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# Assessing and mapping barangay level social vulnerability of Tacloban City and Ormoc City to climate-related hazards

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## Abstract

The destruction left by Typhoon Haiyan in the Philippines highlighted not only the exposure of the country but also the underlying vulnerability of barangays (villages) to climate-related hazards. This study used geographic information system (GIS) tools to characterize social vulnerability to climate-related hazards of barangays of Tacloban City and Ormoc City using a modified social vulnerability index (SoVI). The SoVI used socioeconomic data mainly drawn from census and was computed from 11 indicators influencing sensitivity, adaptive capacity, and exposure. Social vulnerability varies spatially across the study areas, where Barangay 88, said to be the worst-hit barangay in Tacloban, and Barangay Naungan in Ormoc, recorded the highest vulnerability scores. Demographic and socioeconomic shifts are likely in both cities, given the population growth and increasing density of settlements already concentrated in hazard-prone barangays. Measures to reduce vulnerability should be a local priority and would require political will for community-based climate action, disaster risk reduction and management, and risk-sensitive land use development. This study provides an approach for assessing social vulnerability using available census and climate-related hazard data to determine areas for intervention at the barangay level.

Keywords: social vulnerability · climate-related hazards · geographic information systems (GIS) · vulnerability assessment · Haiyan

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## Introduction

Hazards that cause vulnerability have unequal distribution of impacts on a population (Zahran, Brody, Peacock, Vedlitz, & Grover, 2008) and across geography (Cutter & Finch, 2008) due to factors other than forces of nature, such as social systems and power (Wisner, Blaikie, Cannon, & Davis, 2003). Considering the characteristics or the conditions of social processes, economic systems, and power relations which render people susceptible to damage or injury (Cannon, 1994; Wisner et al., 2003), the concept of vulnerability has evolved over time, addressing one of the missing links in how to measure social vulnerability (Cutter & Corendea, 2013).

Vulnerability is the characteristic of a system that refers to its susceptibility to the negative impact of a natural hazard (United Nations International Strategy for Disaster Reduction, 2009) or the adverse effects of climate change (Intergovernmental Panel on Climate Change, 2007); or how that system's ability to prepare for, respond to, and recover from such hazards and adverse effects is affected. Accordingly, disaster impacts are more experienced by communities with the most vulnerable populations, rampant poverty, and least political influence (Asuero et al., 2012).

Social vulnerability provides an understanding of the factors that make some communities more susceptible to the impacts of disasters and of their capacity to recover (Cutter, Boruff, & Shirley, 2003). Vulnerability varies because natural environments, social structure, and housing differ spatially (Uitto, 1998). Accordingly, social vulnerability also varies across geography (Cutter & Finch, 2008) and across many levels of interaction (e.g., individual, community, regional, local) (Thomas, Philipps, Lovekamp, & Fothergill, 2013). Changes in an area's socioeconomic and demographic characteristics, such as population increase due to rural-to-urban transition, brings a certain pattern of exposure to hazards on the changing landscape and the built environment, particularly along coastal areas (Cutter, Johnson, Finch, & Berry, 2007). There have been attempts to incorporate vulnerability metrics at different subnational spatial scales and sub-county units (Cutter & Finch, 2008) such as the model developed by Yusuf and Francisco (2009) to measure sub-national vulnerability to climate change in Southeast Asia.

Typhoon Haiyan (local name Yolanda) is considered the most destructive typhoon ever recorded in the Philippines. It hit the country in November 2013, leaving over 6,300 dead, 1,061 missing, and 28,689 injured and affecting 12,139 barangays, 44 provinces, 591 municipalities, and 57 cities (National Disaster Risk Reduction and Management Council, 2014). Such devastation highlighted the underlying vulnerability of the country, particularly those living near natural hazards and those with low socioeconomic status.

Two years after the typhoon struck, recovery and rehabilitation efforts in affected areas are moving at a slow pace. Most of the displaced populations are still living in temporary shelters where exposure to other forms of hazards may still be likely. The disaster did not only challenge local capacity to face critical pre- and post-disaster issues, but it also put to question the country's social, economic, and even political structures, the very foundation of sustained, if not lessened, vulnerability.

This study attempts to assess the extent to which Tacloban City and Ormoc City are vulnerable to climate-related hazards by measuring the social vulnerabilities of their barangays. The social vulnerability index (SoVI) was built on available and recent barangay-level datasets classified into sensitivity, adaptive capacity, and exposure, then measured using statistical approaches and mapped using geographic information systems (GIS).

