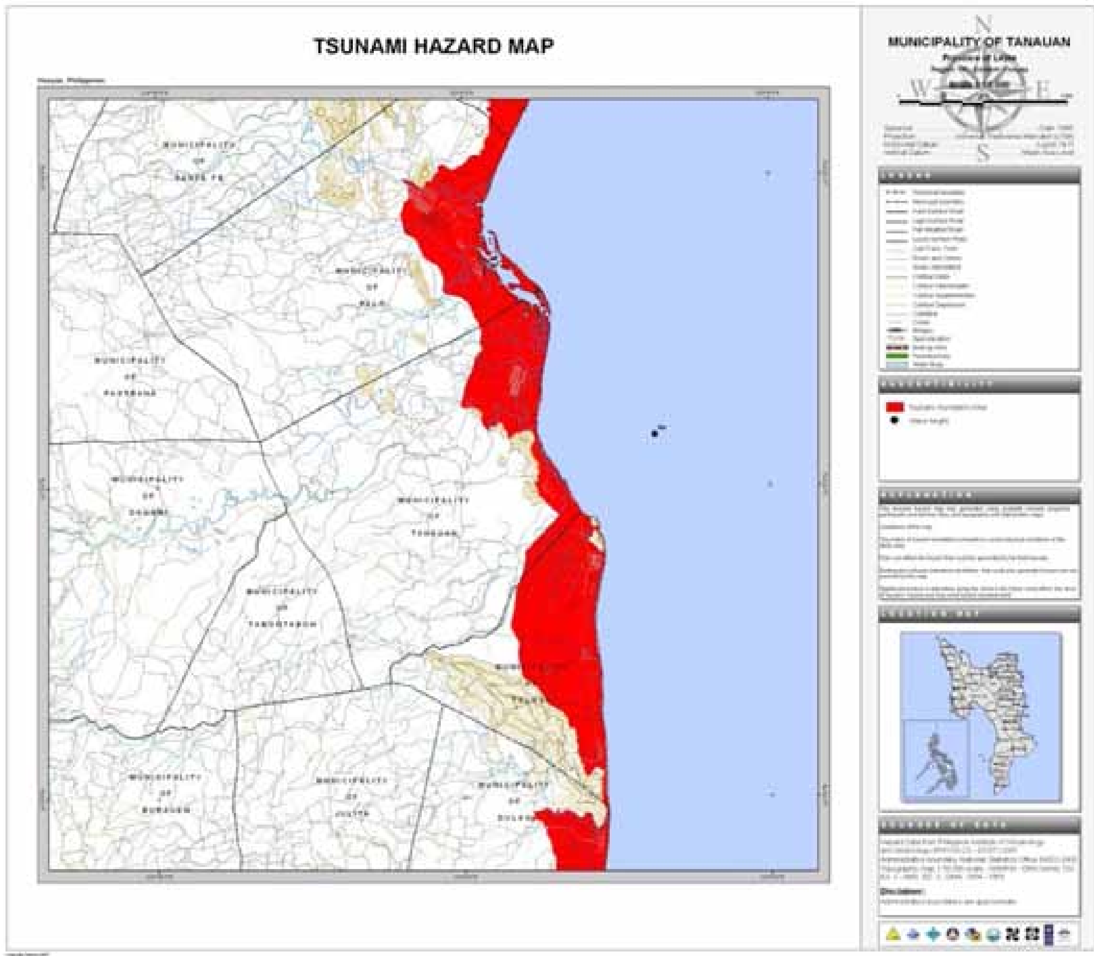
Enlarged part of the legend of PAGASA storm surge hazard

A tangled mess of destroyed houses, piles of debris and toppled trees a day after super typhoon Haiyan hit Tacloban.

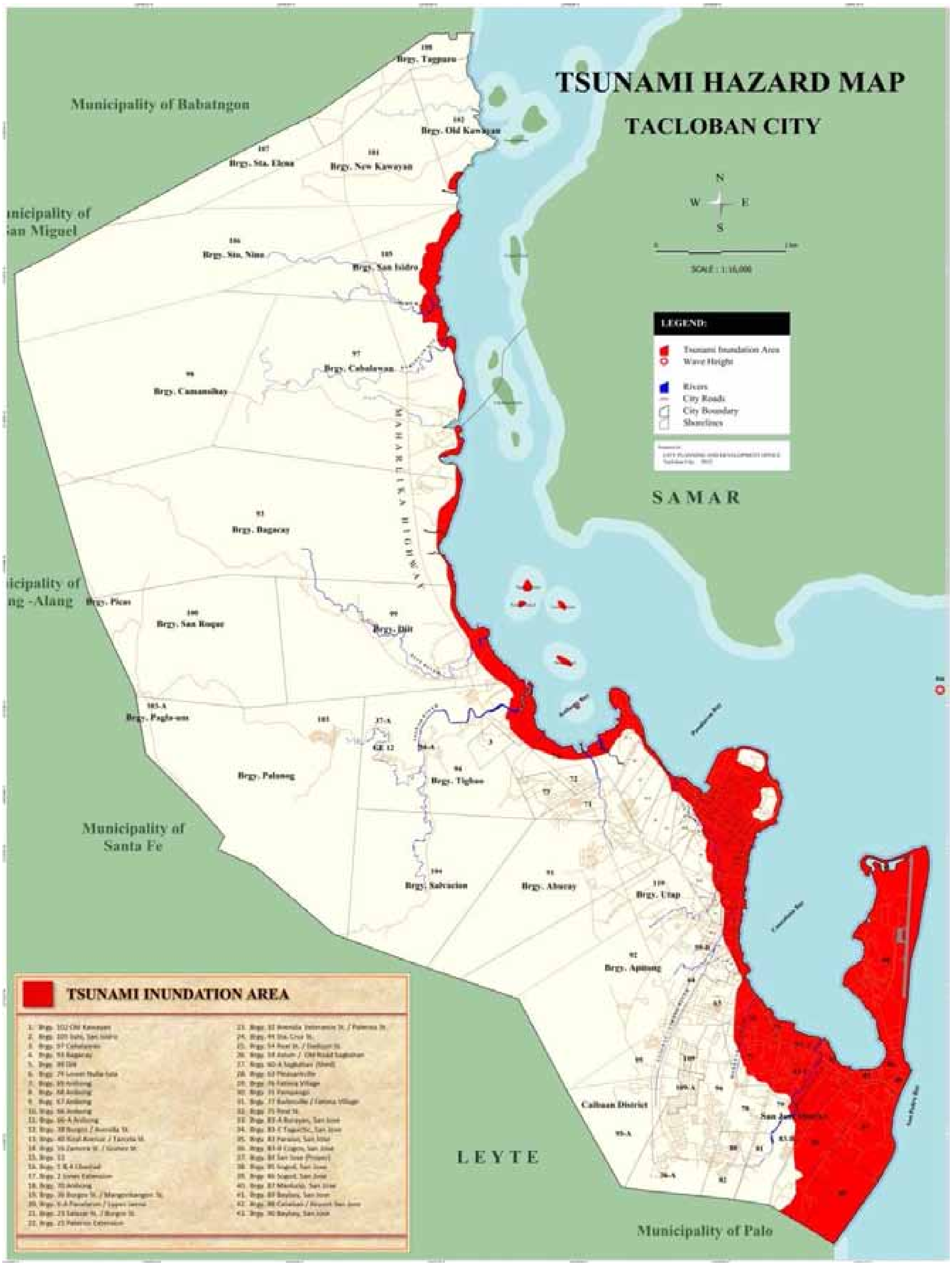
Map 18: Tacloban Tsunami Hazard Map by PHIVOLCS



Map 19: Tsunami Hazard Map covering Palo, Tanauan, Tolosa by PHIVOLCS



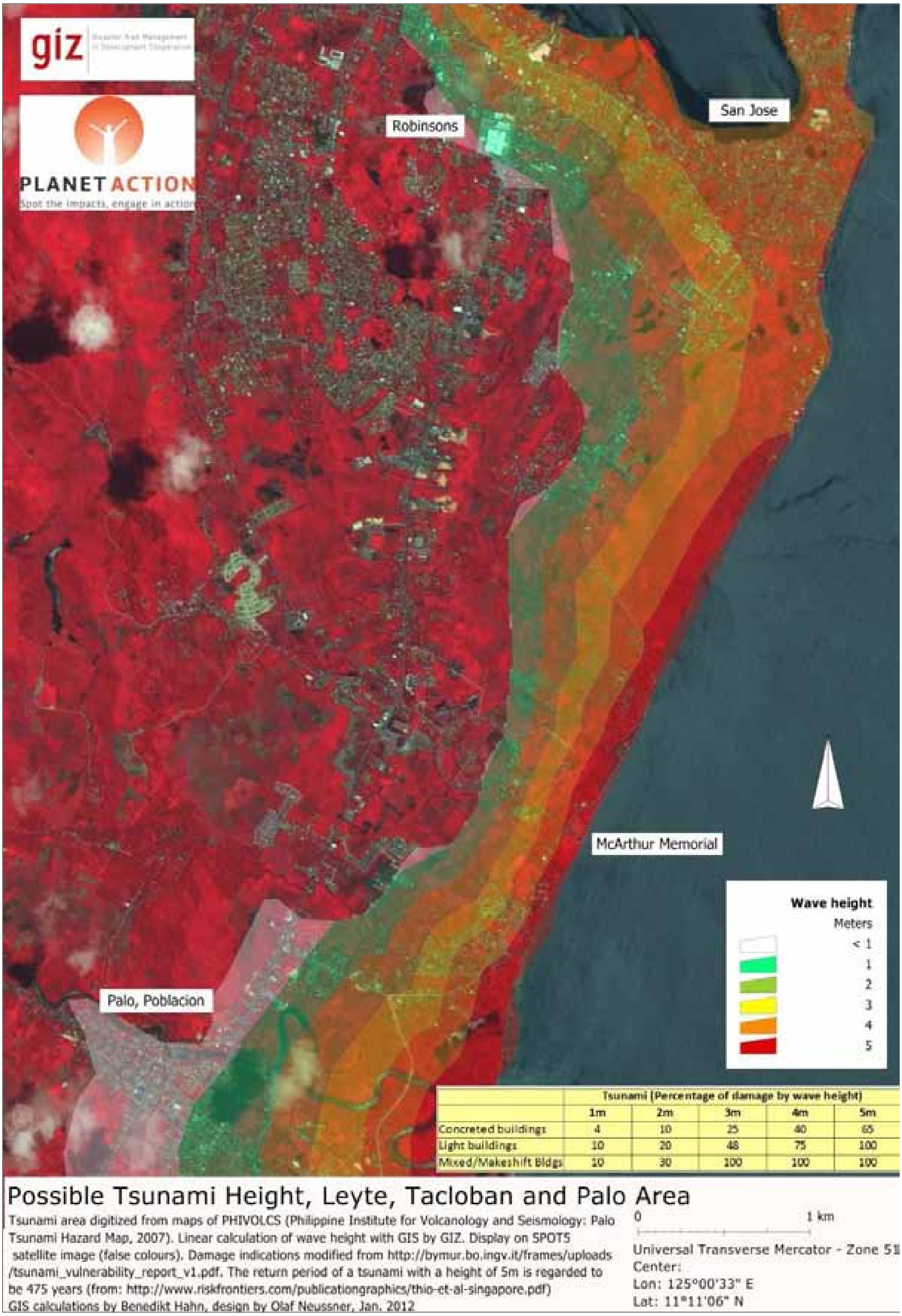
Map 20: Tsunami Hazard Map produced by Tacloban City



The PHIVOLCS map was slightly modified by the City of Tacloban in 2012.

