Lessons Learned from Haiyan

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Initial report can be downloaded from:
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

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<th>Time</th>
<th>Longitude</th>
<th>Latitude</th>
<th>Pressure (hPa)</th>
<th>Diameter of Typhoon (km)</th>
<th>Velocity (km/h)</th>
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Source: digital typhoon
Wind Speed and Pressure at Guiuan

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

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, XI, 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 (Murao 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 (Murao et al., 2014) [Source: NDDRMC Situation Report]

Human losses were mainly caused by storm surge around Tacloban city
Summary of Damage by Typhoon Haiyan

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

<table>
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<th>Death &amp; Miss.</th>
<th>Population</th>
<th>Ratio [%]</th>
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<td>Tacloban</td>
<td>2,542</td>
<td>220,000</td>
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<td>Palo</td>
<td>1,381</td>
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<td>Tanauan</td>
<td>1,252</td>
<td>50,000</td>
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Haiyan, the magnitude of storm surge (JICA)
Vulnerability of the coastal zone

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
Satellite Image Analysis (Bruno et al., 2014)

Mapping Inundation Zone

Legend
Elevation
- 0
- 0-1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-7
- 7-10
- 10-15
- 15-30
- 30-50
- 50-100
- 100-200
- 200-300

ROAD
BOUNDARY

Land Elevation (NAMRIA)

NDWI Threshold
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

[Wind field images for 11/8 6h, 11/8 7h, 11/8 8h, 11/8 9h]
Storm Surge Simulation (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.
Population was concentrated in the coastal areas, and more than 10% of the fatality ratio were found along the coastal areas.
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)
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

18 hr
Landfall

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
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

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)

1. I did not know how to evacuate/did not know what to do
2. The ground was high enough
3. The wave should not be that large
4. I was out of risk area
5. I got no evacuation order
6. It was difficult to get to the shelter area
7. I thought I could run away when the typhoon arrived
8. On duty/at work at time, so could not evacuate
9. Wanted to protect my house/belongings
10. My house was strong enough
11. Other

Note 1: multiple answers were allowed in this question.
Note 2: 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
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/belongins**

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.