

Lessons Learned from Haiyan

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Initial report can be downloaded from:

http://irides.tohoku.ac.jp/media/files/IRIDeS_Report_Haiyan_20140527.pdf

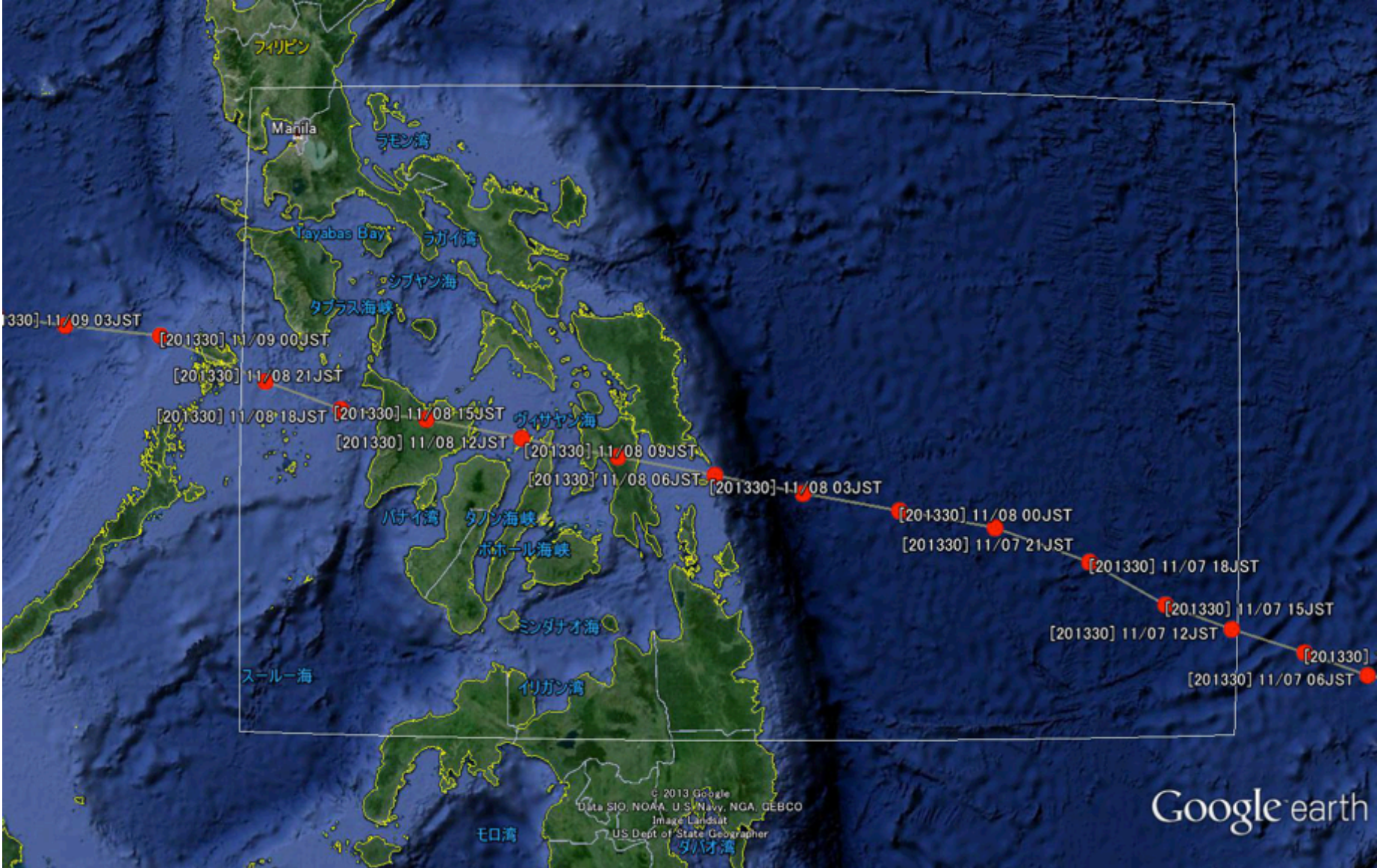


Presentation Outline

- Summary of Typhoon Haiyan
- Initial damage mappings by satellite Images
- Storm Surge Simulation
- On-site Field Surveys
- Evacuation Warning
- Questionnaire survey

Summary of Typhoon Haiyan

Track of Typhoon Haiyan

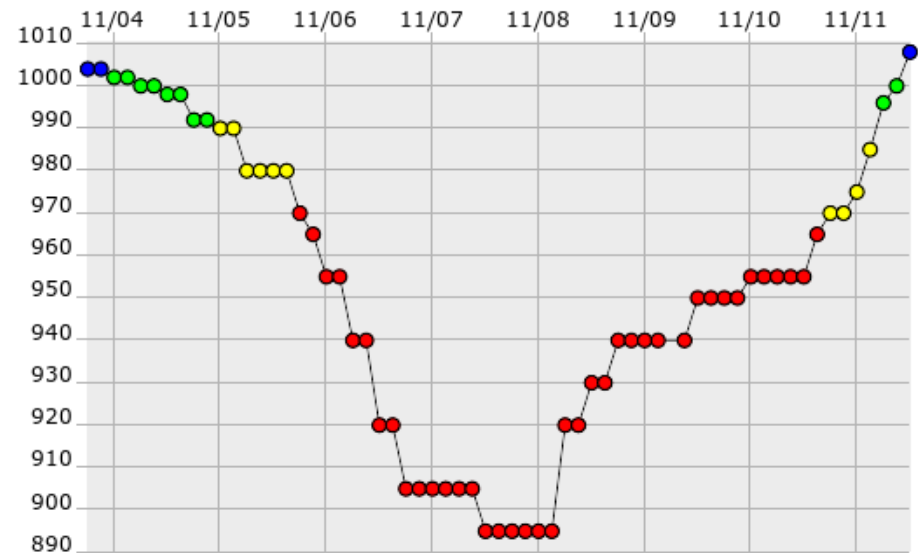
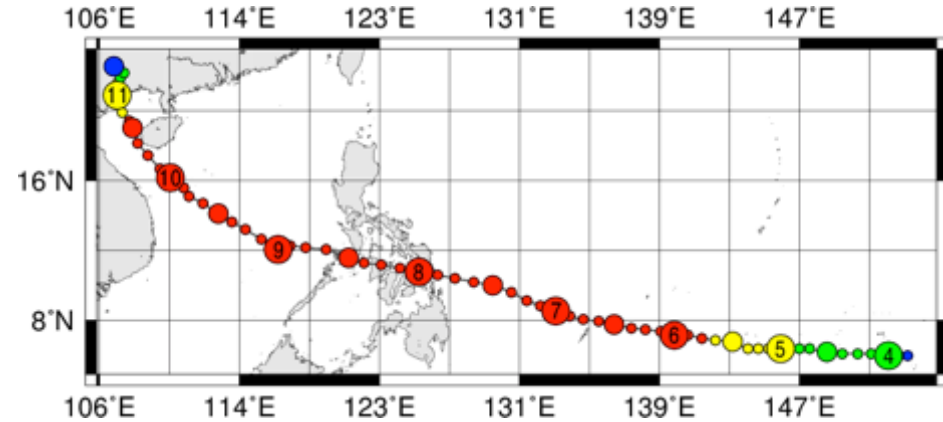


Track Data of Typhoon Haiyan

Date	longitude	latitude	Central Pressure (hPa)	Diameter of Typhoon (km)	Velocity (km/h)
2013/11/07 12:00	131.9	9.0	905	150	31.66
2013/11/07 15:00	131.1	9.3	905	150	38.06
2013/11/07 18:00	130.2	9.8	905	150	43.09
2013/11/07 21:00	129.1	10.2	895	150	41.01
2013/11/08 00:00	128.0	10.4	895	150	40.91
2013/11/08 03:00	126.9	10.6	895	150	37.25
2013/11/08 06:00	125.9	10.8	895	150	40.78
2013/11/08 09:00	124.8	11.0	895	150	40.73
2013/11/08 12:00	123.7	11.2	895	150	40.69
2013/11/08 15:00	122.6	11.4	920	150	36.55
2013/11/08 18:00	121.6	11.5	920	150	34.54
2013/11/08 21:00	120.7	11.8	930	150	50.70

Time : JST

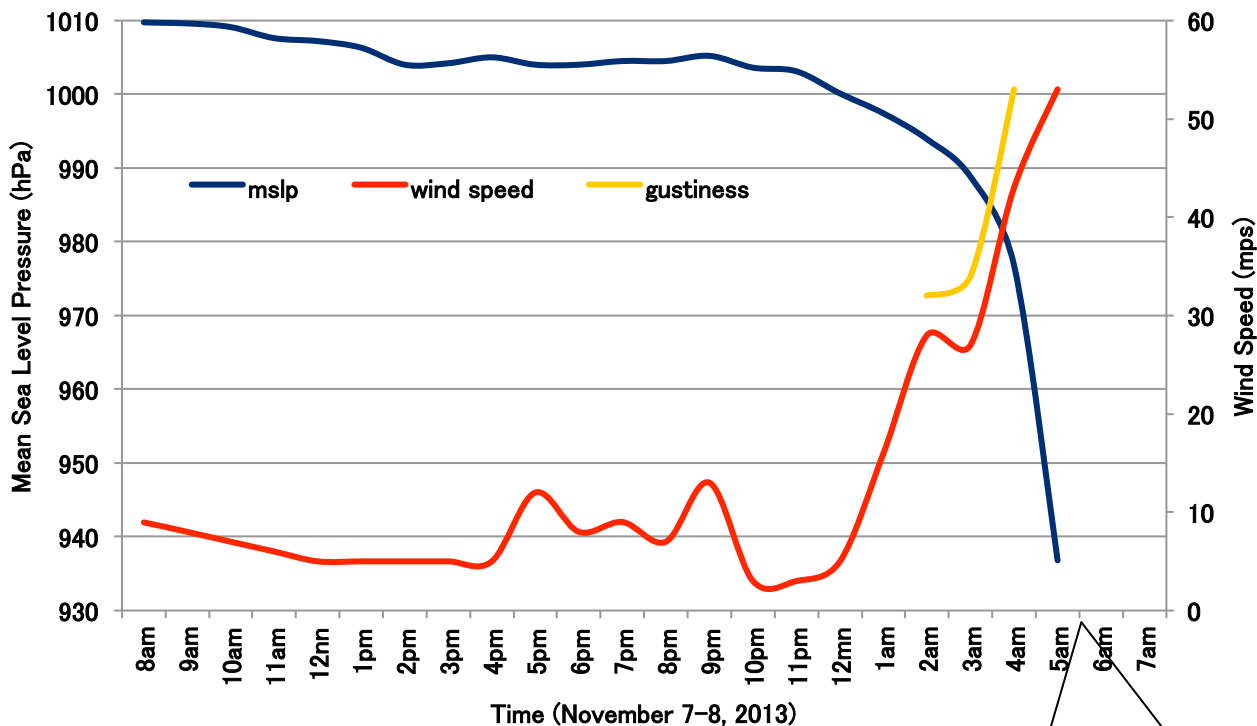
Source: digital typhoon



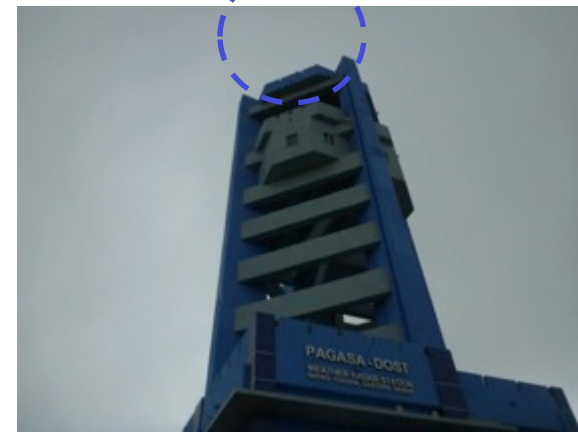
Time : UTC

Wind Speed and Pressure at Guiuan

98558 Guiuan



Guiuan Location



Measure was damaged at the time of the passage of typhoon Yolanda (6am Pressure : 910hPa)