On the basis of this map GIZ calculated inundation heights and displayed this in maps with the background of a satellite image. **This map** was given to the City of Tacloban for reference.

Map 21: Tsunami Hazard Map of Southern Tacloban by GIZ



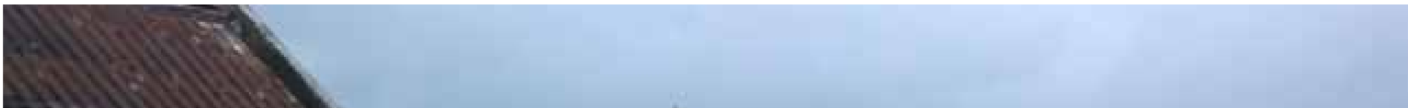
	Tsunami (Percentage of damage by wave height)				
	1m	2m	3m	4m	5m
Concreted buildings	4	10	25	40	65
Light buildings	10	20	48	75	100
Mixed/Makeshift Bldgs	10	30	100	100	100

Most LGU officials tasked with disaster management in the coastal LGUs said they checked hazard maps to determine who needs to be evacuated and which evacuation centres are safe. Only two out of ten interviewees said they did not check this. The respondents who stated that they verified the location of evacuation centres include Tacloban and Palo. In both places many people died from the storm surge in evacuation centres.

GIZ interviewed 29 coastal residents in early December 2013. Nine of them said they either did not know whether their houses were in potential storm surge areas or they assumed it was not (e.g. 500 meter from shore). This means approximately a third of those people whose houses were most likely in storm surge hazard areas were not aware of this fact.

6.3. Rain and river floods

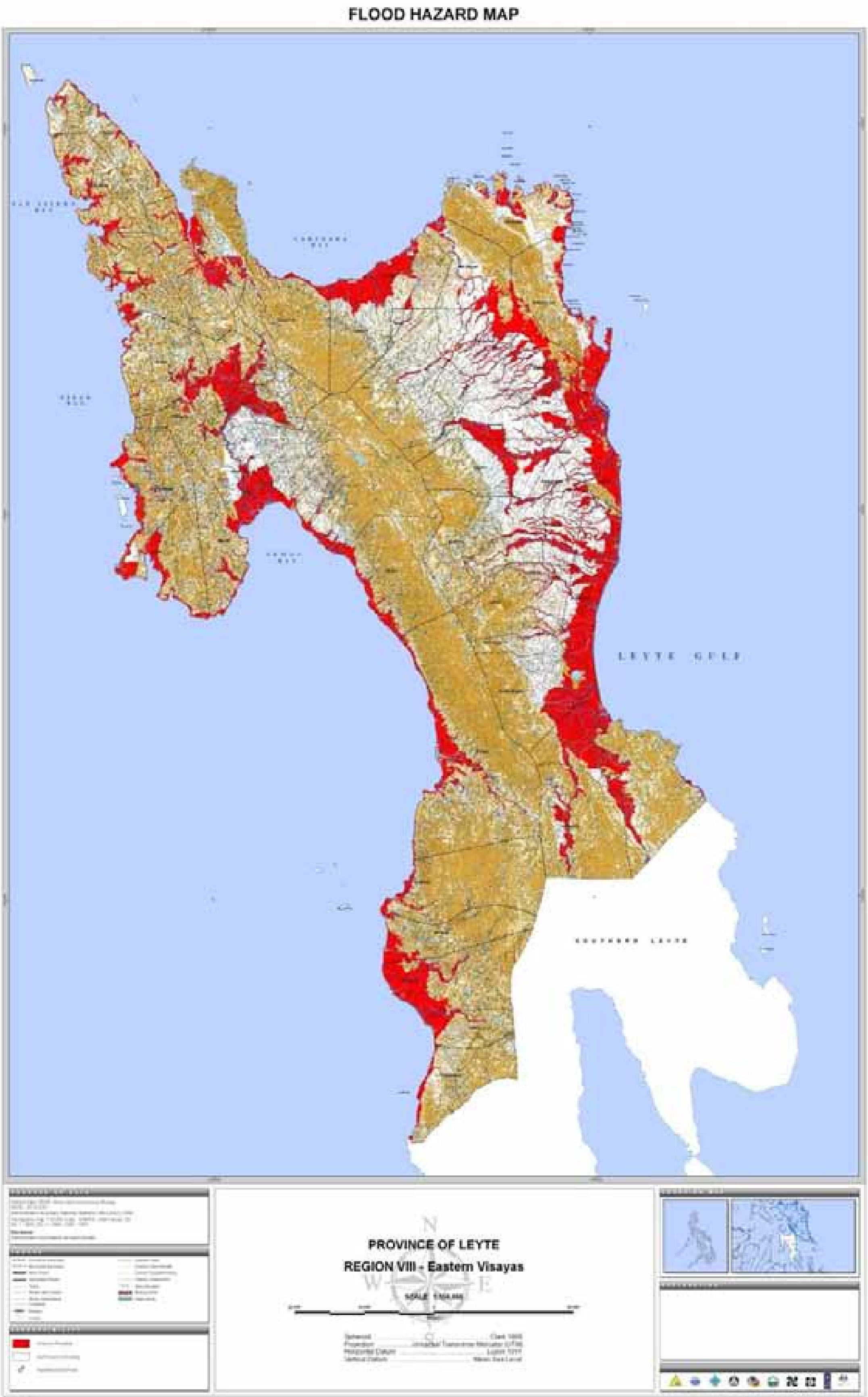
The MGB published a flood hazard map for the province of Leyte in 2007 (**Map 23**). This map displays rain induced floods and not storm surge. It does not quantify the flood hazard in terms of probability or water height. It appears that the map needs some verification. Community based mapping efforts in some LGUs revealed discrepancies to the MGB map. According to accounts of communities flood prone areas are often smaller than the map of MGB indicates. This applies especially to beaches which are not flood prone, but in some case barangay residents also identified areas as flood prone which are not marked on the MGB map.



© Photo by Ruth Cabangangan on November 8, 2013

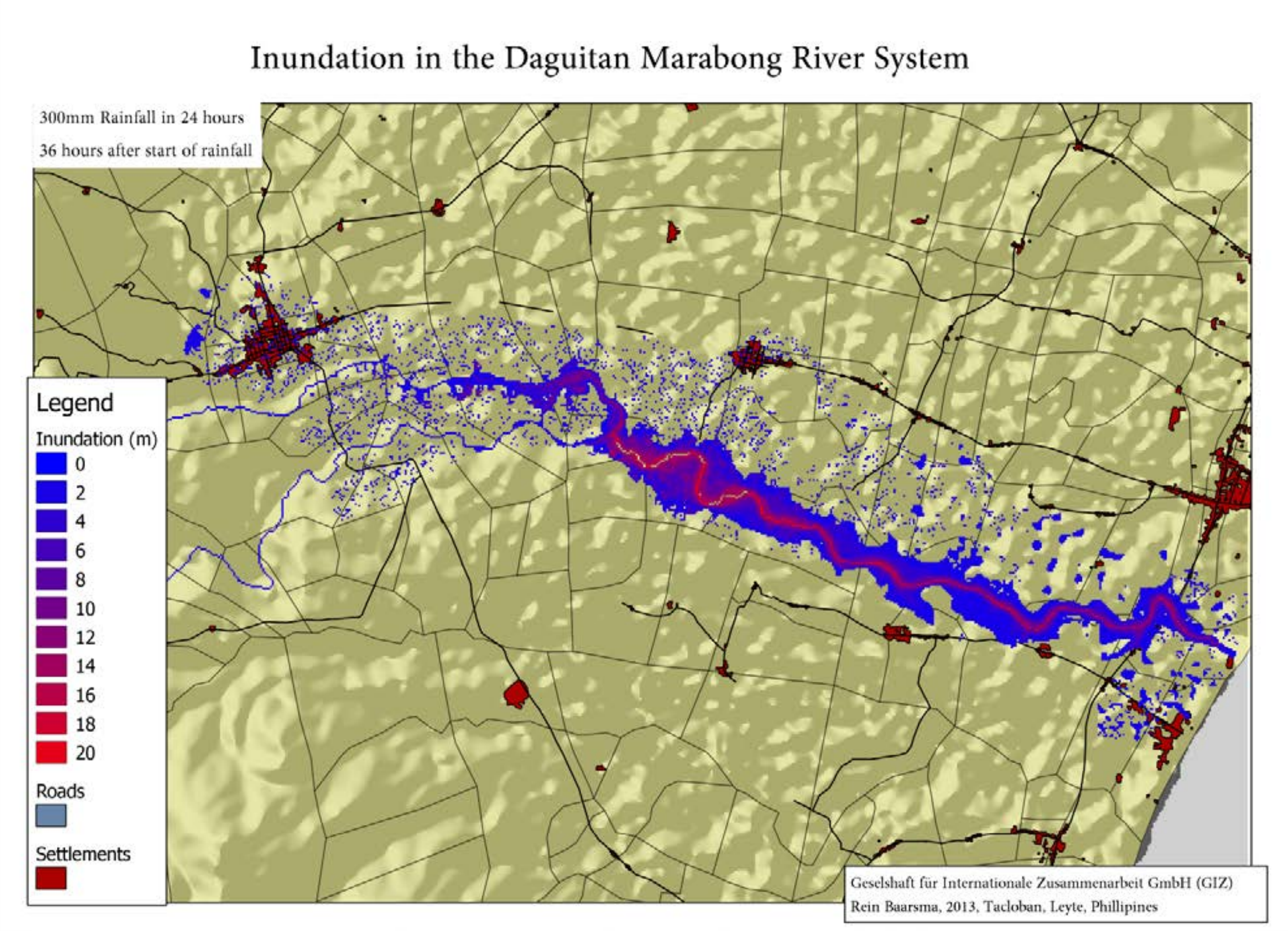
Houses submerged in floodwaters in the aftermath of Typhoon Haiyan in the town of Dagami.