## Materials and Methods

### Scope and Limitations

The geographical scope of the study covers the barangays of Tacloban and Ormoc in Leyte Province, coastal cities which were heavily affected by the impacts of the Typhoon Haiyan (Figure 1).

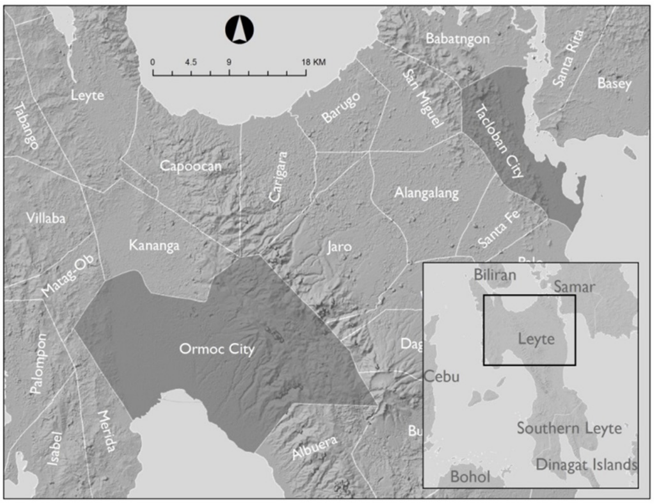


**Figure 1**. Location map of study sites.

Typhoon Haiyan had a devastating impact on the cities of Tacloban and Ormoc where most of the fatalities and damage occurred due to storm surge and wind. In particular, the effects in Tacloban were aggravated because the coastal area is below sea level and has many key public infrastructures such as schools, hospitals, and private residences. Tacloban has had an average of 2.3 typhoons per year in the last 50 years, and is now considered as among the Philippines cities that are most vulnerable to climate change (WWF & BPI, 2013).

The mapping extent is barangay level, with raw scales of 1:50,000 for flood and landslide hazard maps and

1:25,000 for storm surge maps. However, a careful recognition of the complexity of integrating hazard datasets of varying scales used to calculate areas per level of hazard susceptibility with socioeconomic data is required in the use and interpretation of the vulnerability maps. In addition, the vulnerability maps do not represent the absolute and actual vulnerability of barangays due to scarcity of other important indicators available at the barangay level. However, the measurement of relative vulnerability among barangays allows for informed interventions aimed at reducing vulnerability.

Moreover, there may be discrepancies on the barangay boundaries between the maps generated by the study and the boundaries Tacloban City currently uses. During the course of data gathering, the available shapefiles were still based on the old city boundaries despite the fact that the city already uses a different boundary configuration on the ground. This study opted to refer to these outdated shapefiles because the census data and other local reports are still based on them.

## Construction of Social Vulnerability Index (SoVI)

The first step in measuring the social vulnerability of barangays was to identify relevant indicators from existing knowledge and literature on social vulnerability. All dimensions of vulnerability were assessed using GIS with respect to the susceptibility of the barangays to climate-related hazards, such as landslide, storm surge, and flood (Figure 2), to classify the level of vulnerability of barangays.

Secondary data used included National Statistical Coordination Board (NSCB) 2010 demographic and employment data, GIS vector climate-related hazard datasets from the Yolanda Rehabilitation Scientific Information Center (YoRInfo Center), and Community Based Monitoring System (CBMS) 2011 data on households living in makeshift houses (CBMS, 2011, NSCB, 2010, NSCB, 2012, NSO, 2007, NSO, 2010).

The SoVI per barangay (Table 1) was derived using indicators representing exposure, adaptive capacity, and sensitivity adopted from the Economy and Environment Program for South East Asia (Yusuf & Francisco, 2009), focusing on generally accepted aspects of social vulnerability as proposed by Cutter et al. (2009). The sub-indicators under each major component were given equal weights relative to the number of indicators in that component. This balanced weighted approach (Hahn, Riederer, & Foster, 2009; Sullivan, Meigh, & Fediw, 2002) was used due to the arbitrary relationships among different indicators. Thus, the components of vulnerability (Table 2) were assessed at the scale of 0 to 1 with equal weighting given to all associated sub-indicators.