Time : Local time

Source : PAGASA

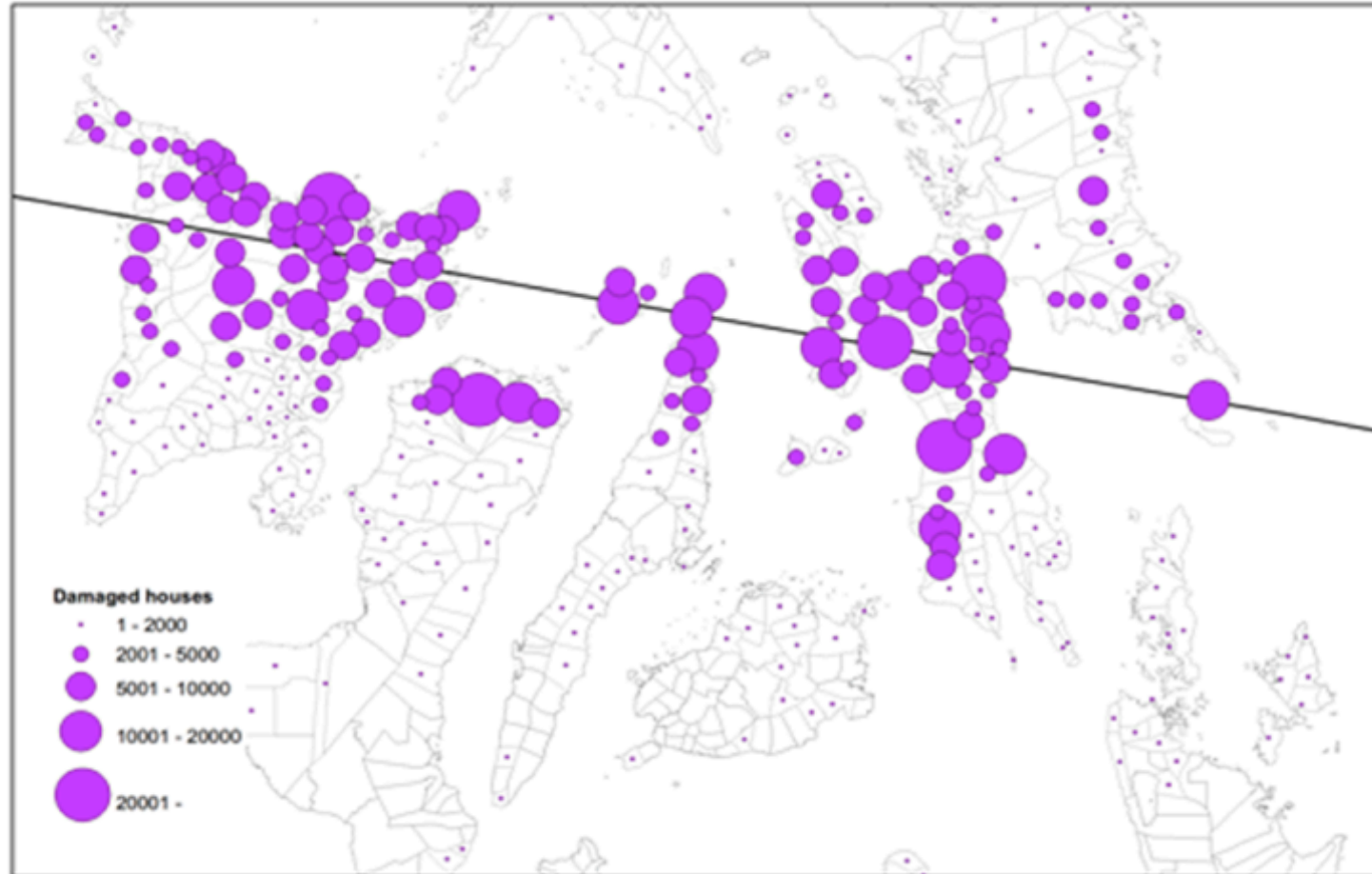
Video recording (iCyclone.com, 2014)

Summary of Damage by Typhoon Haiyan

- Casualties : **6,069** individuals were reported dead , **27,468** injured and **1,779** are still missing
- Damaged Houses : The number of damaged houses decreased to **1,140,332** houses
 - Totally = 550,928
 - Partially = 589,404
- Affected Population :A total of **3,424,593** families / **16,078,181** persons were affected in 12,139 barangays in 44 provinces , 591 municipalities and 57 cities of Regions **IV-A, IV-B, V , VI , VII, VIII, X, X I** , and **CARAGA**

Source :NDRRMC Update on Typhoon Yolanda As of Dec 16.2013, 6:00am

Summary of Damage by Typhoon Haiyan



The number of houses damaged by Typhoon Haiyan (Muraio et al., 2014)
[Source: NDDRMC Situation Report]

House damages were mainly induced by strong wind.

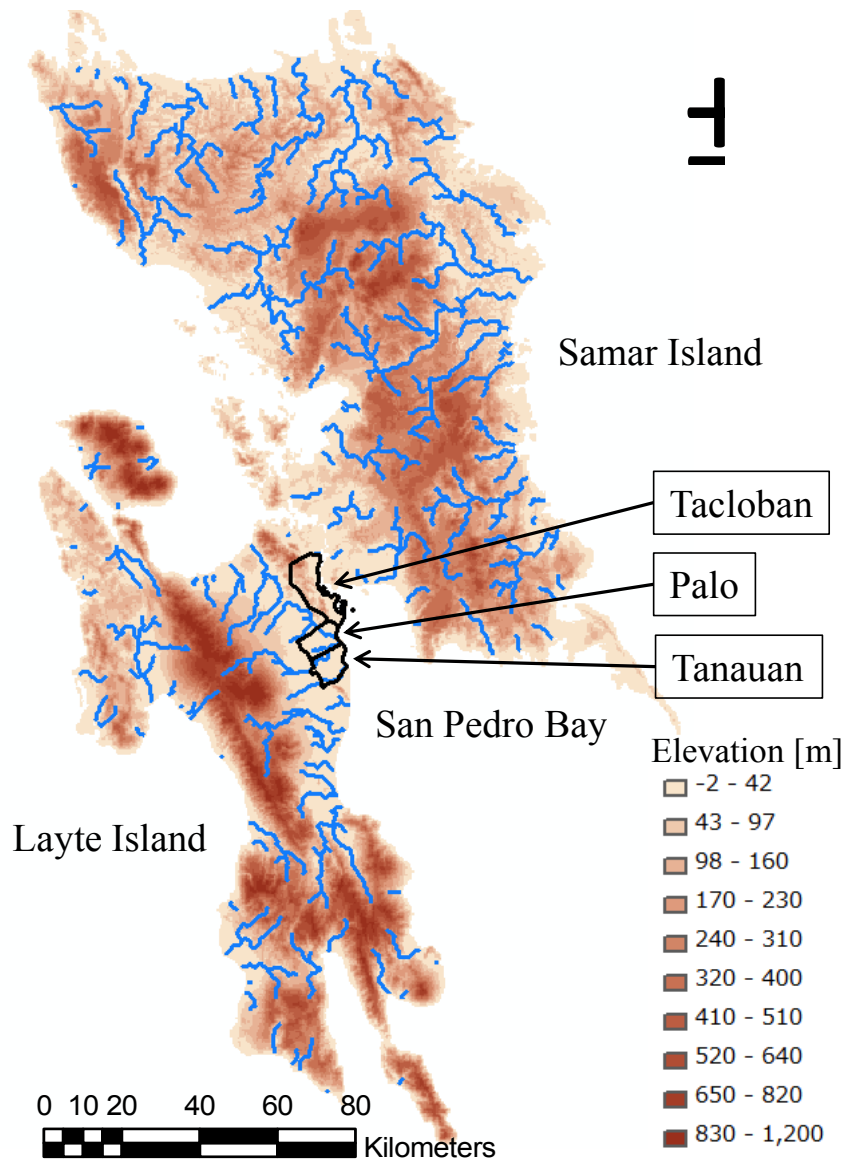
Summary of Damage by Typhoon Haiyan



The number of dead (Muraio et al., 2014) [Source: NDDRMC Situation Report]

Human losses were mainly caused by storm surge around Tacloban city

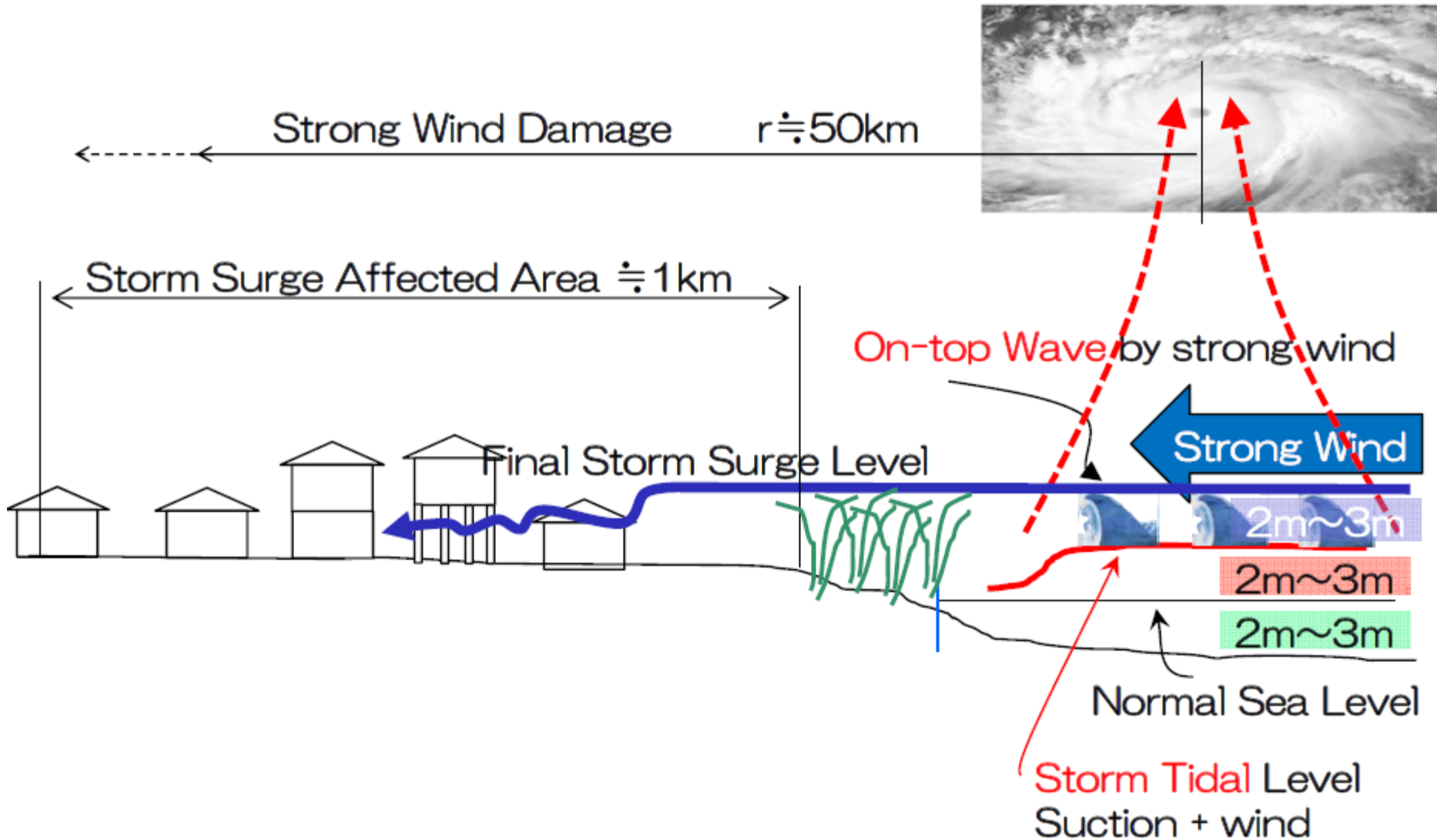
Summary of Damage by Typhoon Haiyan



	Death & Miss.	Population	Ratio [%]
Tacloban	2,542	220,000	1.2
Palo	1,381	63,000	2.2
Tanauan	1,252	50,000	2.5

The number of dead (Kure et al., 2014)

Haiyan, the magnitude of storm surge (JICA)