Map 23: Flood Hazard Map by MGB



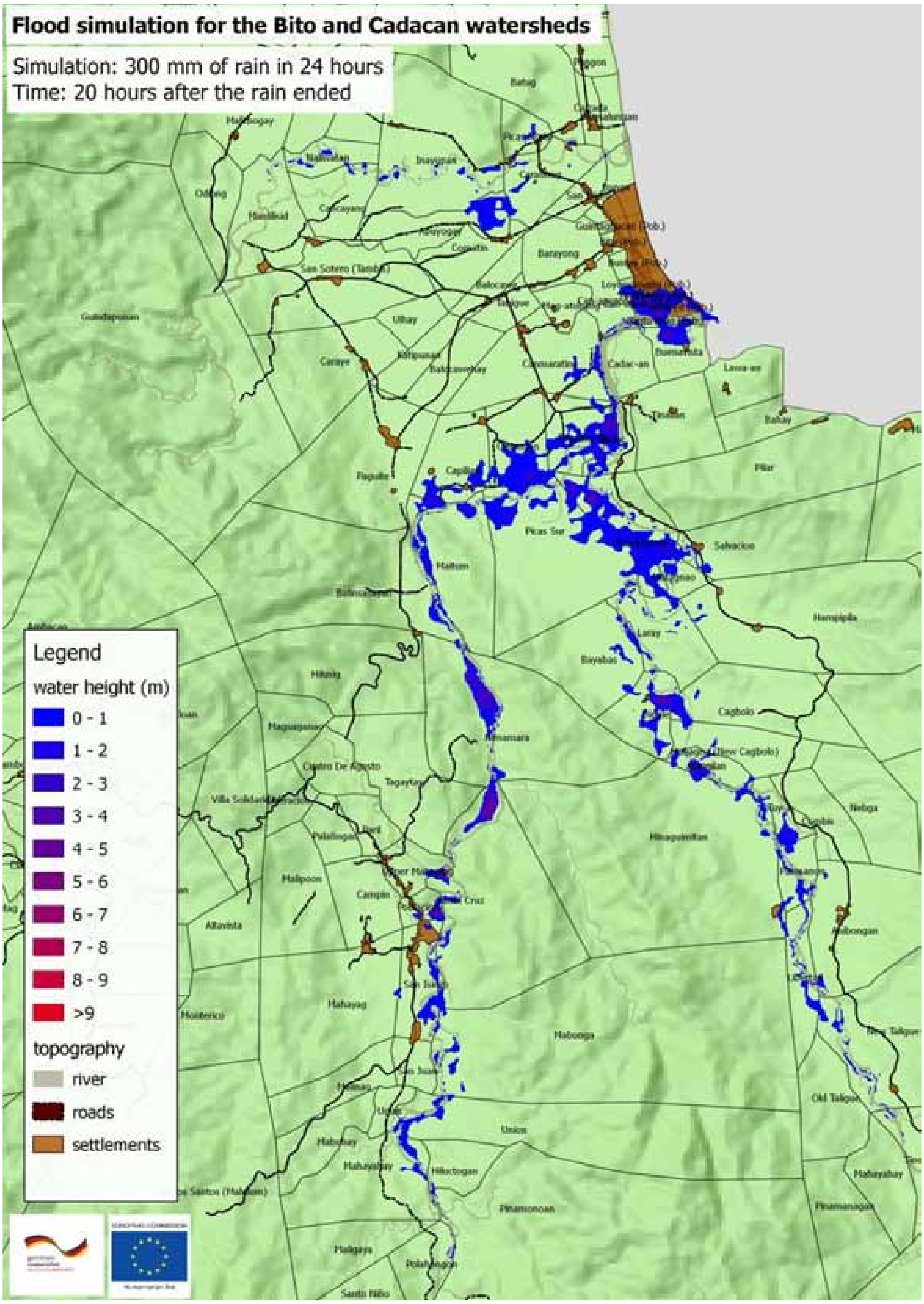
GIZ supported the development of computerized flood models in four rivers in Leyte. Two of the finished models cover watersheds affected by Haiyan/Yolanda on the East coast of Leyte. The models cover most parts of Mahaplag, Abuyog, Javier, Burauen, Julita, and Dulag (**Maps 24, 25**).

Map 24: Modelled Flood in the Daguitan-Marabong Watersheds



Submerged cars sit in floodwaters in the aftermath of Typhoon Haiyan in the town of Dagami.

Map 25: Modelled Flood in the Cadac-an - Bito Watersheds



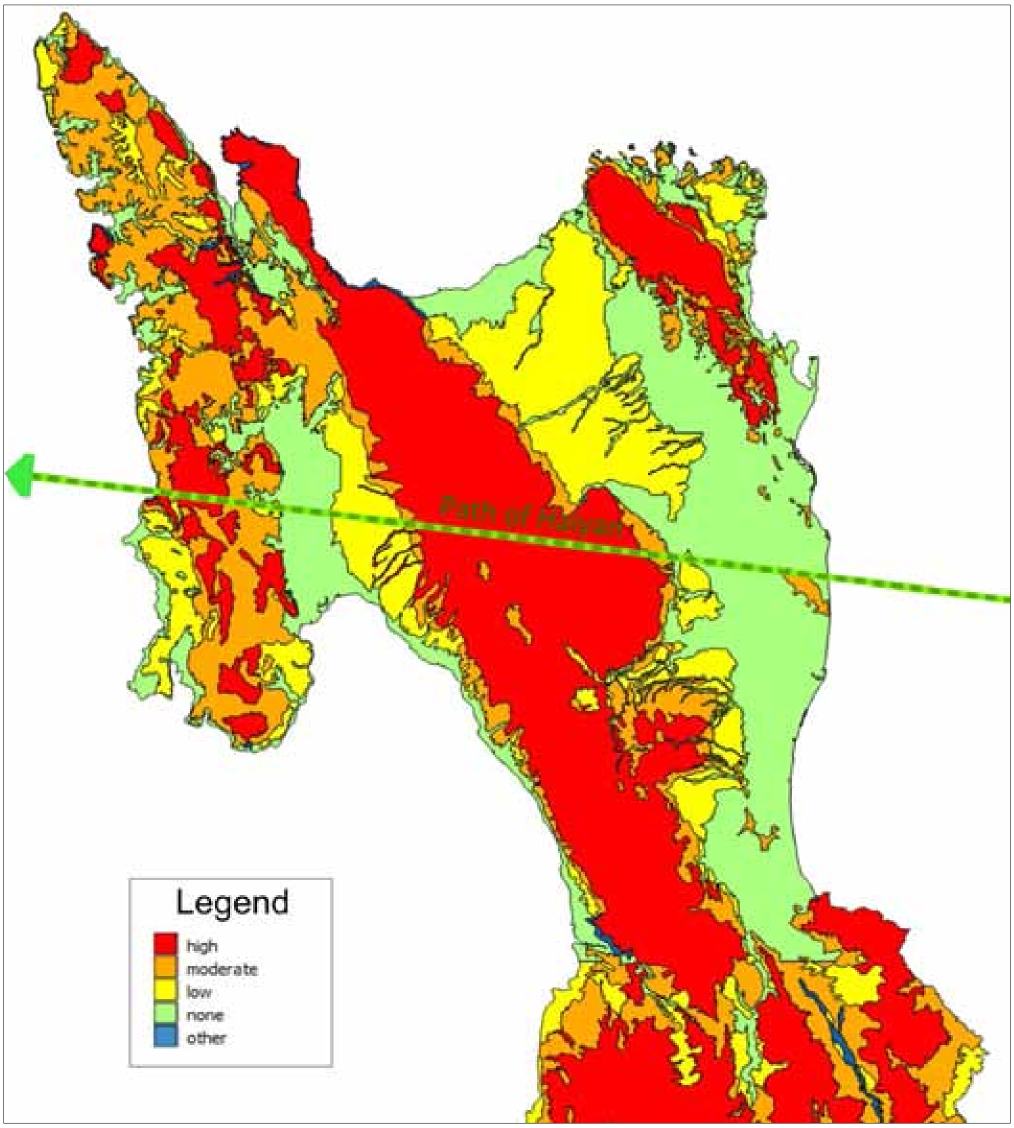
Sets of maps with time steps of different rain scenarios were handed over to the operation centres of the Local Flood Early Warning Systems of the respective river systems.

6.4. Landslides

The Mines and Geoscience Bureau (MGB) published a map displaying the susceptibility to rain-induced landslides in three categories, high, moderate and low (**Map 22**). The map of MGB does not quantify the danger of the different categories, therefore estimations of the danger in these areas are difficult. Based on historic landslides in Leyte GIZ estimated that the probability of an actual landslide happening is approximately 1:2500 for the high susceptibility area.

The map of MGB shows that most of Leyte is landslide prone, though to varying degrees. In case of a strong typhoon excessive rains may be expected and precautions for people in these areas are advisable. At least the amount of rain falling should be observed. In case it is unusually high (e.g. 80 mm in 3 hours) evacuation to less landslide prone areas is strongly recommended.

Map 22: Rain Induced Landslide Susceptibility by MGB



Data (shape files) from MGB based on survey from 2007. Corrections for consistency by GIZ.