**Table 1**. List of vulnerability components, indicators and sub-indicators used for computing barangay SoVI.

| Indicators | Major component/ Factor | Sub-indicators and classification/ranking | | Unit | Functional relationship to vulnerability | Source |
|---|---|---|---|---|---|---|
| Unemployment | Sensitivity | Proportion of unemployed persons in the labor force (15 y.o. and above) | | % | ↑ | NSCB |
| Population at risk | Sensitivity | Population density | | pop/ha | ↑ | NSCB |
| | Sensitivity | Proportion of elders (>65 y.o.) | | % | ↑ | NSCB |
| | Sensitivity | Proportion of children (0-5 y.o.) - 0-17 | | % | ↑ | NSCB |
| | Sensitivity | Proportion of persons with disabilities | | % | ↑ | CBMS |
| | Sensitivity | Proportion of informal settlers households | | % | ↑ | NSCB |
| Poverty | Adaptive Capacity | Poverty incidence | | | ↑ | NSCB |
| Climate induced hazards | Exposure | Landslide susceptibility | Very high landslide susceptibility | ha | ↑ | UP DREAM YoRInfo Center |
| | | | High landslide susceptibility | ha | | |
| | | | Moderate landslide susceptibility | ha | | |
| | | | Low landslide susceptibility | ha | | |
| | Exposure | Flood susceptibility | Very high flood susceptibility | ha | ↑ | UP DREAM YoRInfo Center |
| | | | High flood susceptibility | ha | | |
| | | | Moderate flood susceptibility | ha | | |
| | | | Low flood susceptibility | ha | | |
| | | Storm surge susceptibility | High storm surge susceptibility | ha | ↑ | UP DREAM YoRInfo Center |
| | | | Moderate storm surge susceptibility | ha | | |
| | | | Low storm surge susceptibility | ha | | |
| Indicators | Major component/ Factor | Sub-indicators and classification/ranking | | Unit | Functional relationship to vulnerability | Source |
| Housing materials | Exposure | Proportion of HH living in makeshift houses | | % | ↑ | CBMS |

*Abbreviations*. NCSB = National Statistical Coordination Board; CBMS = Community Based Monitoring System; UP DREAM YoRInfo Center = University of the Philippines Disaster Risk and Exposure Assessment for Mitigation, Yolanda Rehabilitation Scientific Information Center; HH = household

**Table 2**. Categorization, description, and sources of selected sub-indicators (mostly adopted from [Cutter et al., 2003]).

| Indicators (Major Components) | Sub-indicators | Concept and description | Sources |
|---|---|---|---|
| Unemployment (Sensitivity) | Unemployed persons in the labor force | Employment loss | Mileti, 1999 |
| Population at risk (Sensitivity) | Population density | Population growth/ density | H. John Heinz III Center for Science, Economics, and the Environment, 2000; |
| | | Age spectrum extremes | Cutter, Mitchell, & Scott, 2000; |
| | | Special needs populations | Morrow, 1999; and Puente, 1999 |
| | Elders children | | Cutter et al., 2000; O'Brien & Mileti, 1992; Hewitt, 1997; and (Ngo, 2001 Morrow, 1999 and Tobin & Ollenburger, 1992 |
| | Persons with disability | Special needs populations | H. John Heinz III Center for Science, Economics, and the |
| | Informal settlers | Renters/informal settlers | Environment, 2000 and Platt, 1991 |
| Poverty (Adaptive capacity) | Poverty incidence | Socioeconomic status | H. John Heinz III Center for Science, Economics, and the Environment, 2000; Burton, Kates, & White, 1993; Wisner et al., 2003; Peacock, Gladwin, & Morrow, 1997; Hewitt, 1997; Puente, 1999; and Platt, 1991 |
| Climate induced hazards (Exposure | Flood<br>Storm surge<br>Landslide | Susceptibility to floods, storm surges and landslides | Balica, Wright, & Meulen, 2012; Cannon, 1994; and Hammill, Bizikova, Dekens, & McCandless, 2013 |
| Housing materials (Exposure) | Households living in makeshift houses | Housing and the built environment | Bolin & Bolton, 1986; Bolin & Stanford, 1991; Godschalk, Brower, & Beatley, 1989; Mitchell, Abdel-Ghaffar, Gentry, Leatherman, & Sparks, 1986; and White & Haas, 1975 |

The indicators used and prescribed by Cutter et al. (2009) in their study were modified in this study based on the context of the study areas and the availability of data. A SoVI was constructed with the same indicators as that of Cutter's but the sub-indicators were redeveloped to fit the situations and conditions in the study areas. These sub-indicators were chosen to ensure that the units and sources of data are consistent for standardization (Figure 2).