Vulnerability of the coastal zone



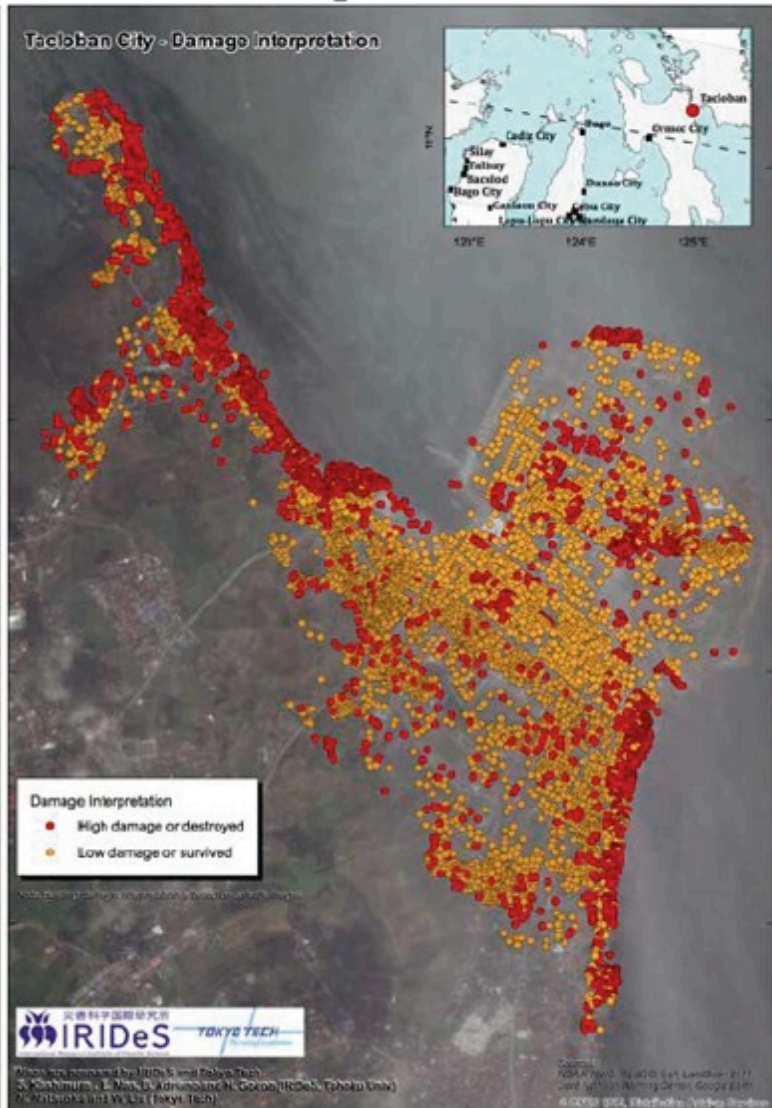
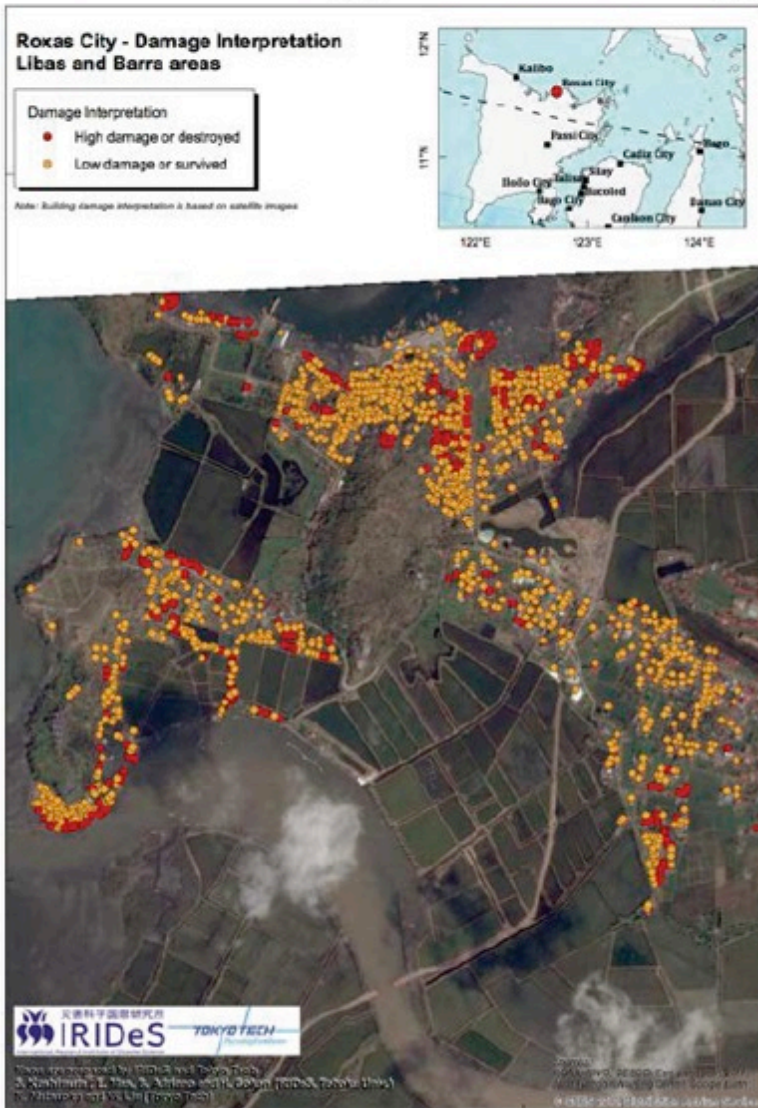
Google map around Tacloban city before Haiyan

Houses were concentrated in the coastal shorelines because of small or no payment for land owner.

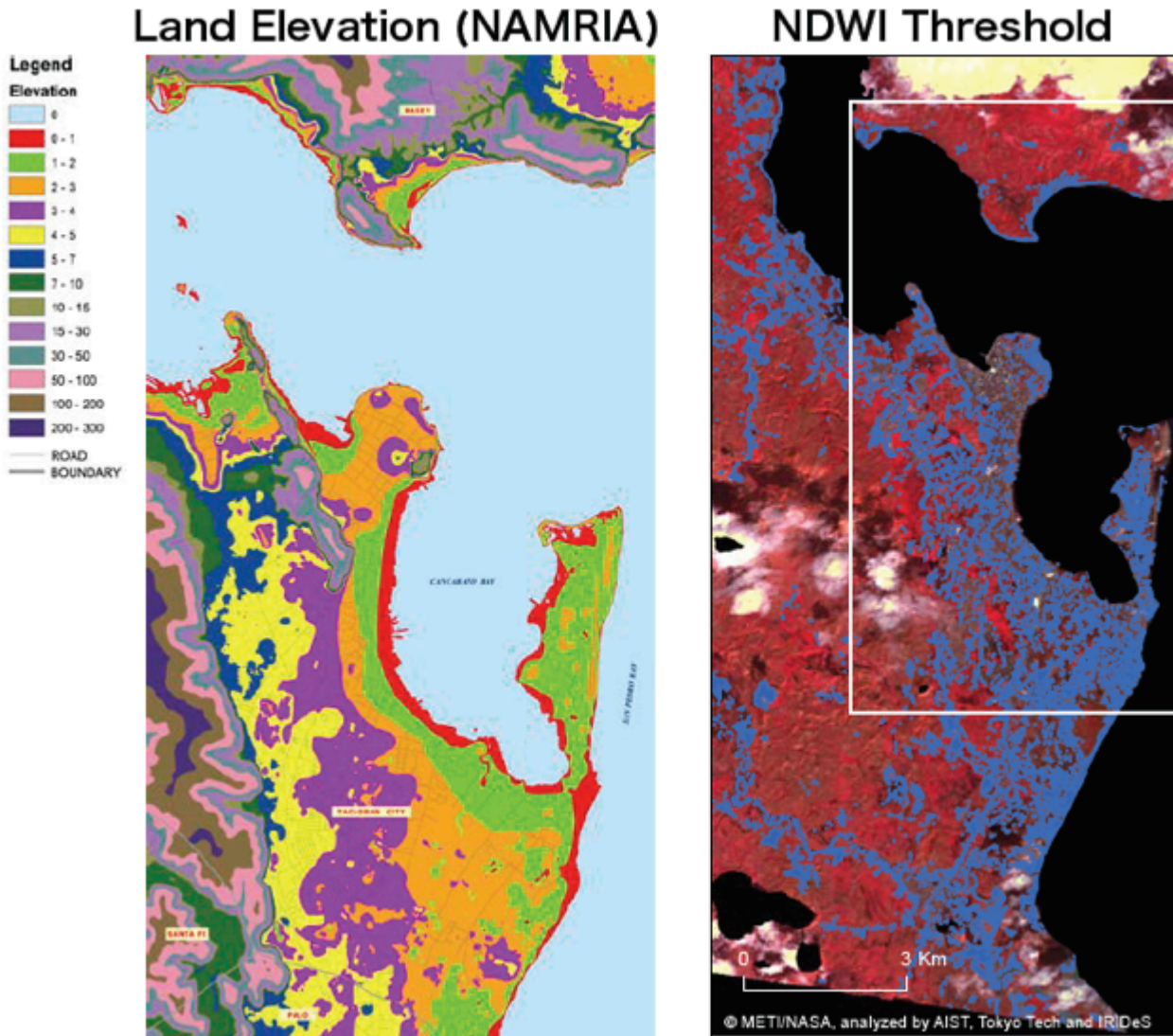
Initial damage mappings by satellite images

Satellite Image Analysis (Mas et al., 2014)

Building Damage Interpretation

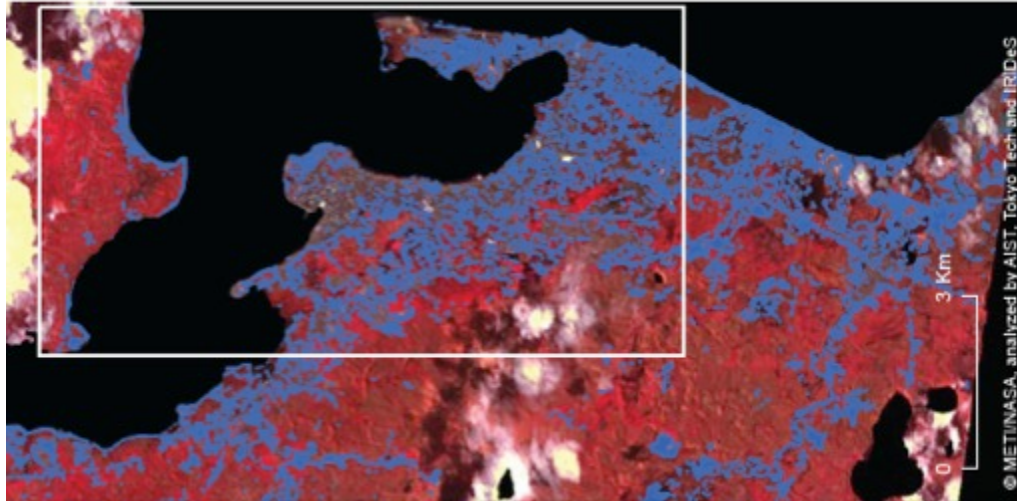


Mapping Inundation Zone



Mapping Inundation Zone (Bruno et al., 2014)

Satellite Image Analysis (Koshimura et al.)



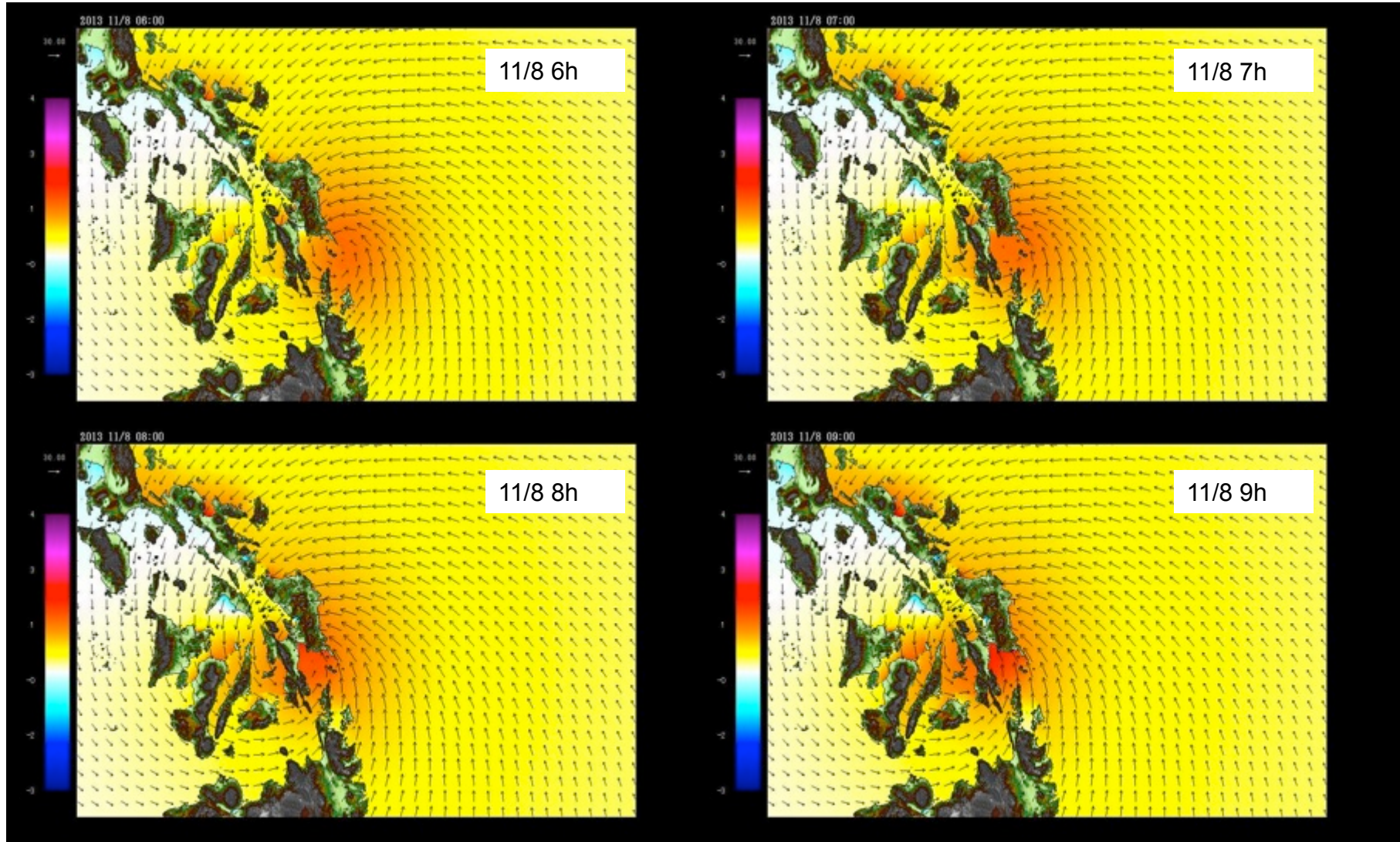
Field Survey Results (JSCE)