6.5. Vulnerabilities

Vulnerability is defined as the characteristics and circumstances of a community, system or asset that makes it susceptible to the damaging effects of a hazard (from UNISDR: UNISDR Terminology on Disaster Risk Reduction (2009)). Here the physical dimension of vulnerability and the social dimension are discussed in some detail.

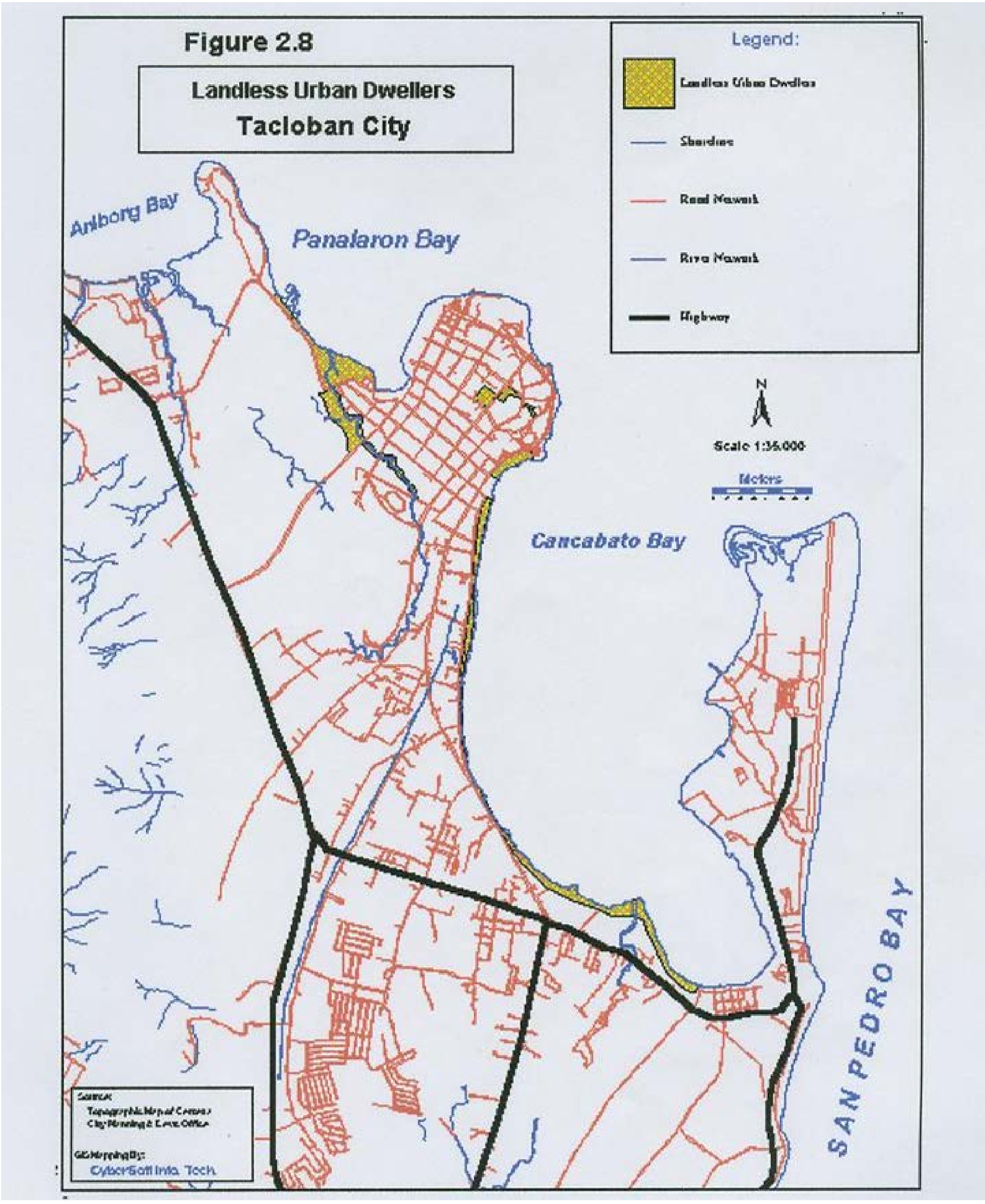
Physical assets include different forms of land use like forests, agricultural crops and build-up areas, including infrastructure. Their vulnerability is described by vulnerability curves showing the degree of damage caused by different levels of the hazard. In the context of casualties caused by Haiyan/Yolanda the vulnerability curves for buildings are important. They should be specific for typical Philippines buildings, but unfortunately relatively few locally adjusted data exist. However, available data can be used in the absence of more locally adjusted data. GIZ compiled physical vulnerability data for many hazards and they are displayed in **Appendix 2** for the two main hazards in connection to Haiyan/Yolanda, high winds and storm surge. The data give a good indication that the forecasted wind speeds and storm surge heights would have caused damages up to 80% of the exposed assets.

Storms with wind speeds of more than 250km/h are known to cause major damages on buildings. Many residential dwellings are made of light materials particularly vulnerable to high winds. An example of a map with such dwellings is displayed in **Map 26**.


© Photo by Benni Thiebes on November 8, 2013

Debris lines the streets of Paterno in Tacloban after Typhoon Haiyan.

Map 26: Informal Settlements in Tacloban

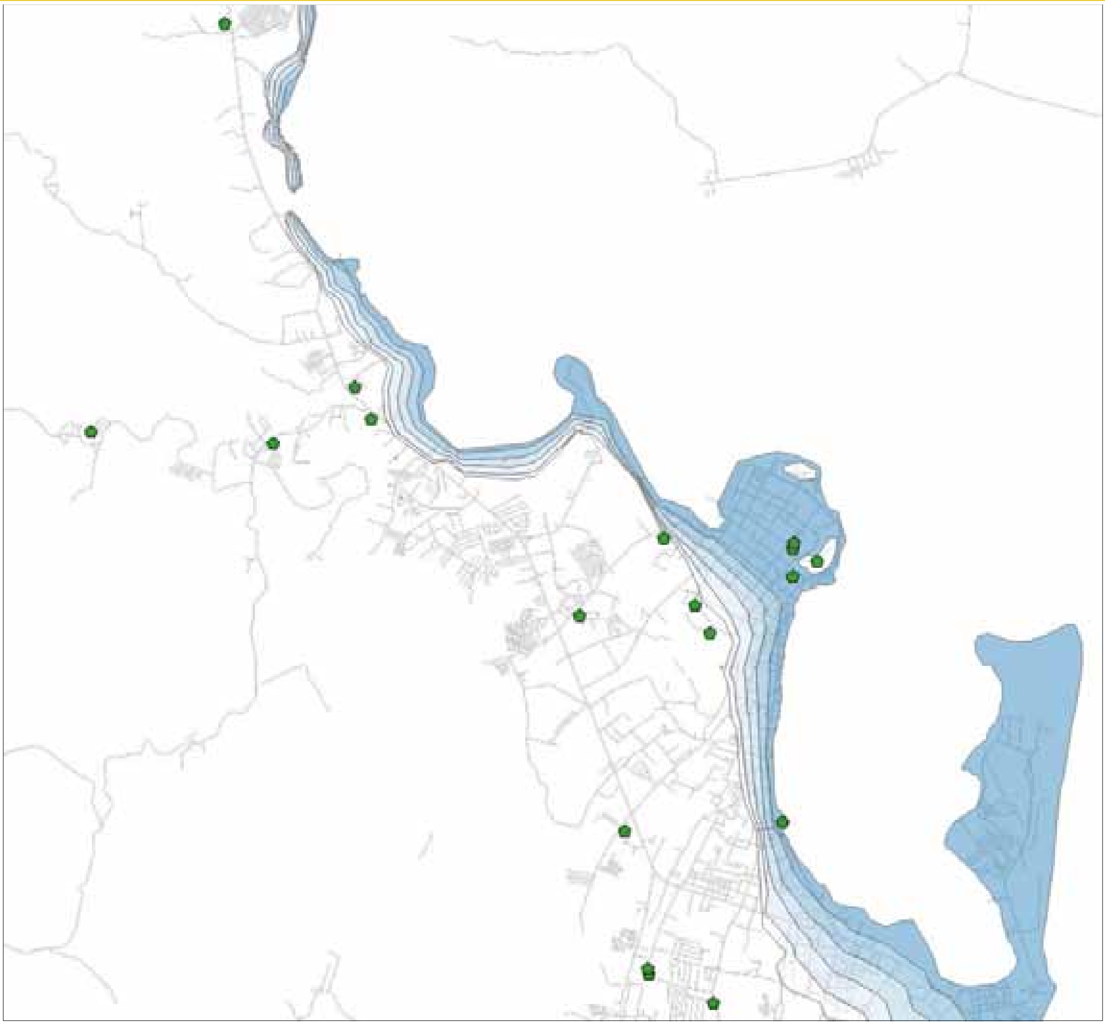


It is noteworthy that this map of Tacloban is not up to date. In November 2013 the extent of informal urban settlements with light material was considerably bigger than indicated in **Map 26**.

A special concern is the vulnerability of evacuation centres. According to different hazard maps (PAGASA: storm surge; PHIVOLCS: tsunami) a number of them were located within these hazard areas and should have been especially retrofitted to shelter persons from waves and high water levels (e.g. built on very strong stilts). It appears that they were not designed to host people seeking protection from storm surges or tsunamis as most of them were single floor buildings without stilts. An exception is the Astrodome in Tacloban. It is higher than expected water levels, but people were also hosted in the ground floor.

According to eye witnesses some of them drowned.

Map 27: Selected Evacuation Centres in Tacloban



Shades of blue: Water height calculated by GIZ from tsunami hazard map (0-5m) [36], green pentagons: evacuation centres, grey lines: roads (from Open Street Map)

At least four evacuation centres lie in the tsunami hazard area and they are not retro-fitted to withstand tsunamis or storm surges. Several evacuation centres in other LGUs were also located in the tsunami hazard area (e.g. San Joaquin Central School in San Joaquin, Palo) and many people died there.

The Regional Office of Civil Defence (OCD) was asked by the OCD Head Office in Manila to check the safety of the location of evacuation sites in relation to natural hazards (see **Appendix 1**). OCD Region 8 told GIZ that this check was carried out together with DPWH, MGB and DOH, led by OCD. Results of such checks are not known to GIZ. The utilization of many evacuation sites during Haiyan/Yolanda in hazardous areas suggested that the check was either not carried out in a responsible manner or did not lead to adequate action by responsible offices.