Indicators were normalized to a value between 0 and 1, multiplied by the assigned relative weights to generate the normalized indicator scores ($I_i$). These normalized indicator scores ($I_i$) were combined to generate the normalized scores of sensitivity ($S$), adaptive capacity, ($AC$) and exposure ($E$). The maximum and minimum values of the barangays were used to convert the indicator to a normalized index so it could be incorporated into the components of the SoVI. For units such as the 'proportion of unemployed persons in the labor force (15 years old and above)', the minimum value and the maximum value were set at 0 to 100, respectively, which represent percentage, and were standardized in a scale from 0 to 1.

The scores of the components were then multiplied equally by 0.33 and added altogether for the SoVI which ranges from 0 to 1, and classified into three classes using natural breaks (Jenks) method in GIS. Features are divided into classes whose boundaries are adjusted where there are relatively huge differences in the data values, such that high values for the index imply high vulnerability, moderate values imply moderate vulnerability and low values imply low vulnerability. The indicators were normalized using the methodology employed to calculate the Human Development Index (United Nations Development Programme [UNDP], 2014). Because all indicators have functional relationship with vulnerability, normalization was calculated as follows:

$$I_i = \frac{X_i - MinX_i}{MaxX_i - MinX_i} \quad (1)$$

where $X_i$ is the actual value, $MinX_i$ is the minimum value, and $MaxX_i$ is the maximum value of the indicator.

The ranks of certain indicators and sub-indicators (e.g.,'area of level of hazard susceptibility') were assigned to values arranged in ordinal numbers which correspond to weights that add up to 1 (100%). The area per level of susceptibility of each hazard was calculated using calculate geometry function of ArcGIS 10.2.

**Table 3**. Ranking and assignment of ordinal weights for storm surge vulnerability.

| Storm surge susceptibility | Rank relative to vulnerability | Ordinal weight |
|---|---|---|
| High susceptibility | 1 | 0.5 |
| Moderate susceptibility | 2 | 0.33 |
| Low susceptibility | 3 | 0.167 |
| | Total | 1 |

Ordinal weight is computed as:

$$\mathrm{Wr} = \frac{r}{\sum_{k=1}^{n} r} \quad (2)$$

where $r$ is the rank, $n$ is the number of ranks, and $k$ is 1. SoVI was then calculated as follows:

$$SoVIb = WbSb + WbACb + WbEb \quad (3)$$

where $b$ is the barangay, $S$ is sensitivity, $AC$ is adaptive capacity, and $E$ is exposure; such that barangay b equals the equally weighted values of $S$, $AC$, and $E$. The weight of each major component ($W_{Ci}$), where $C$ is one of the major components, indexed by $i$, is measured by 1 over the number ($n^C$) of the major components, which is 0.33 (Table 3).

$$W_C i = 1/ n^C \tag{4}$$

The same approach was used to calculate the weights ($W_{Sc}$) of the sub-indicators (Table 3).

$$W_{Sc} = 1/ n_S i \tag{5}$$

**Table 4**. Weights of sub-indicators.

| Major Components | Weight of major components ($W_C i$) | No. of indicators ($n_s i$) | Weight of sub-indicators ($W_s i$) |
|---|---|---|---|
| Sensitivity | 0.33 | 6 | 0.17 |
| Adaptive Capacity | 0.33 | 1 | 0.33 |
| Exposure | 0.33 | 4 | 0.25 |

$$S = f(U, PAR) \tag{6}$$

where $U$ is unemployment and $PAR$ is population at risk

$$AC = f(Pov) \tag{7}$$

where $Pov$ is poverty

$$E = f(CH, HM) \tag{8}$$

where $CH$ is climate-induced hazards (landslide, flood and storm surge) and $HM$ is housing materials

## Results and Discussion

From the identified indicators, the social vulnerabilities of the barangays were evaluated and ranked. These indicators have sub-indicators that could determine the characteristics of a particular barangay that make it more vulnerable to disasters relative to other barangays. For instance, in Tacloban City, the most socially vulnerable barangay has the demographic and socioeconomic characteristics that make it more sensitive to climate-related hazards: it is the most populated, it is highly exposed due to its location, and it has the least adaptive capacity due to its high poverty incidence. Therefore, its social vulnerability score is the highest among all barangays in Tacloban.