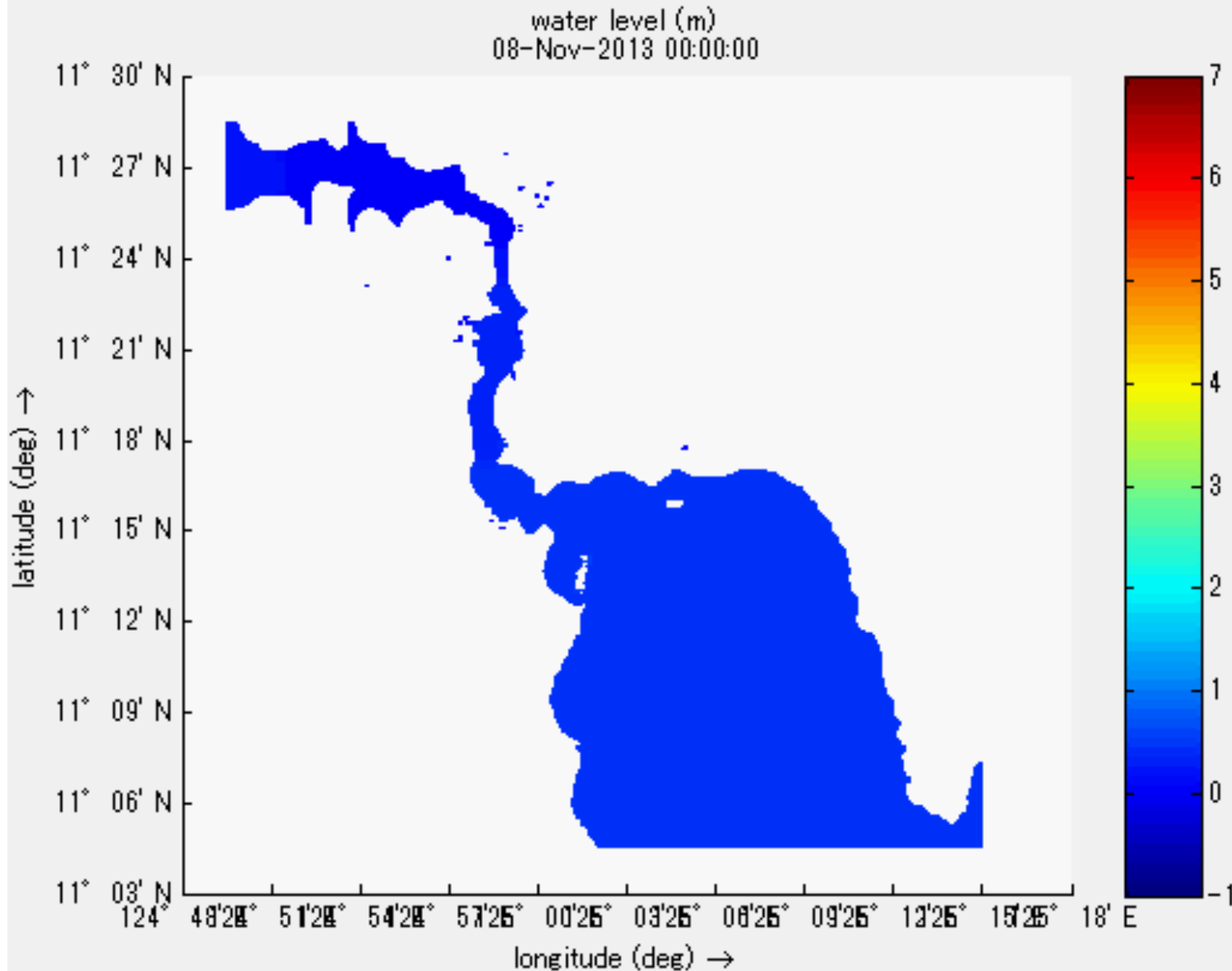
Storm Surge Simulation

Wind Field (PACIFIC CONSULTANTS CO.,LTD)

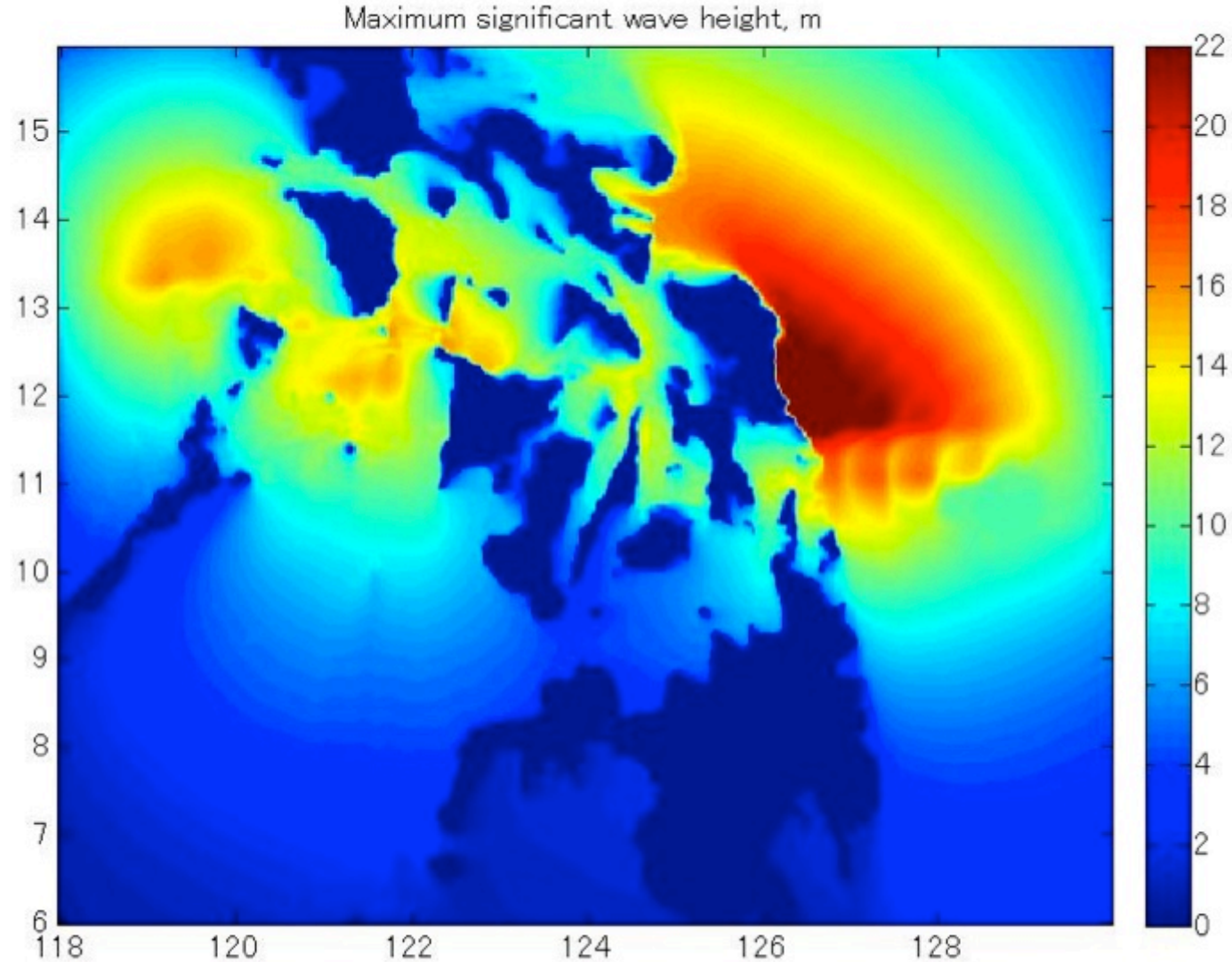
Time : JST



Storm Surge Simulation (Bricker et al., 2014)



Maximum significant wave height, m (Bricker, et al., 2014)



Water levels were dominated by high waves in eastern Samar.

On-site Field Survey

IRIDeS Fact-finding mission to Philippines

IRIDeS Survey Team

Hazard and Damage Evaluation Team

Disaster Medical Science Team

Disaster Recovery Team

Warning and Evacuation Assessment Team

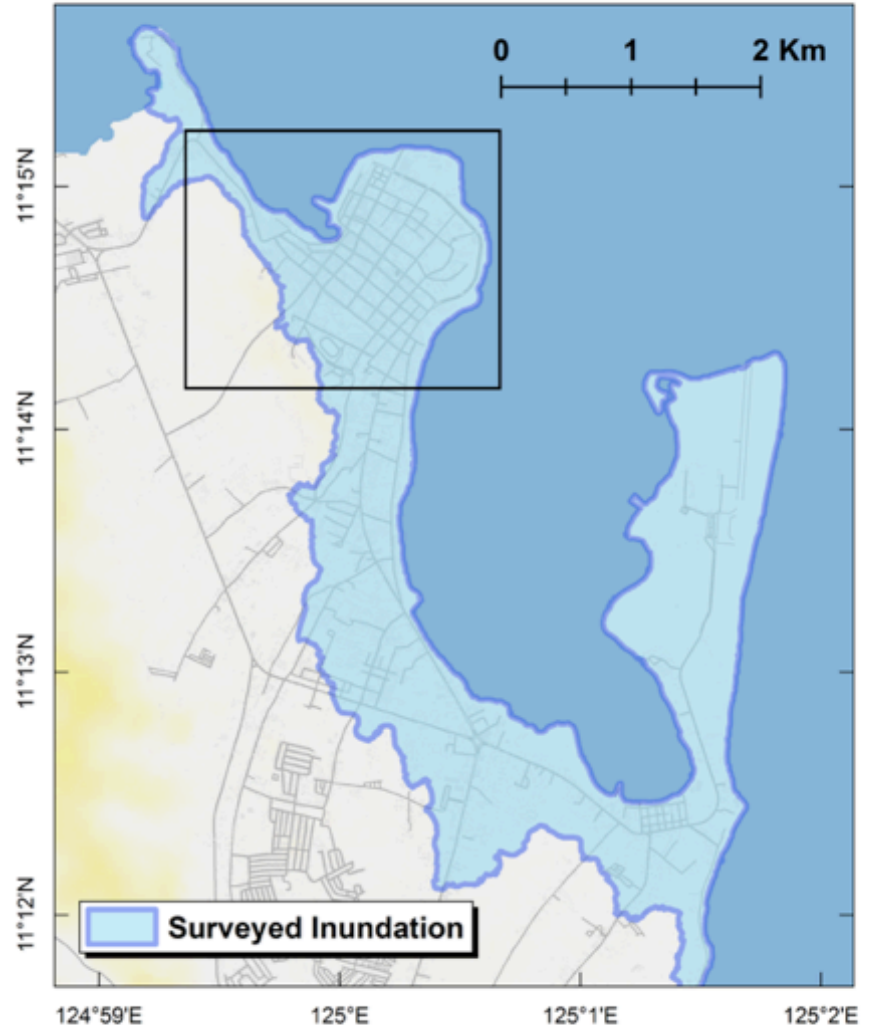
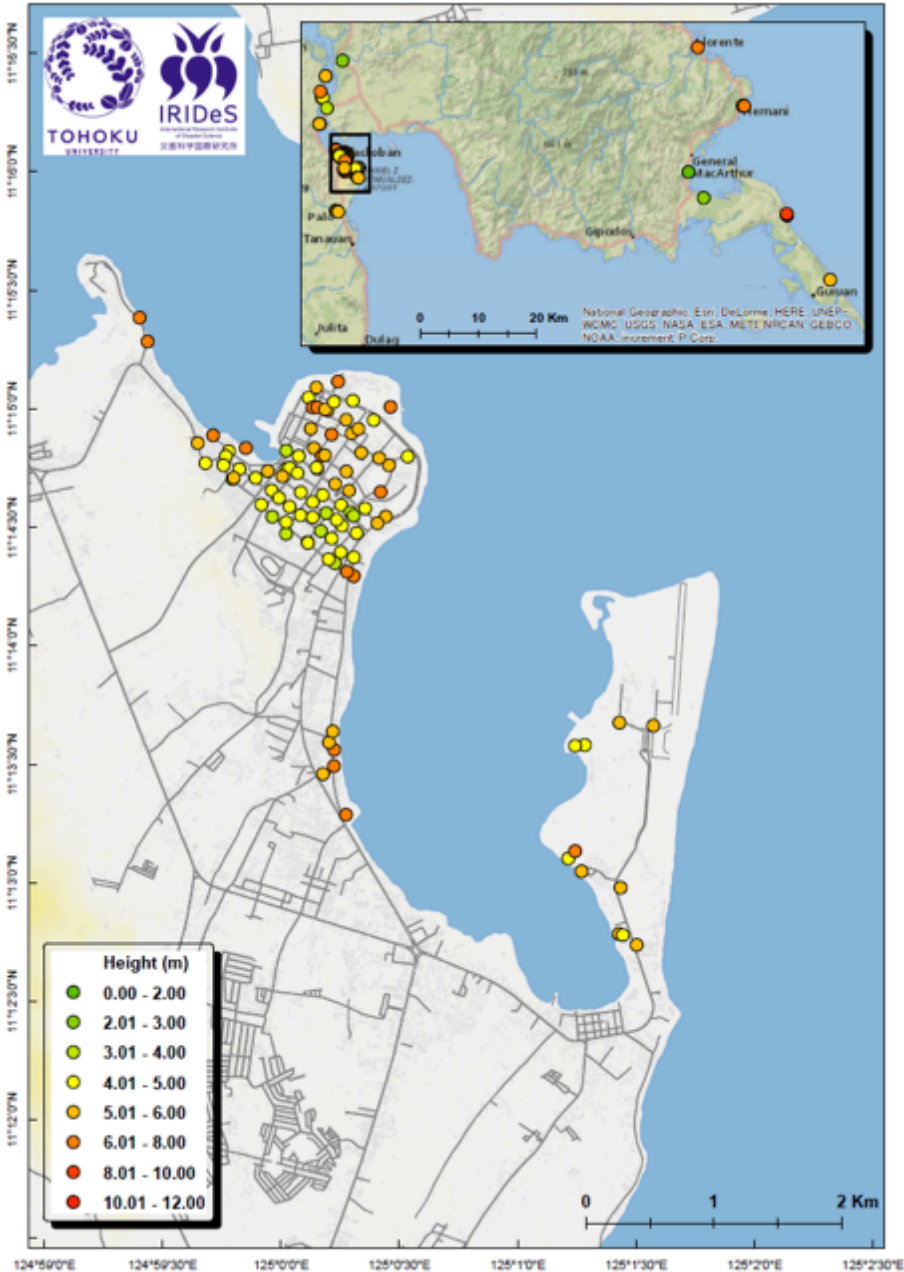
Counter Parts:

PAGASA, DPWH, DOH, UP, JICA, JSCE, etc.

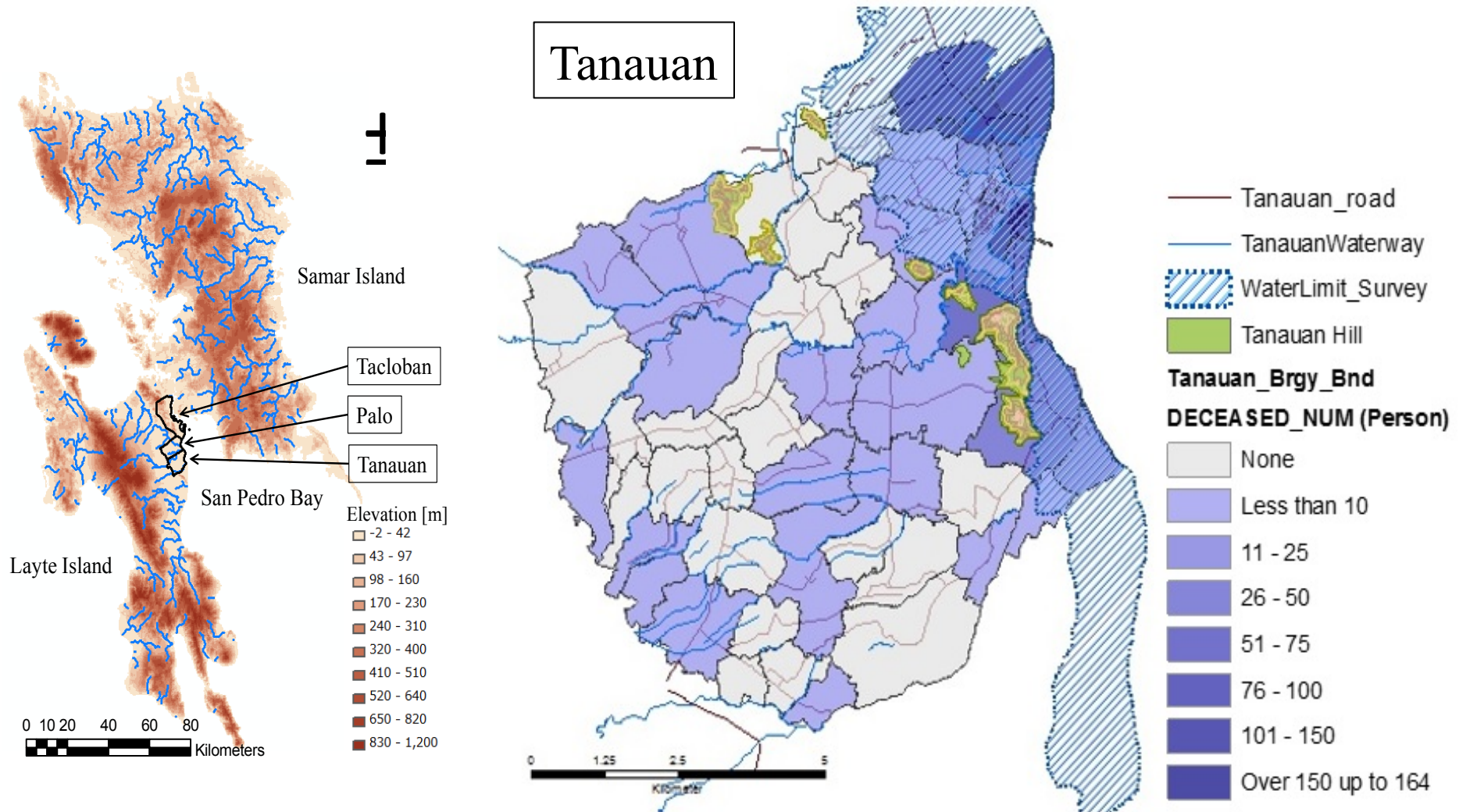
Survey Results (Inundation Heights)



Survey Results (Inundation Heights and Area, Mas et al., 2014)

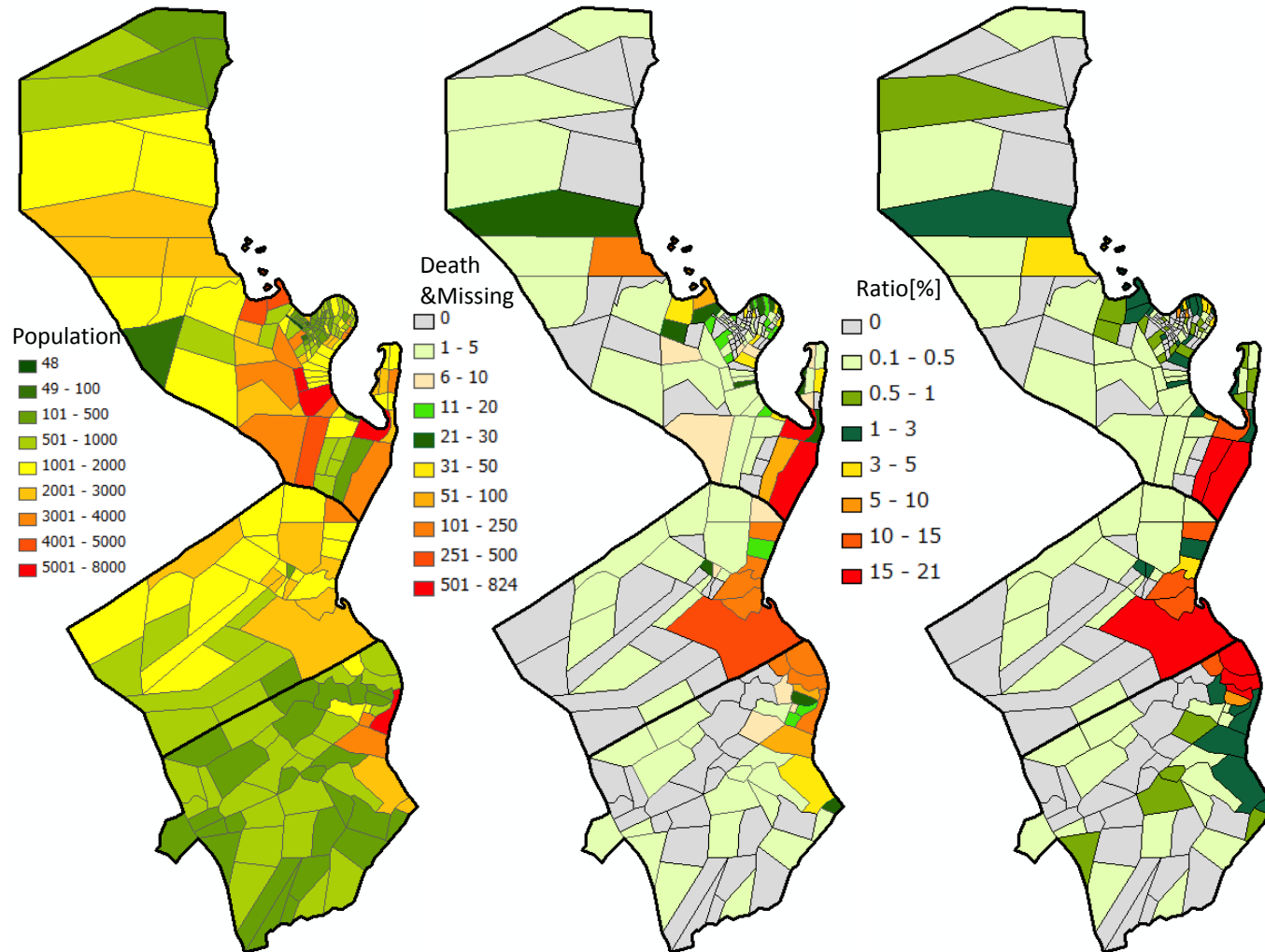


Survey Results (Inundation area, Yi et al., 2014)



Developed inundation zone was much larger than that on the flood, storm surge and tsunami hazard maps of Tacloban and Tanauan.