6.6. Summary for risk knowledge

A. The official storm surge hazard map underestimated the inundation area of the storm surge. The actual area was larger and close to the inundation area shown in the official tsunami hazard map.

B. The storm surge hazard map only indicates water heights of 1-4 meter. Though the legend of the map shows surge heights up to 12 meter, they are not displayed on the map. As PAGASA forecasted a 7 meter height of expected storm surge it was not possible to relate this map to the predicted surge.

C. There is sufficient information available concerning the vulnerabilities of buildings to high wind speeds and to storm surge as it is similar to a tsunami.

D. Though a spectrum of risk information was available, those in charge of risk management were partly unaware of the hazard and vulnerability information and/or did not use the information appropriately.

E. OCD/LGUs apparently did not properly check the safety of the locations of evacuation centres with respect to high storm surges or the check was performed and did not result in appropriate actions.

F. Some evacuation centres were located in storm surge areas.

7 Early detection of Haiyan/ Yolanda

In the Philippines the central government institution tasked with the detection of hydro-meteorological hazard events is PAGASA, but others are involved too. The NOAH project of DOST operates a set of rain gauges and river level sensors to detect emerging floods. NOAH also runs computer simulations of storm surges and displays calculated chances of rain for the next six hours on their website. In some rivers flood early warning systems operated by LGUs are in place. Furthermore Typhoon2000[37] and Weather Philippines Foundation[38] provide weather related services partly generated from own resources like Automatic Weather Stations. Some media houses also employ their own weather forecasters.

On international level, there are several institutions observing the development and progress of typhoons in the Western Pacific and some of them include predictions of storm surges and rain in their services.

There are four hazards with the potential of causing damages and casualties associated with tropical cyclones. By definition of a tropical cyclone high wind speeds are the prime hazard. Tropical cyclones are categorized by wind velocity and not by the amount of rain they may bring or the storm surges they may cause. Therefore torrential rains and resulting floods and landslides as well as storm surges are regarded as secondary hazards coming often together with a tropical cyclone. However, all of them may also happen without a tropical cyclone.

7.1. Storm

PAGASA issued several storm warnings before Haiyan/Yolanda made landfall in Guiuan, Eastern Samar. The warnings correctly described the actual wind speed category and the location (Southern part of Eastern Samar and then Northern part of Leyte Island). It included the declaration of storm warning signals on a per province basis. All provinces in the path of the typhoon were assigned the highest warning level. The information from PAGASA was published in the daily Bulletins of the NDRRMC and widely spread by media.

Several other official weather agencies also published track and wind speed forecasts. All of these forecasts agreed on the track via the Eastern Visayas and in the days before landfall that the typhoon would have a wind speed of more than 250km/h. The popular website Typhoon2000 links to the websites of the different weather agencies and many disaster managers check the different forecasts via this portal.

The media actively disseminated the facts from the weather agencies and the warning levels issued by PAGASA. Based on warnings of PAGASA the Philippine president, Benigno Aquino, appeared on TV on 07.11.2013 and emphasised the warnings of the weather agency[39].

7.2. Storm surge

At least two agencies are known of having issued computer simulations of storm surges caused by Haiyan/Yolanda for Leyte before the storm made landfall. One was published by the Joint Research Center (JRC) of the European Union: on 6 Dec. at 20:00 h local Philippine time it predicted water heights of 2.6 meter for the Tolosa-Tacloban area[40]. Project NOAH ran a simulation and came up with water heights of 4.5 meter for Tacloban.

Table 1: Storm Surge Heights Predictions by NOAH[41]

Province	Location	Storm Surge + Tide (m)	Date and Time of Peak Height
Eastern Samar	Matarinao Bay	5.3	11-08-2013 09:50,
Biliran	Poro Island, Biliran Str	4.7	11-08-2013 12:10,
Leyte	Tacloban, San Juanico Str	4.5	11-08-2013 11:00,
Quezon	Port Pusgo	4.4	11-09-2013 02:20,
Eastern Samar	Andis Island, Port Borongan	4.3	11-08-2013 09:30,
Quezon	Santa Cruz Harbor	4.2	11-09-2013 02:20,
Palawan	Port Barton	3.9	11-09-2013 02:00,
Iloilo	Banate	3.9	11-09-2013 02:10,
Leyte	Palompon	3.9	11-08-2013 12:40,
Leyte	Ormoc	3.8	11-08-2013 13:20,

PAGASA warned of a storm surge relatively late. No warning was issued on 06.11.13, 18:00h[42] and on 07.11.13, 06:00h[43]. The first storm surge warning by PAGASA came on 07.11.13, 12:00h: it warned of a surge with a 7 meter height[44]: The second warning came on 07.11.13, 18:00h again with a 7 meter storm surge height[45].

Interestingly two DOST institutions, PAGASA and Project NOAH, published different expected storm surge heights before the typhoon made landfall in Leyte (PAGASA: 7 meter, NOAH: 4.5 meter for Tacloban). Though it seems that decision makers and the general public usually trust the warnings of PAGASA more than NOAH, the latter one's simulation appeared to be nearer to the actual water height. For disaster managers who may check the forecasts from both institutions, the substantial difference in predicted water level heights might be confusing.

7.3. Rain and river floods

When typhoons approach the Philippines they often bring large amounts of rain with them, which often cause floods. PAGASA warned of such floods in the weather bulletins before rain actually fell[46]. This general warning does not mean floods will actually occur. These still needs to be detected based on the actual amount of rain falling in a particular watershed and on the water level upstream, which is an indicator of expected floods in flat downstream areas in such river basin. Weather Wunderground also regarded heavy rains together with high winds as the deadliest danger of Haiyan/Yolanda on 7.11.13[47].

There are several GIZ-supported local flood early warning systems in place in Leyte (Pagsangaan River, Binahaan River, Marabong/Daguitan Rivers, Cadac-an/Bito Rivers). Flooding occurred in only one of them (Binahaan), but the warning system failed to detect it. . According to eye witness accounts the water came from a tributary of the Binahaan River from the Guinarongan area. The warning system has no water level sensor in this area. Furthermore the radio connection of the other sensors to the operation center in Palo stopped working around 06:00 h on 8 Nov. 2013[48].

Project NOAH has rain and water level sensors operating in Leyte, but they are not directly used for early warning purposes. All Leyte-based NOAH sensors stopped transmitting data in the morning (06:30h[49], 06:45h[50] 07:20h[51], 08:00h[52]).

The JRC did not anticipate extreme rains for the Philippines in the context of Haiyan/Yolanda[53] and thus was closer to reality than PAGASA (which agency expected up to 30mm per hour rain).

7.4. Landslide

PAGASA warned of landslides in bulletins before the storm made landfall[54], but no significant landslide happened in Leyte in connection to Haiyan/Yolanda.

7.5. Summary for the early detection of Haiyan/Yolanda

A. The forecast of the storm path and strength by many agencies, including PAGASA, was very accurate days before the storm made landfall.

B. JRC warned of a storm surge on 06.11.13, while PAGASA did this one day later at 12:00h. PAGASA's forecast of the height of the storm surge was too high, while the forecasts made by the JRC and NOAH were closer to the actual height of the storm surge recorded in Tacloban.

C. PAGASA overestimated the amount of rain and the danger of landslides.

D. The rain and water level sensors of NOAH failed with the breakdown of the mobile network system and thus could not produce data when needed.

E. GIZ supported sensors mostly failed due to antenna damages.

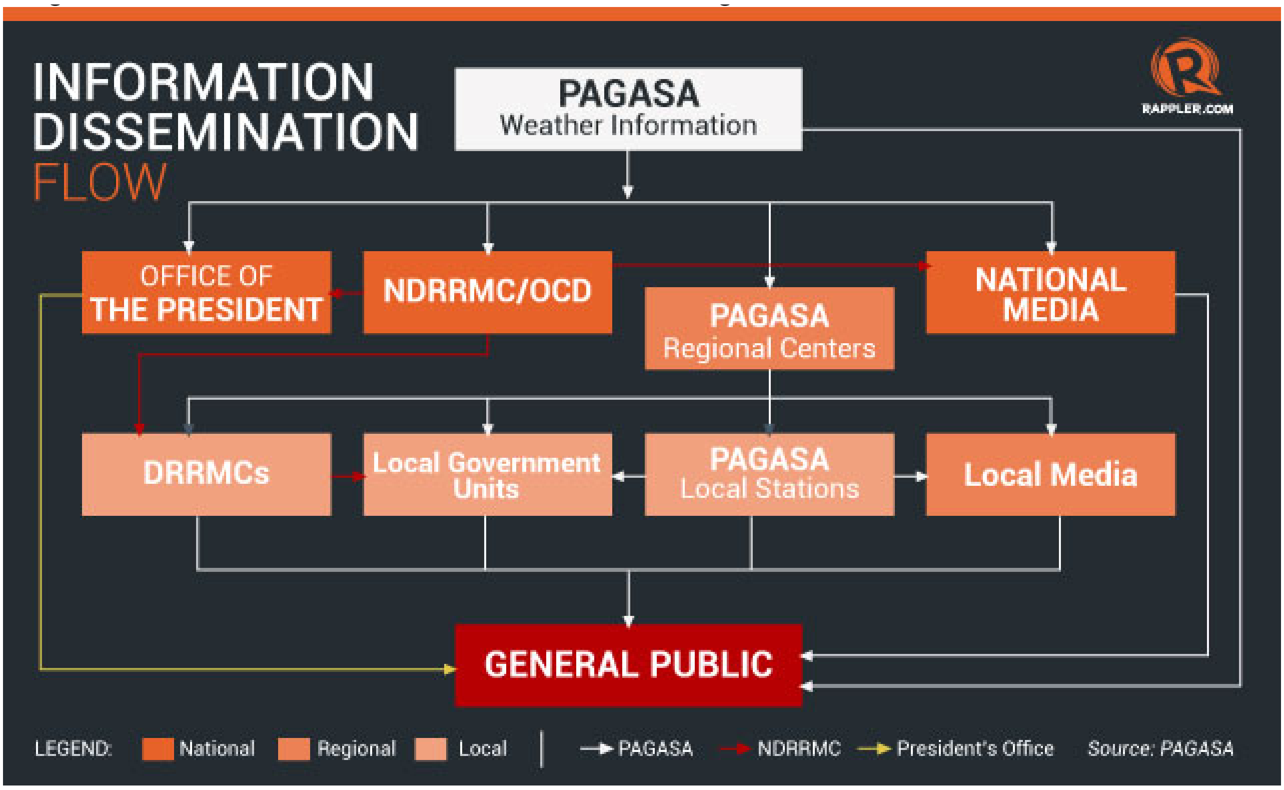
8 Communication of warning

Once a dangerous hazard event is detected by an authorized institution, the persons in the potentially affected areas need to be informed about this so that they can take appropriate action to prevent or reduce damages and losses including themselves. Communication has to be fast enough to give people time for their preparatory activities (e.g. evacuation). Messages have to be clear and unambiguous. Everybody has to understand what danger is coming up and what to do about it. This includes professionals tasked with disaster management as well as communities.