In the case of Ormoc City, the barangay that got the highest social vulnerability index is the barangay most exposed to climate-related hazards and also has the highest number of population at risk. However, unlike in Tacloban, the SoVI scores of the barangays in Ormoc do not have significant differences. Ormoc City is geographically more exposed to hazards than Tacloban City. A number of barangays in Ormoc are located along the shore and a number of those are prone to riverine flooding. Furthermore, the remaining parts of Ormoc are the rural areas whose populations are dependent to fishing and planting—livelihoods at risk to disasters. Thus, all barangays are almost equally vulnerable to disasters.

### Tacloban City

Based on the computed vulnerability, Barangay 88 is consistently highest in all factors of vulnerability, recording a large differential vulnerability value relative to other barangays. The overall social vulnerability of every barangay is determined by its respective sensitivity, exposure, and adaptive capacity indices. The values were classified into the clusters of low, moderate, and high (Table 5). Tacloban yielded a value of 6.52%, or 9 of its barangays with high vulnerability index. Among these barangays, Barangay 88 got the highest index of 0.66792 (Table 6), almost twice as high as the second highest, Barangay 99 (Diit), with the next highest vulnerability index of 0.39874. Barangay 88 consistently got the highest index for all the indicators whereas Barangay 99 consistently got high indices.

Barangay 88 is located in San Jose area in the peninsula facing San Pedro Bay (Figure 2). It is where Daniel Z. Romualdez (DZR) Airport is located and according to the interviews and other accounts, the most devastated barangay during Typhoon Haiyan. The barangay was practically washed out, the airport included, when the typhoon hit. Barangay 88 is a highly-urbanized, densely populated barangay with a number of commercial establishments within the residential areas. Most of its former residents were fisherfolks dependent on San Pedro Bay for income.

Barangay 99 is located in the central part of the City. It has the highest unemployment rate and the most number of persons with disabilities among all the barangays. It is facing the Samar Island in the east and is thus at lower risk to storm surges relative to Barangay 88, but has Tigbao River connected to San Juanico Strait, making it as flood-prone as Barangay 88.

**Table 5**. Range of values for sensitivity, adaptive capacity, exposure, and overall social vulnerability for Tacloban City.

| | S | AC | E | V |
|---|---|---|---|---|
| Low | 0.00148-0.02870 | 0.00000-0.03753 | 0.00328-0.02372 | 0.00749-0.09772 |
| Moderate | 0.02975-0.08384 | 0.04012-0.10784 | 0.02542-0.05634 | 0.09772-0.24304 |
| High | 0.08769-0.20234 | 0.05694-0.33000 | 0.05833-0.13559 | 0.24304-0.66792 |

Among the 51 barangays with moderate vulnerabilities, only Barangay 71 (Naga-Naga) has high sensitivity and exposure, while the rest merely have high indices on exposure. Barangay 71 is a densely populated coastal community near Anibong District where Barangays 68, 69, and 70 are located. The latter barangays also have moderate vulnerabilities computed from their high exposure indices and moderate sensitivity and adaptive capacity indices. Anibong District has several coastal communities with a high number of houses on stilts over the waters. It was also where the 8 cargo vessels were swept inland by the storm surges brought by Typhoon Haiyan.

More than half or 78 of the total barangays have low vulnerability (Figure 3). These are mostly the barangays in the downtown area and a few small communities in the outskirts of the city.