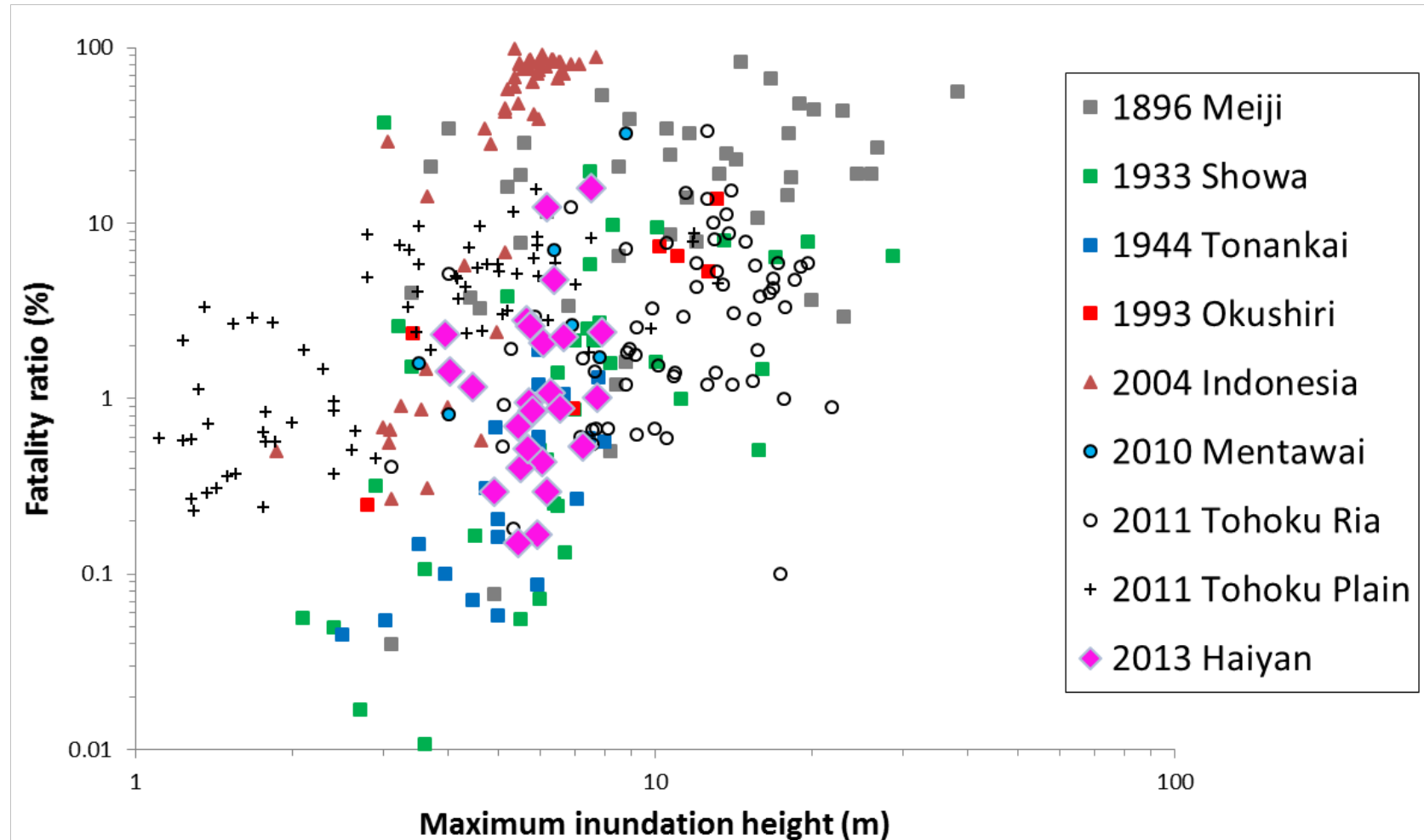
Survey Results (Kure et al., 2014)



Population (left), number of deaths and missing people (middle) and fatality ratio [%] (right)

Population was concentrated in the coastal areas, and more than 10 % of the fatality ratio were found along the coastal areas.

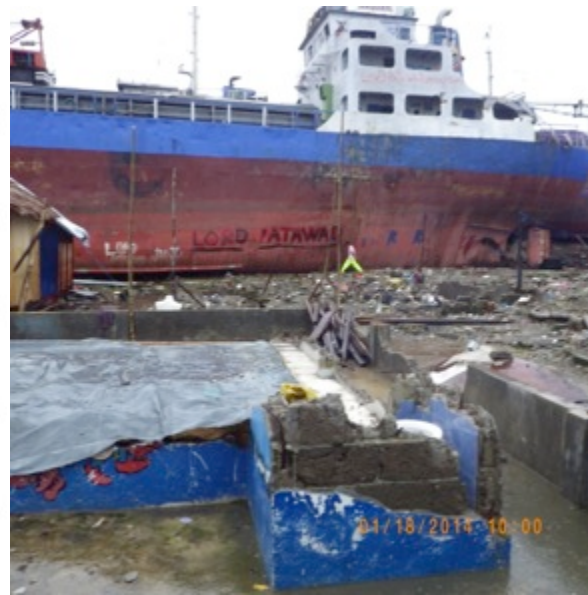
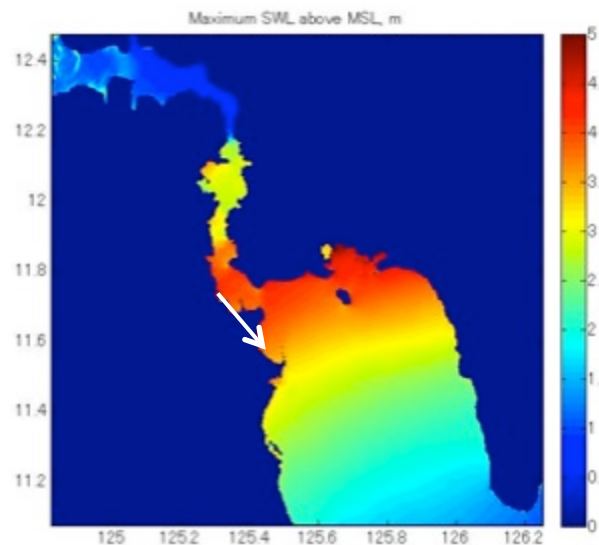
Survey Results (Kure et al., 2014)



Scale of human damage caused by Haiyan was similar to that caused by any other historical tsunami disaster, clearly indicating the massive external force and the vulnerability of those coastal areas

Types of damage in downtown Tacloban near the shoreline

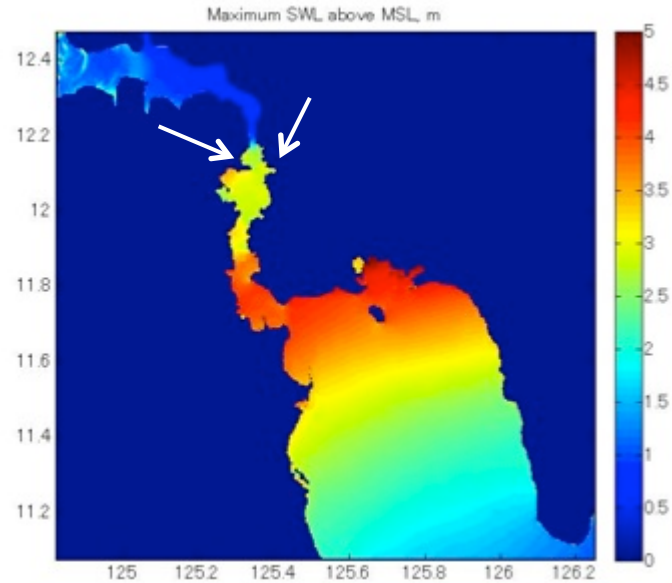
- Surge up to 8 m above sea level
- Scour around structures
- Beached ships destroyed homes
- Most buildings destroyed



Types of damage in downtown Tacloban near the shoreline



Surge travelled far to the north in Samar-Leyte strait

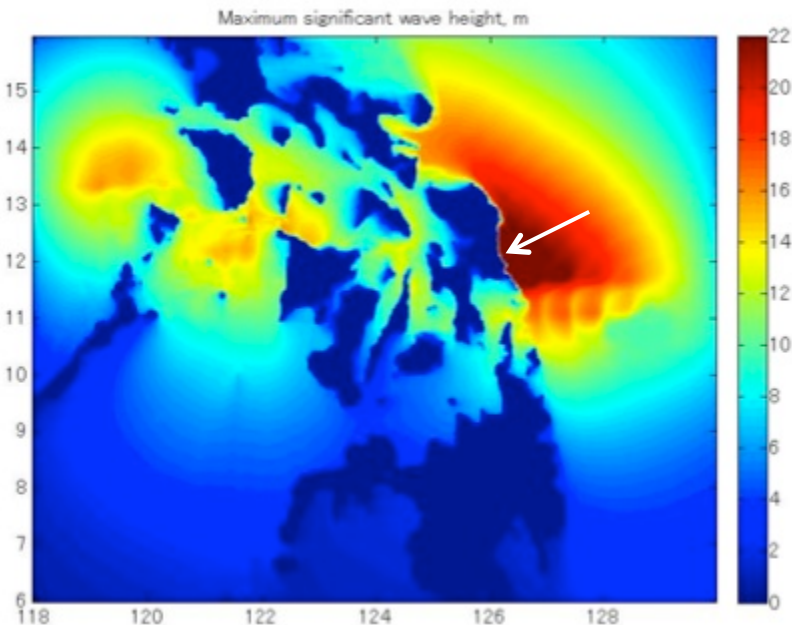


- Northern Leyte and Samar villages feel neglected because NGO's and foreign governments haven't paid attention to them

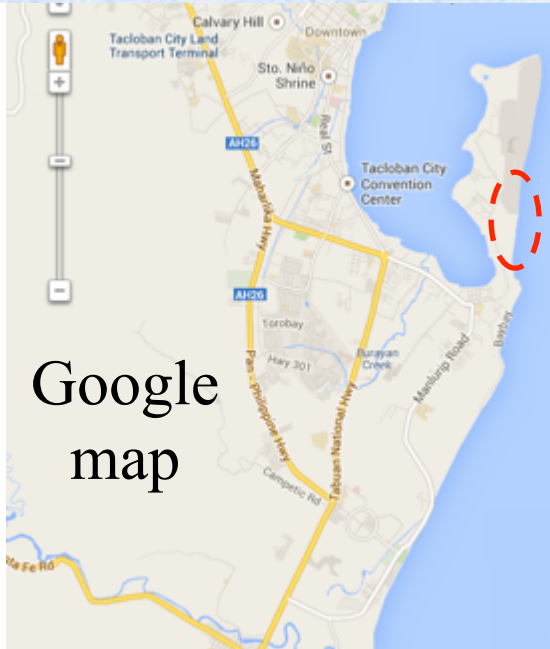


Damage in Eastern Samar

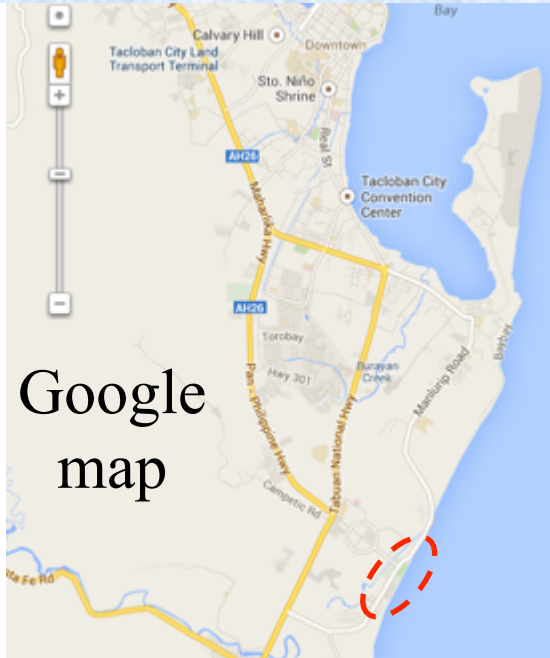
- Waves only (no storm surge)
 - Waves break over coral reef, then run up onto land as bores
 - Inundation and run-up measured up to 12 m above sea level
- RC structures destroyed
- Foundation blocks transported up to 30 m landward



Seawall Damage (Airport)



Seawall Damage (MacArthur Landing Memorial Park)



Google
map



Widespread damage due to wind



Widespread damage due to wind



Layte Convention Center



Findings and Observations

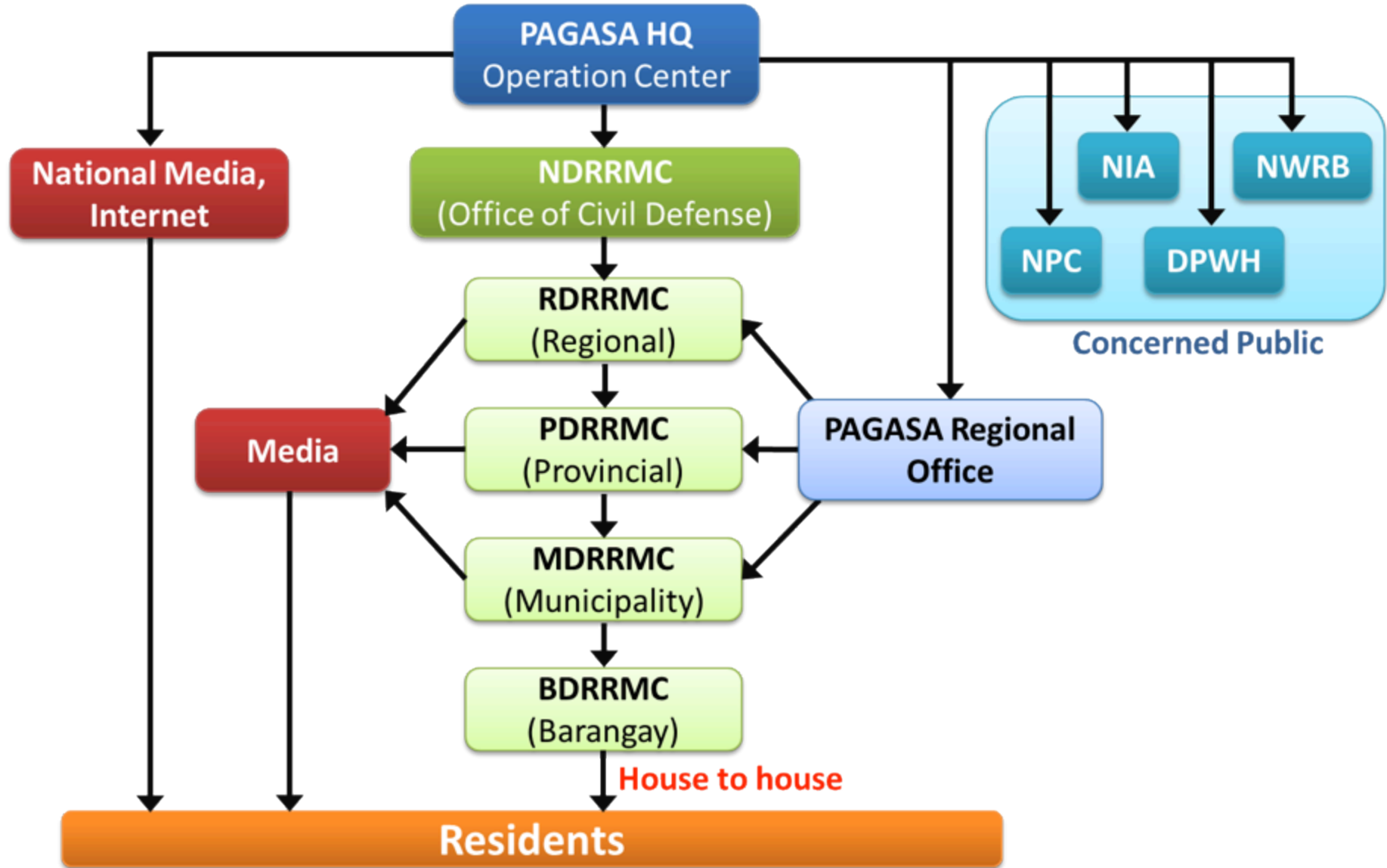
- Detailed inundation maps in and around Tacloban and Tanauan were obtained. And **inundation zone was much larger than that on the existing hazard maps.**
- Surges up to 8 m were observed around Tacloban city
- Significantly large waves up to 12 meter were observed in Eastern Samar.
- Surge travelled far to the north in Samar-Layte strait