In the case of tropical cyclones like Haiyan/Yolanda, PAGASA was tasked with the detection of the threat and the agency issues warnings. These warnings included general warnings called "signals" with different levels (1-4) on province level, technical details (position of the eye of the cyclone, etc.), estimations of rainfall, and warnings for sea travel, against possible flashfloods and landslides as well as storm surges.

As displayed in **Diagram 1** there are several ways how the forecast and how warnings will reach the general public. Professionals dealing with disasters have NDRRMC/OCD as the central point responsible for the coordination of preparatory activities, which also includes issuing of early warnings.

Diagram 1: Information Dissemination for Warnings of PAGASA



From interviews conducted by GIZ after the disaster, it appeared that the population and officials received the warning early enough for preparations. There was only one interviewee (of a total of 29 residents) who felt that he/she was informed too late.

All persons interviewed by GIZ (41 in total) were aware of the approaching typhoon. Most residents quoted TV as their main source of information, while many also mentioned local government (barangay) officials. This means the warning was very successful in terms of coverage.

However, there were concerns about the clarity of the information given by PAGASA. In Situation Report 4 (07.11.2013, 18:00h) NDRRMC (based on PAGASA data) warned that for Leyte "winds of more than 185 [sic] are expected in at least 12 hours" (Signal No. 4).

However, the warning against flash floods, landslides and storm surge did not include Leyte but provinces further away from the storm centre (see **Appendix 4**)[55]. This might be just a small omission error, but for careful readers it appeared as if there was no danger of a storm surge, flash floods and landslides for Leyte and other parts of Region 8.

Many residents of coastal areas and political decision makers openly admitted that they were not familiar with the term "storm surge"[56]. The same was true for many coastal residents interviewed by GIZ. One person interviewed by GIZ said: "I don't understand 'storm surge'. If they said tsunami or tidal wave we should have evacuated."

Most coastal residents interviewed by GIZ remembered that they were warned of a "super typhoon"[57] and many were obviously impressed by the fact that the President of the Republic himself appeared on TV and conveyed the warning to the general public. Out of 29 respondents (residents) to GIZ questions four said that the typhoon warning signal was number 5 (though 4 is the highest number). There were also community members who did not remember the signal number at all or gave 3 as the signal (it was 4).

In summary, it seemed that the PAGASA warnings failed to sufficiently explain and clarify the specific dangers that were coming to the public.

While the true nature and extent of the danger was probably unclear to most residents, many coastal residents said that they received orders to evacuate from the authorities. In some places, residents were even forced to evacuate from the coast. But even with a clear evacuation message from the government a large part of the population did not leave their homes in the danger zones. The interviews of GIZ gave a very mixed picture. In some places residents estimated that almost everybody evacuated, while in other places only very few left. In many places it seemed to be around 50% according to residents' estimates.

As this report concluded that 94% of the casualties along the coast died from the storm surge (see chapter "Consequences of shortcomings in early warning"), it is crucial to understand why people who were aware of the evacuatoion orders did not follow it. This decision to stay was a fatal misjudgement for many. One of the main reasons given by respondents of the GIZ interviews was the fear of theft/looting. Some also laughed off the evacuation order or underestimated the height and force of the water.

9 Summary for communication of warnings

A. The warnings from the government and media came days before the typhoon made landfall and therefore there was enough time for preparations and evacuations before 7 November.

B. Government offices asked residents near the coast repeatedly to evacuate and used force in a few cases.

C. PAGASA/NDRRMC failed to emphasize the seriousness of the storm surge but stressed a rain warning.

D. Warning by many institutions, including OCD and LGUs, was apparently not serious enough to make people understand that their lives are in jeopardy if they stay on and do not evacuate.

E. Many did not understand the term "storm surge" and it was also not well known from past media reports.

F. Accounts of residents suggest that a large part of the population in storm surge areas did not evacuate and the high death rate at the coast also suggests that many citizens did not leave the danger zone.

© Photo by Benni Thiebes on November 8, 2013

Paterno Street is reduced into a vast wasteland after the widespread destruction of Typhoon Haiyan.

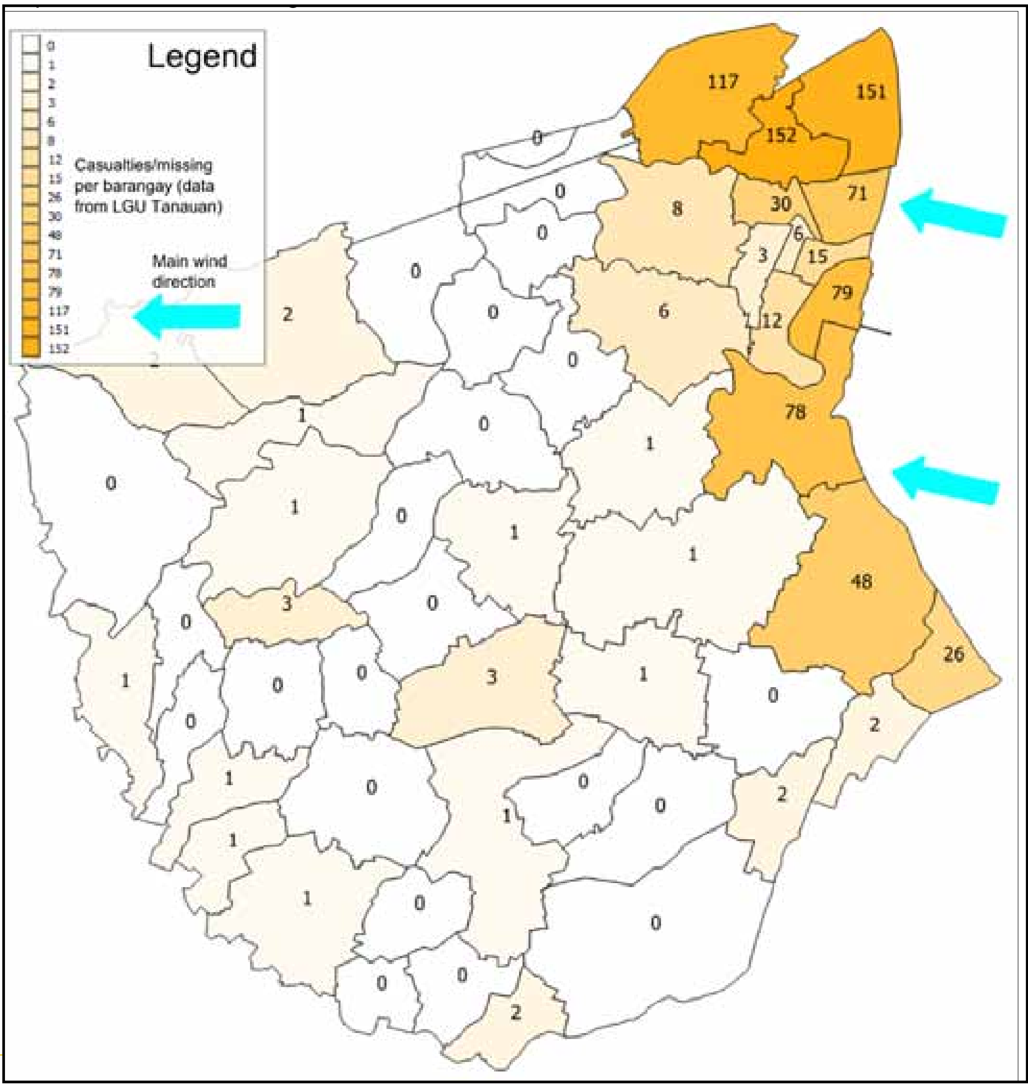
10 Consequences of shortcomings in early warning

Haiyan/Yolanda made its first landfall in the Philippines in Guiuan in Eastern Samar at full force, but the death toll was low compared to Leyte. It was most likely that the location of the settlements protected them against the typhoon. They were situated at the Western side of the peninsula where a chain of hills protected them from the full force of Westerly winds. Furthermore, the wind at the town of Guiuan was off shore, reducing the danger of a storm surge.

The death rate at the Eastern coast of Leyte was high (see **Appendix 3**) because wind speed was still near peak, and no hills provided protection for the residents. From Tolosa to Tacloban the wind was on-shore producing a substantial storm surge in a densely populated area. The storm weakened while crossing Leyte and slowed down further while moving Westward.

No official count of deaths categorized by the four possible hazards (wind, landslide, flood, storm surge) has been done yet the spatial distribution of dead is revealing.

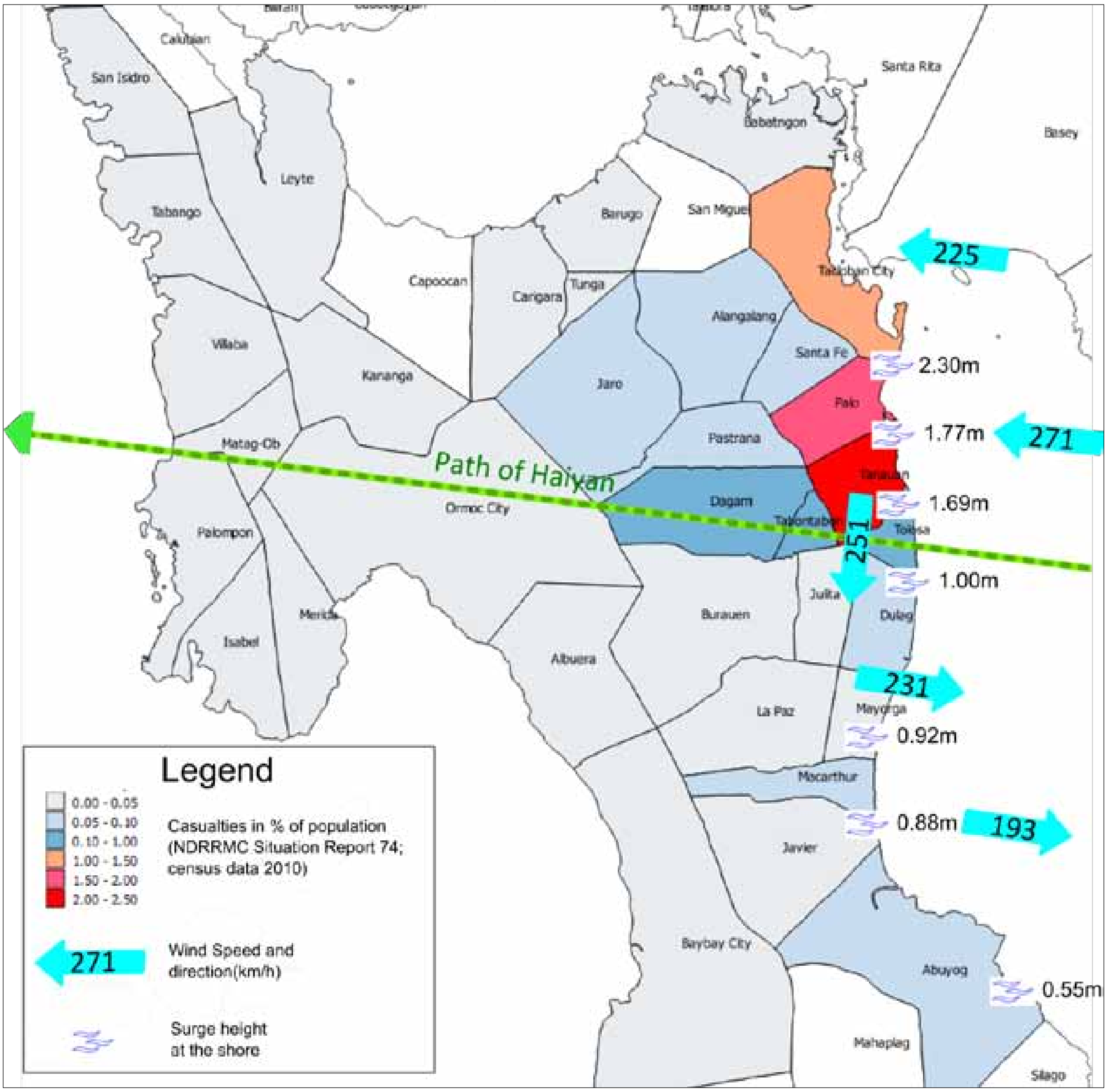
Tanauan has a breakdown of dead and missing by barangay (**Map 28**). There were only few casualties in the barangays not affected by storm surge, while the highest death toll can be observed where the wind/storm surge hit the coast with full force.



Map 28: Dead and missing in Tanauan

Note: The total number of dead/missing given by the LGU is lower than the numbers in the NDRRMC situation reports.

Map 29: Wind Speeds, Storm Surge Heights and Casualties in Leyte



Wind speed and surge height from JRC[17]

An estimation of the deaths caused by storm surge may be conducted by comparing the death rate (dead in percent of total population) of neighbouring inland LGUs with coastal LGUs. Dagami, Jaro, Tabontabon, Alangalang, Santa Fe and Pastrana experienced almost the same wind speeds as Tanauan, Palo and Tacloban (**Map 29**). The average death rate of the inland LGUs is 0.090 while for the coastal LGUs it is 1.788. The difference is most likely explained by casualties from the storm surge. If this difference is converted to actual numbers the victims are distributed as shown in **Table 2**.

Table 2: Estimated distribution of dead from high winds and from storm surge in Tacloban, Palo, and Tanauan

Local Government Unit	Dead due to storm	Dead due to storm surge	Total dead
Palo	56	1,033	1,089
Tacloban	199	2,297	2,496
Tanauan	45	1,207	1,252

From this **Table,** it is 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).

If those who died in the storm surge would have evacuated to safer areas, a death rate similar to the inland LGUs would have applied to them. More effective evacuations would have saved many lives.

Appendices

Appendix 1: OCD letter concerning safety of evacuation centre

REPUBLIC OF THE PHILIPPINES
DEPARTMENT OF NATIONAL DEFENSE
OFFICE OF CIVIL DEFENSE
CAMP GENERAL EMILIO AGUINALDO, QUEZON CITY, PHILIPPINES

21 MAR 2013

MEMORANDUM
No. 169, s. 2013

TO : ALL CONCERNED OCD OFFICIALS AND PERSONNEL

SUBJECT : ADMINISTRATOR'S GUIDANCE

The following set of policy guidance is published to serve as guide for all OCD officials and personnel in the performance of their respective duties, responsibilities and functions and thereby contribute to OCD's mission accomplishment.

On Operations:

1. All Regional Directors shall always provide leadership role as Chairperson of their respective Regional Disaster Risk Reduction and Management Councils (RDRRMCs). They shall –

   1.1 Finalize and implement Regional DRRM Plans NLT 30 June 2013;
   1.2 Conduct DRRM Summit in respective regions NLT 3rd week of August 2013;
   1.3 Require LCEs to submit Local DRRM Plans NLT 01 October 2013;
   1.4 In coordination with LGUs and technical experts, you shall ensure that establishment of Evacuation Sites are compliant with hydro-meteorological and geo-hazard assessments;
   1.5 Immediately report details of all incidents initially through SMS to be followed by a written report.

2. Organize the Accredited Community Disaster Volunteers (ACDV) and the National Services Reserve Corps (NSRC) for future utilization.

3. Prepare for the Quarterly National Simultaneous Earthquake Drill on the 3rd week of April 2013 and the quarterly schedule thereafter.

4. Sustain operational readiness of the established clusters.

On Administration:

1. All Regional Directors shall submit the following monthly reports NLT the 15th day of the month;

   1.1 Status of Funds
   1.2 Fund Utilization Report
   1.3 Accomplishment Report
   1.4 Inventory of NFIs stock-on-hand

Telefax: NDRRMC Opcen +63 (2) 911-1406; 912-2665; 912-5668; NDRRMC Secretariat +63 (2) 912-0441; 912-5947

2. Likewise, all Regional Directors shall –

   2.1 Rationalize POEs in the proposal and actual implementation of DRRM projects;
   2.2 Monitor, evaluate and submit progress reports of all infrastructure projects funded under the Quick Response Fund (QRF);
   2.3 Continuously program training for concerned member agencies and individuals;
   2.4 Come up with articles highlighting significant activities which will form part of the OCD Newsletter, *"The Civil Defense Gazette"*;
   2.5 Ask/seek clearance from the CDA before leaving respective areas of responsibility (AOR);

3. The efficient use of material and human resources shall be emphasized. We shall aim for cost-effectiveness in our operations and rationalize our expenditures accordingly.

4. As public servants, we must render services in accordance with Civil Service laws, rules and regulations. Every employee must behave in accordance with his/her functions in the organization. All are encouraged to time-in not later than 8:30AM and observe punctuality at all times.

5. The Administrator's authority and responsibility is inherent to the position. Giving of feedback and keeping the Administrator informed on concerns are highly encouraged and must be observed. Key personnel can only decide on issues within their level of authority and competence. Otherwise, follow the normal chain of authority for approval or disapproval of any activity or transaction.

6. Heads of offices/units and staff officers are expected to observe established staff functions and completed staff work.

All personnel shall remember the OCD Battle Cry– **O** for *Orchestrate*; **C** for *Commitment*; and **D** for *Deliver*. ***"We orchestrate disaster risk reduction and management activities with utmost commitment to deliver what is best for the country and our people."***

Be guided accordingly.