Reasons for magnification of damage due to Haiyan

- Large Hazard
 - Super typhoon (Category 5)
 - Worst path** to the densely populated area and generate significantly high surges and waves in the coastal area
- **Concentration of population** and assets in the coastal area
- Weak mitigation system in terms of hard and soft measures
 - vulnerable buildings and evacuation facilities**

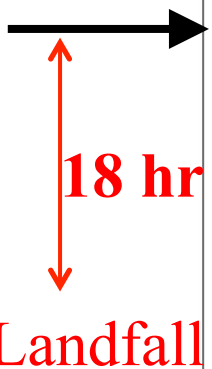
Evacuation Warning

Disaster Information Transfer System (Miyamoto et al., 2014)




PAGASA Warning Records

- 11:00, 5th Nov., Weather Advisory #1
- 10:30, 6th Nov., Weather Advisory #2
- 23:00, 6th Nov., Severe Weather Bulletin #1
- 5:00, 7th Nov., Severe Weather Bulletin #2
- 11:00, 7th Nov., Severe Weather Bulletin #3**
- 17:00, 7th Nov., Severe Weather Bulletin #4
- 20:00, 7th Nov., Severe Weather Bulletin #4-a
- 23:00, 7th Nov., Severe Weather Bulletin #5
- 2:00, 8th Nov., Severe Weather Bulletin #5-a
- 5:00, 8th Nov., Severe Weather Bulletin #6**
- 11:00, 8th Nov., Severe Weather Bulletin #7
- 17:00, 8th Nov., Severe Weather Bulletin #8
- 23:00, 8th Nov., Severe Weather Bulletin #9
- 5:00, 9th Nov., Severe Weather Bulletin #10
- 11:00, 9th Nov., Severe Weather Bulletin #11
- 15:30, 9th Nov., Severe Weather Bulletin #12




Landfall



Republic of the Philippines
Department of Science and Technology
PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND
ASTRONOMICAL SERVICES ADMINISTRATION (PAGASA)
Weather Forecasting Section, Weather Branch
WFFC Bldg., BR Road, Diliman, Quezon City 100
TELE: 66602 WAMM, FN FAX NOS: 926-4258, 926263, 9272873, 927540
Website: <http://www.pagasa.dost.gov.ph> Email: pagasa_wb@pacific.net.ph Voice Server: 433-88AN

SEVERE WEATHER BULLETIN NUMBER THREE
TROPICAL CYCLONE WARNING: TYPHOON "YOLANDA" (HAIYAN)
ISSUED AT 11:00 AM, 07 NOVEMBER 2013
(Valid for broadcast until the next bulletin to be issued at 5 PM today)
TYPHOON "YOLANDA" HAS MAINTAINED ITS INTENSITY AS IT THREATENS EASTERN VISAYAS.

Location of eye/center:	At 10:00 AM today, the eye of Typhoon "YOLANDA" was located based on all available data at 637 km East of Hinatuan, Surigao Del Sur or 738 km Southeast of Guiuan, Eastern Samar (8.9°N, 132.1°E).	
Strength:	Maximum sustained winds of 215 kph near the center and gustiness of up to 250 kph.	
Movement:	Forecast to move West Northwest at 30 kph.	
Forecast Position:	Typhoon "YOLANDA" is expected to be still over the sea at 64 km Southeast of Guiuan, Eastern Samar by tomorrow morning and expected to make landfall over Guiuan, Eastern Samar (9-10 am). It will be at 122 km West of Coron, Palawan by Saturday morning. On Sunday, it will be at 954 km West of Manila or outside the Philippine Area of Responsibility.	

PUBLIC STORM WARNING SIGNAL				
PSWS	LUZON	VISAYAS	MINDANAO	POTENTIAL IMPACTS OF THE WINDS
# 3 (Winds of 101-185 kph is expected in at least 18 hrs)		Eastern Samar, Samar, Leyte and Southern Leyte.	Siargao Island and Dinagat Province	<ul style="list-style-type: none"> • Heavy damage to agriculture • Some large trees uprooted • Majority of ripa and cogon houses unrolled or destroyed • considerable damage to structures of light to medium construction • Moderate to heavy disruption of electrical power and communication services • Travel by land, sea and air is dangerous
# 2 (Winds of 61-100 kph is expected in at least 24 hrs)	Sorsogon and Masbate including Ticao Island	Northern Samar, Biliran Province, Bantayan and Camotes Islands, Northern Cebu including Cebu City, and Bohol	Surigao Del Norte, Camiguin, Surigao Del Sur and Agusan Del Norte	<ul style="list-style-type: none"> • Moderate damage to agriculture • Rice and corn adversely affected • Few large trees uprooted • Large number of ripa and cogon houses partially or totally unrolled • Some old galvanized iron roofing may roll off • Travel by all types of sea vessels is risky • Travel by all types of aircrafts is risky
# 1 (Winds of 30-60 kph is expected in at least 36 hours)	Camarines Norte, Camarines Sur, Catanduanes, Albay, Mindoro Provinces, Burias Island, Romblon, Marinduque, Calamian Group of Island and Southern Quezon	Aklan, Capiz, Iloilo, Antique, Guimaras, Negros Occidental and Oriental, Rest of Cebu and Siquijor	Misamis Oriental and Agusan del Sur	<ul style="list-style-type: none"> • Twigs and branches of trees may be broken • Some banana plants may tilt or land flat on the ground • Rice in flowering stage may suffer significant damage • Some ripa and cogon houses may be partially unrolled • Sea travel of small seacrafts and fishing boats is risky

- Yolanda, after hitting Guiuan, is expected to traverse the provinces of Leyte, Biliran, Northern tip of Cebu, Iloilo, Capiz, Aklan, Romblon, Semirara Island, Southern part of Mindoro then Busuanga and will exit the Philippine landmass (Saturday Morning) towards the West Philippine Sea.
- 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 seaboard 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 flash-floods 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.
- The public and the disaster risk reduction and management council concerned are advised to take appropriate actions and watch for the next bulletin to be issued at 5 PM today.

those living in coastal areas under signal #3 and #2 are alerted against storm surges which may reach up to 7-meter wave height.

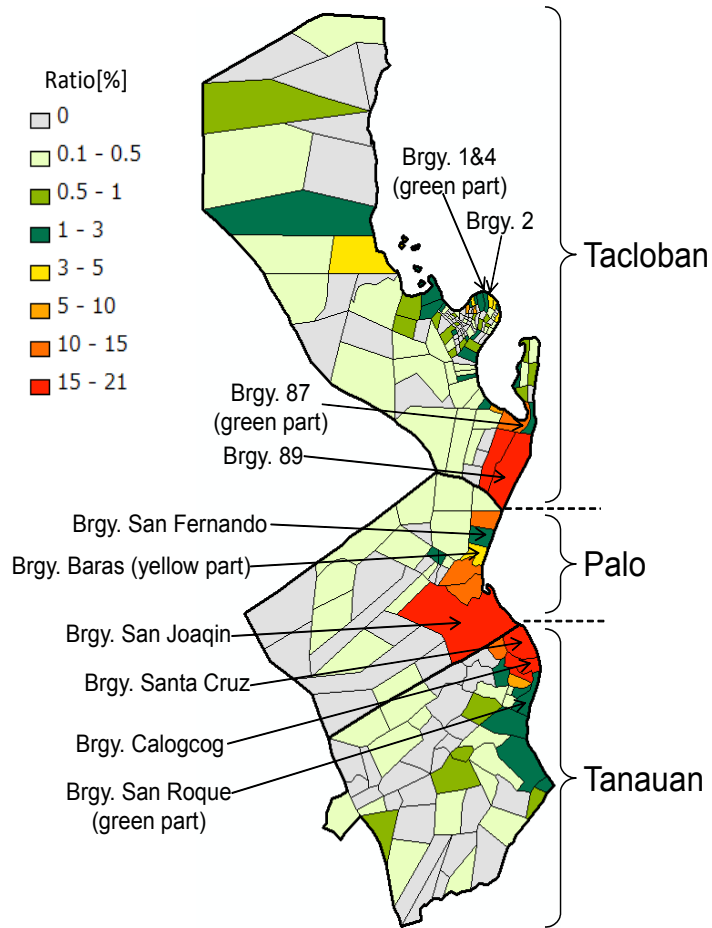
Questionnaire survey

(Jibiki et al., 2014)

Questionnaire survey under the support of UP students



Questionnaire survey



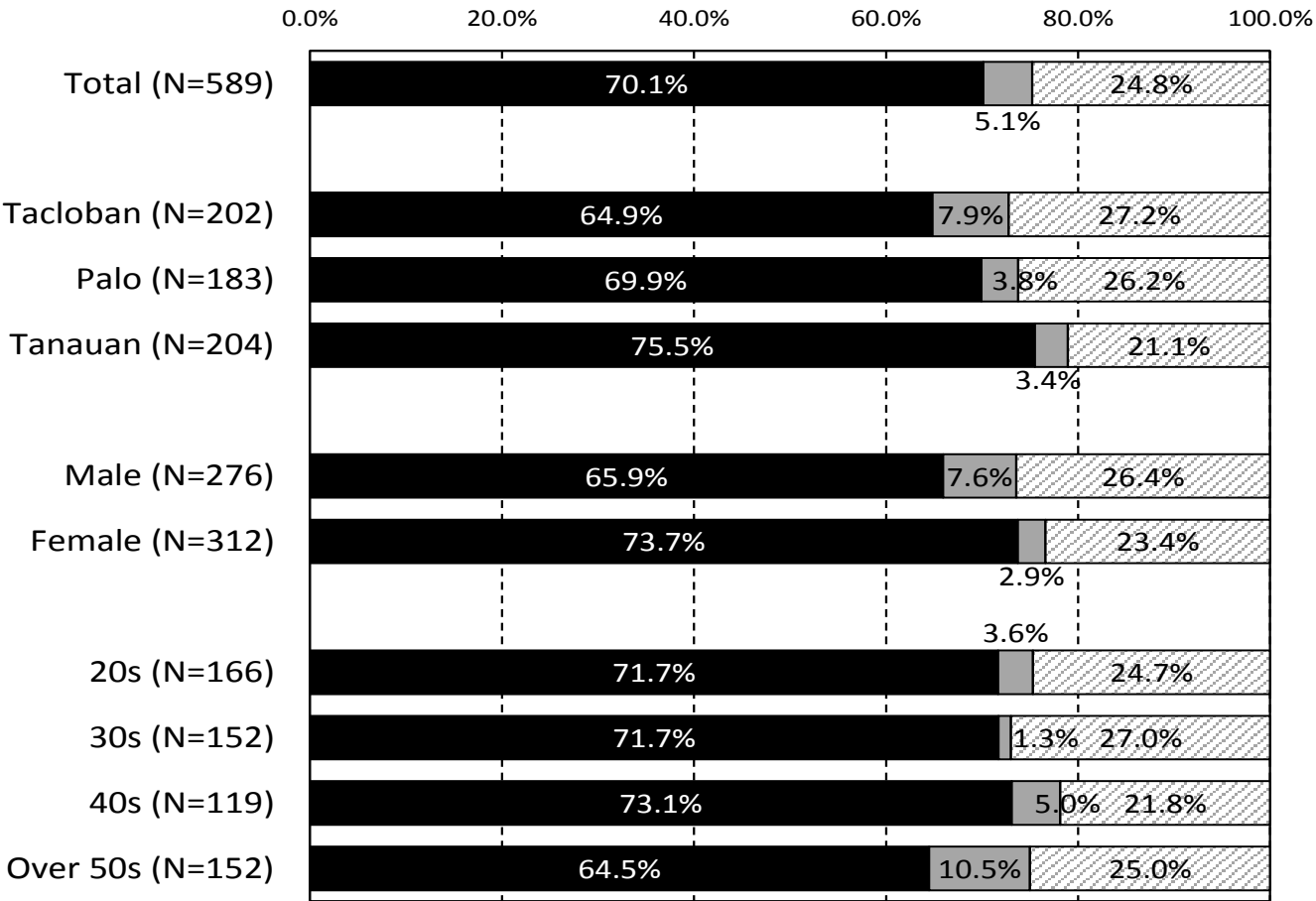
Tacloban + Palo + Tanauan

	20s	30s	40s	Over 50s	Sum
Male	91 (14.2%)	78 (12.2%)	66 (10.3%)	76 (11.9%)	311 (48.5%)
Female	93 (14.5%)	91 (14.2%)	65 (10.1%)	81 (12.6%)	330 (51.5%)
Sum	184 (28.7%)	169 (26.4%)	131 (20.4%)	157 (24.5%)	641 (100.0%)

Distribution of the death and missing ratio of each Barangay in survey area.