USEC EDUARDO D. DEL ROSARIO
Administrator

Appendix 2: Typical damages caused by typhoon and storm surge

Intensity scale for natural hazards

Intensity class qualification	Damage level (exposed reference element: overall development)	Typhoon – Natural phenomena: PAGASA Storm warning signals	Typhoon – Natural phenomena: Saffir-Simpson Hurricane Scale (Wikipedia)	Typhoon – Types of damage (examples): Population	Types of damage: Buildings, infrastructure		Types of damage: Agriculture, forests, nat. environment	
					Saffir-Simpson Hurricane Scale (Wikipedia)	PAGASA	(Saffir-Simpson Hurricane Scale)	PAGASA
I_0 Very low	≤5% damage	1-3 (1: wind speed: 30-60km/h; 2: 60-100km/h; 3: 100-185km/h)	Category 1: 119–153 km/h (sustained winds)		Category 1 storms usually cause no significant damage to building structures; however, they can tip over unanchored mobile homes. Poorly attached roof shingles or tiles can blow off. Also, they produce some coastal flooding, as well as minor pier damage	Category 3: Majority of all nipa and cogon houses may be unroofed or destroyed and there may be considerable damage to structures of light to medium construction. There may be widespread disruption of electrical power and communication services. In general, moderate to heavy damage may be experienced, particularly in the industrial sectors.	Category 1 storms usually cause no significant damage, but they can uproot or snap trees.	Category 3: Many coconut trees may be broken or destroyed. Almost all banana plants may be downed and a large number of trees may be uprooted. Rice and corn crops may suffer heavy losses. In general, moderate to heavy damage may be experienced, particularly in the agricultural sectors.
I_1 Low	5–10% damage		Category 2: 154–177 km/h (sustained winds)		Storms of this intensity damage some roofing material, and also produce damage to poorly constructed doors and windows. Considerable damage is caused to poorly constructed signs, and piers. Mobile homes, whether anchored or not, are usually badly damaged, and many manufactured homes also suffer structural damage. Also, small craft in unprotected anchorages may break their moorings.		Considerable damage is caused to vegetation,	
I_2 Moderate	10–50% damage	4 (wind > 185km/h)	Category 3: 178–209 km/h (sustained winds)	Hurricanes of this intensity are extremely dangerous to populated areas.	These storms can cause some structural damage to small residences and utility buildings, particularly those of wood frame or manufactured materials with minor curtainwall failures. Buildings that lack a solid foundation, such as mobile homes, are usually destroyed, and gable-end roofs are peeled off. Manufactured homes usually sustain very heavy and irreparable damage. Flooding near the coast destroys smaller structures, while larger structures are hit by floating debris. Additionally, terrain may be flooded well inland.	Category 4: Most residential and institutional buildings of mixed construction may be severely damaged. Electrical power distribution and communication services may be severely disrupted. In the overall, damage to affected communities can be very heavy.		Category 4: Coconut plantation may suffer extensive damage. Many large trees may be uprooted. Rice and corn plantation may suffer severe losses. In the overall, damage to affected communities can be very heavy.
I_3 High	50–80% damage		Category 4: Sustained winds 210–249 km/h		Category 4 hurricanes tend to produce more extensive curtainwall failures, with some complete roof structural failure on small residences. Heavy, irreparable damage and near complete destruction of gas station canopies and other wide span overhang type structures are also common. Mobile and manufactured homes are leveled. These hurricanes cause major erosion of beach areas and terrain may be flooded well inland as well			
			Category 5: Sustained winds: ≥250 km/h		Cat. 5. These storms cause complete roof failure on many residences and industrial buildings, and some complete building failures with small utility buildings blown over or away. Collapse of many wide-span roofs and walls, especially those with no interior supports, is common. Very heavy and irreparable damage to many wood frame structures and total destruction to mobile/manufactured homes is prevalent. Only a few types of structures are capable of surviving intact, and only if located at least four to eight km inland. They include office, condominium and apartment buildings and hotels that are of solid concrete or steel frame construction, public multi-story concrete parking garages, and residences that are made of either reinforced brick or concrete/cement block and have hipped roofs with slopes of no less than 35 degrees from horizontal and no overhangs of any kind, and if the windows are either made of hurricane resistant safety glass or covered with shutters			

Intensity scale for natural hazards

Intensity class qualification	Damage level (exposed reference element: overall development)	Storm Surge		
		Natural phenomena	Types of damage (examples)	
		Max. Wave height	Buildings, infrastructure	Agriculture, forests, nat. environment
I_0 Very low	≤5% damage	On windward coasts, sea level rise of 4-5 ft (1.2-1.5 m) above normal in open bays and inlets due to storm surge and wind-driven waves; breaking waves inside bays can reach 5-7 ft (1.5-2.1 m) above normal; 2-3 ft (0.6-1.0 m) additional water across reef.	Wind-driven waves may inundate low-lying coastal roads where reefs are narrow. Minor pier damage. Some small craft in exposed anchorages break moorings.	
I_1 Low	5–10% damage	On windward coasts, sea level rise of 6-8 ft (1.8-2.4 m) above normal in open bays and inlets due to storm surge and wind-driven waves; breaking waves inside bays can reach 7-9 ft (2.1-2.7 m) above normal; water is about 3-5 ft (1.0-1.5 m) above normal across reef flats.	Wind-driven waves will inundate low-lying coastal roads below 4 ft (1.0 m) on windward locations where reefs are narrow. Some erosion of beach areas, some moderate pier damage, and some large boats torn from moorings.	Some erosion of beach areas.
I_2 Moderate	10–50% damage	On windward coasts, sea level rise of 9-12 ft (2.7-3.6 m) above normal in open bays and inlets due to storm surge and wind-driven waves; breaking waves inside bays can reach 11-14 ft (3.3-4.2 m) above normal; water is about 5-7 ft (1.5-2.1 m) above normal across reef flats.	Wind-driven waves will inundate low-lying coastal roads below 7 ft (2.1 m) of elevation on windward locations where reefs are narrow. Many large boats and some large ships torn from moorings.	Considerable beach erosion.
		On windward coasts, sea level rise of 13-18 ft (3.9-5.5 m) above normal in open bays and inlets due to storm surge and wind-driven waves; breaking waves inside bays can reach 15-24 ft (4.5-7.3 m) above normal; water is about 8-12 ft (2.4-3.7 m) above normal across reef flats.	Severe damage to port facilities including some loading derricks and gantry cranes. Most ships torn from moorings.	Large boulders carried inland with waves. Severe beach erosion. Wind-driven waves will inundate coastal areas below 12 ft (3.7 m) elevation.
I_3 High	50–80% damage	On windward coasts, sea level rise of > 25 ft (> 7.6 m) above normal in open bays and inlets due to storm surge and wind-driven waves; breaking waves inside bays can be > 30 ft (9.2 m) above normal; water is about 12-18 ft (3.7-5.5 m) above normal across reef flats. Serious inundation likely for windward coastal areas below 18 ft (5.5 m) elevation.	Extensive damage to port facilities including most loading derricks and gantry cranes. Virtually all ships, regardless of size, torn from moorings.	Very large boulders carried inland with waves. Extensive beach erosion. Serious inundation likely for windward coastal areas below 18 ft (5.5 m) elevation.

Appendix 3: Casualties in Leyte

Casualties in Leyte

Local Government Unit	Dead (number)	Dead (% of population)
Abuyog	33	0.05775
Alang-Alang	41	0.08834
Albuera	11	0.02712
Babatgnon	9	0.03519
Barugo	2	0.00665
Baybay	2	0.00194
Burauen	6	0.01228
Carigara	11	0.02318
Dagami	43	0.13655
Dulag	26	0.06230
Isabel	6	0.01376
Jaro	28	0.07070
Javier	6	0.02093
Julita	2	0.01500
Kananga	24	0.04997
La Paz	6	0.03135
Leyte Leyte	7	0.01866
Mc Arthur	10	0.05341
Matag-ob	8	0.04680
Mayorga	4	0.02722
Merida	9	0.0331
Ormoc	37	0.01935
Palo	1084	1.73610
Palompon	7	0.01292
Pastrana	10	0.05990
San Isidro	2	0.00700
Santa Fe	11	0.06295
Tabango	5	0.01566
Tabontabon	12	0.12197
Tacloban	2498	1.1285
Tanauan	1252	2.49805
Tolosa	32	0.17298
Tunga	1	0.01534
Villaba	12	0.03090

From: NDRRMC: Yolanda Situation Report No. 74, 27.12.2013

Appendix 4: NDRRMC warning of Yolanda

Areas Having Public Storm Warning Signal			
PSWS #	**Luzon**	**Visayas**	**Mindanao**
Signal No.4 (Winds of more than 185 is expected in at least 12 hours)	None	Eastern Samar Samar Leyte Southern Leyte Biliran Island	None
Signal No.3 (Winds of 101-185 kph is expected in at least 18 hours)	None	Northern Samar Masbate Northern Cebu including Cebu City Bantayan Island	Siargao Island Dinagat Province
Signal No. 2 (Winds of 61-100 kph is expected in at least 24 hours)	Sorsogon Romblon Albay Burias Island	Bohol Negros Occidental Negros Oriental Aklan Capiz Antique Rest of Cebu Iloilo Guimaras	Surigao Del Norte Surigao del Sur Agusan del Norte
Signal No. 1 (Winds of 30-60 kph is expected in at least 36 hours)	Camarines Norte Camarines Sur Catanduanes Mindoro Provinces Marinduque Northern Palawan including Calamian Group of Island and Southern Quezon	Siquijor	Misamis Oriental Agusan del Sur

- Estimated rainfall amount is from 10.0 - 30.0 mm per hour (Heavy - Intense) within the 600 km diameter of the Typhoon
- Sea travel is risky over the **northern and eastern seaboards of Northern Luzon and over the eastern seaboard of Central Luzon**
- Residents in low lying and mountainous areas under signal #3,#2 & #1 are alerted against possible flashfloods and landslides. Likewise, those living in coastal areas under signal #3 and #2 are alerted against storm surges which may reach up to 7-meter wave height

From: NDRRMC: Situation Report No. 4, Yolanda, 07.11.2013, 18:00h

Appendix 5: Questions to officials and residents by GIZ

Questions for Officials

Place (LGU, brgy)
Function of the interviewee
Who coordinated with your LGU about Typhoon Yolanda?
What and when were actions taken by the LGU before Yolanda?
Are maps with evacuation routes and evacuation centers available?
How and when the residents warned about the upcoming typhoon?
Did the LGU facilitated evacuation? When was that?
To what extent did the residents in storm-surge-prone areas follow the evacuation advice?
How many evacuation centers did the LGU have?
How many persons were accommodated in the centers before the storm?
Did you check on the storm surge (or tsunami) hazard map who should be evacuated and what evacuation centers are safe from storm surge?
Where were those evacuation centers located?
Did your LGU organize evacuation drills before(when, where)?

Additional for regional and provincial respondents
Did you check the safety of the locations of evacuation centers?
Did you advise LGUs about the severity of the storm, storm surge, floods, landslides? How (in writing? When?)
Do you have statistics of casualties by hazard? (e.g. storm, storm surge) By barangay?
What sources of information did you use concerning the hazards?
Were there any reported floods caused by rivers?
Any reports about landslides?
Other comments:

Questions for Residents

Place (LGU, Brgy.)
Male/female
Age
Occupation
Did you get to know the storm warnings before “Yolanda”?
By what means did the warning reach you?
What was the content of the warning?
When exactly did you get a typhoon warning?
Do you know what alert level was the warning (specify)?
What did you do when you received a warning?
Were you told where to evacuate to? By whom? Where to? How serious?
If you did not evacuate, why?
In your opinion: How many percent of your barangay did stay in their houses?
If you did evacuate, where to?
Was an evacuation organized by officials (describe)?
Is your house located in a storm surge - prone area (how do you know)?
Do you know the meaning of the Storm Warning Signals (describe them)?
Do you know recommended evacuation routes (describe them)?
Are the routes clearly marked with signboards?
Do you know safe places for evacuation (describe them)?

Are the places clearly marked with signboards?
Did you participate in an evacuation drill (when)?
If yes, what of the drill was helpful for you now?
How will you react when experiencing a warning in future?
How high was the water in your place?
Other comments:

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