Respondents were selected depending on barangay damage in the coastal areas and population conditions of generation and gender in Philippines.

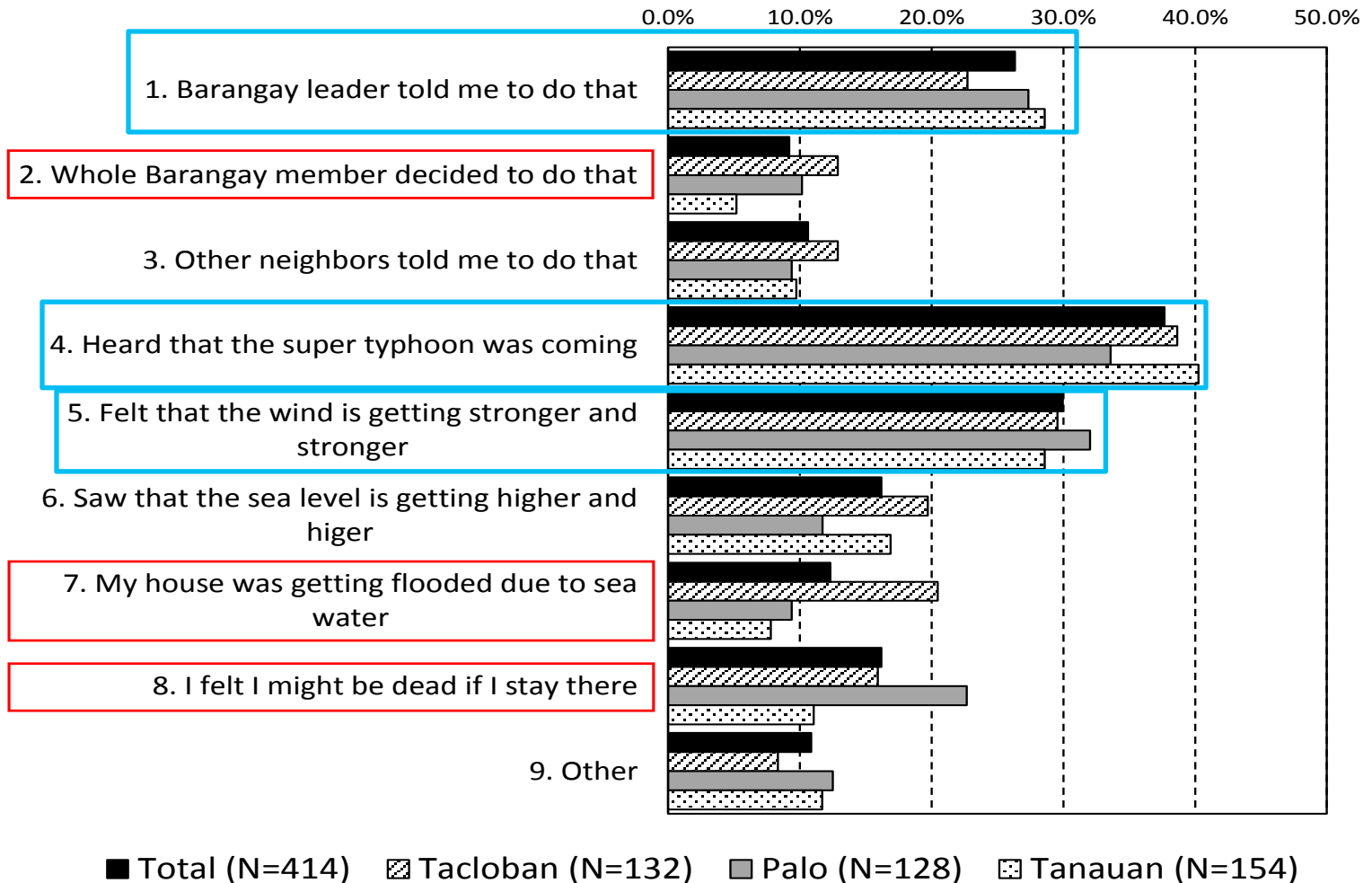
Evacuation behaviors



- Evacuated to some places except my house
- Evacuated to second floor or top roof of my house
- ▨ Not evacuated

About 30% of the respondents did not evacuate to anywhere outside of their houses.

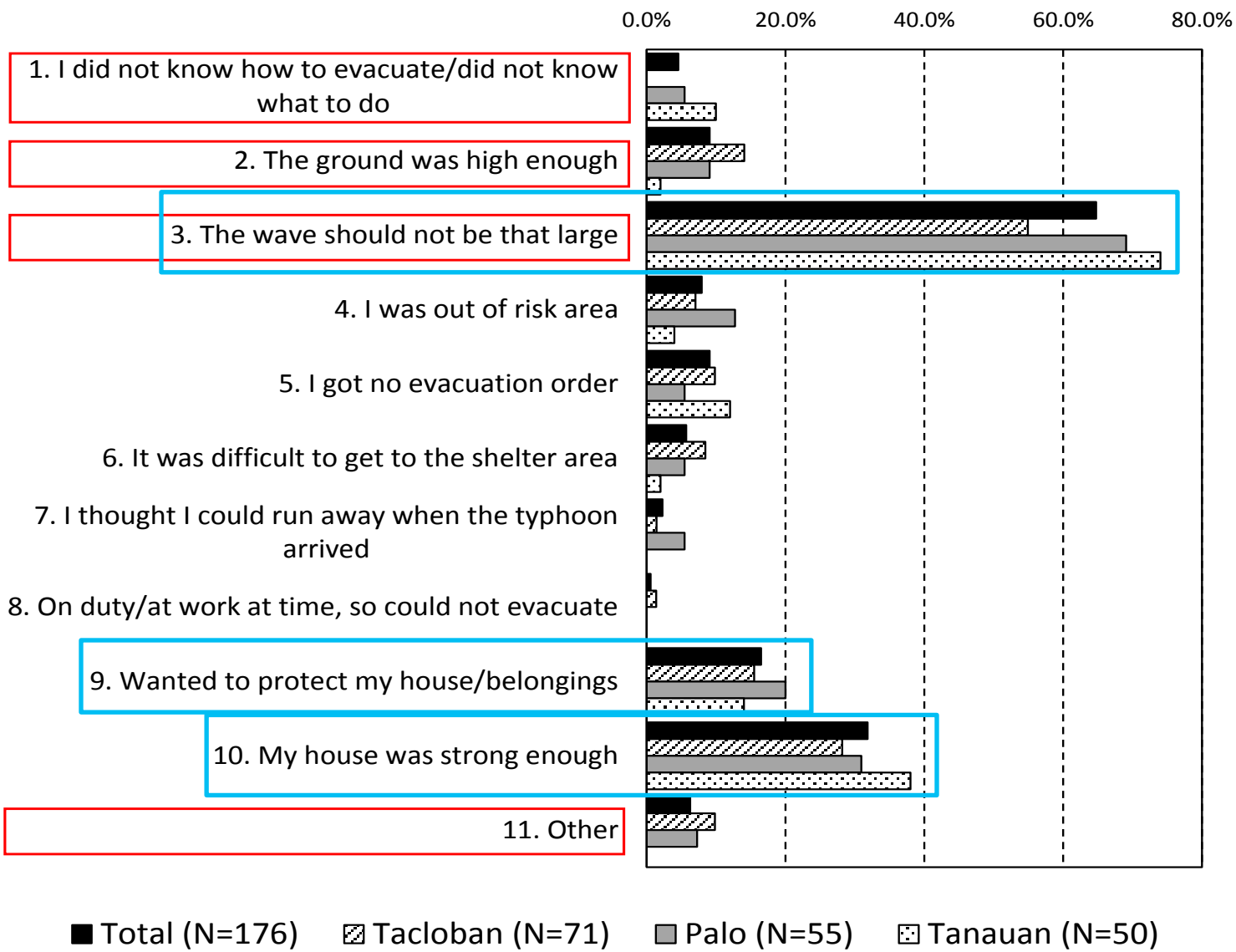
Reasons for evacuation to outside of houses



Note1: multiple answers were allowed in this question.

Note2: Answers highlighted by red boxes have statistical difference among the survey sites.

Reasons for not evacuated to outside of houses (remained at houses)



Note1: multiple answers were allowed in this question.

Note2: Answers highlighted by red boxes have statistical difference among the survey sites.

Questionnaire survey - Results -

- 641 valid respondents in Tacloban, Palo and Tanauan
- About 30% of the respondents did not evacuate to anywhere outside of their houses.
- Reasons for evacuation
 - Heard that super typhoon was coming
 - Felt that wind is getting stronger and stronger
 - **Order from Barangay leader**
- Reasons for not evacuated
 - **The wave should not be that large**
 - My house was strong enough
 - **Wanted to protect my house/belongings**
- Many peoples **do not understand “what a storm surge is”**
- **TV and Radio** are the main sources of information on typhoon

Questionnaire survey - Summary -

- Warnings were transferred relatively well to the coastal barangays
- TV, Radio and barangay leaders played important roles for the evacuation

However,

- many people **did not possess an accurate picture of the event** and underestimate the impact from Haiyan
- many people do not understand “what a storm surge is”
- Some people **wanted to protect their house/belongings**
- Some people and barangay claimed they did not receive warnings

Evacuation facility

- Evacuation facilities

Many facilities such as Tacloban convention center, Leyte convention center, schools, churches were not appropriate for the evacuation (Near sea side, severely damaged by strong wind, etc.).



Tacloban Convention Center



Leyte Convention Center (Palo)

Evacuation facility



Church in Eastern Samar



School in Eastern Samar



School in Tanauan

Reasons for magnification of damage due to Haiyan

- Large Hazard
 - Super typhoon (Category 5)
 - Worst path** to the densely populated area and generate significantly high surges and waves in the coastal area
- Weak mitigation system in terms of hard and soft measure
 - Vulnerability** of buildings and evacuation facilities
- **Poverty**
 - Concentration of population and assets in the coastal area.
 - Young men had to stay in the houses in order to protect their properties during the disaster events.
- **Education**
 - Some people do not understand “what a storm surge is”

Recommendations

- **Storm surge hazard maps** should be updated and developed in coastal areas in the Philippines **under the worst scenario** considering the impacts of climate change, worst path, land use/cover change, etc.
- Inland topography and local bathymetry along the coast should be measured in more detail for the numerical simulation of the storm surge and high wave in the local level.
- Seawalls should be reconstructed and **multiple countermeasures** such as combinations of seawalls, tide-water control forests, no building zones, etc. should be developed from the view point of **efficiency, low cost and easy maintenance.**

Recommendations

- Selection and construction of **suitable evacuation centers** and places. However, it is **not easy** for 200,000 people living in coastal areas of Tacloban city to provide safe place during the super typhoon.
- Education and training to emphasize the urgency of evacuation, especially for the **barangay leaders** (local communities).
- Upgrade of an early warning system for storm surge inundation (**Downscale to the community level**).
- **Warning transfer system in the local communities** (Barangay level). Barangay leader's leadership for the evacuation and information from media and churches are important.