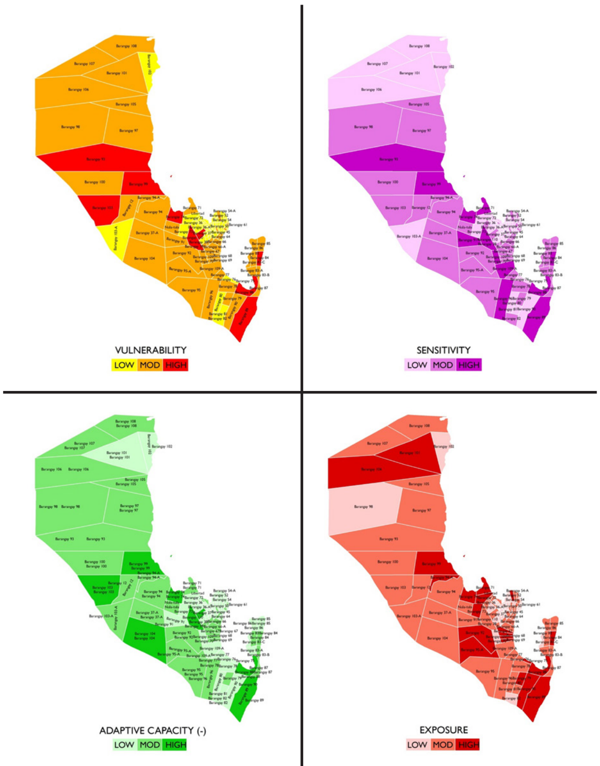


**Figure 2**. Social vulnerability, sensitivity, adaptive capacity, and exposure maps of Tacloban City, per barangay.

**Table 6**. Barangay in Tacloban City with the highest values for sensitivity, adaptive capacity, exposure, and overall social vulnerability.

| | Barangay | Score |
|---|---|---|
| Sensitivity | Barangay 88 | 0.20234 |
| Adaptive capacity | Barangay 88 | 0.33000 |
| Exposure | Barangay 88 | 0.13558 |
| Social vulnerability | Barangay 88 | 0.66792 |

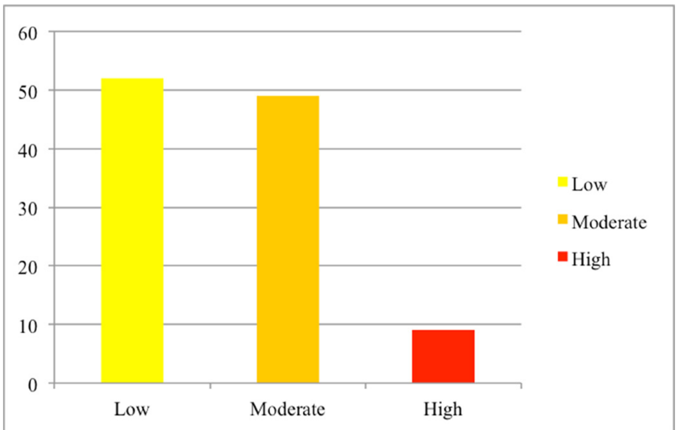


**Figure 3**. Number of barangays in Tacloban City per degree of social vulnerability.

## Sensitivity

The proportions of unemployed persons in the labor force (15 years old and above), informal settlers households, vulnerable sectors, and the population density were considered in measuring sensitivity. These proportions were normalized then ranked to assess the sensitivity among the barangays. Out of the 138 barangays of Tacloban City, 13 fell within the range of 'high sensitivity' (Figure 4). These are among the most populated barangays with a high number of informal settlers, according to the data from the CBMS. Barangay 88 has the highest sensitivity with 0.202469. It consistently has the highest number of population at risk and unemployed. The increasing number of population during daytime and the concentration of settlements in Tacloban can be attributed to the series of migrations from neighboring towns for economic reasons. Furthermore, fish vendors and other informally-employed residents were rampant in the barangay because of the coastal location of the barangay.

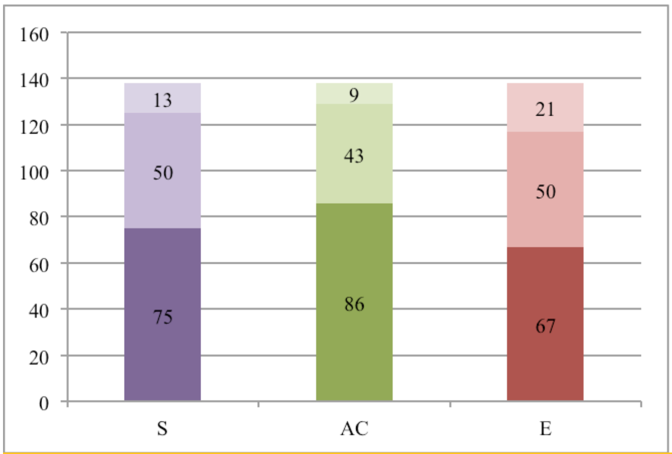


**Figure 4**. Number of barangays in Tacloban City per degree of sensitivity, adaptive capacity, and exposure. Lightest to darkest color denotes low to high index.

About 50 barangays have moderate sensitivity to climate-related hazards (Figure 4). Several of these barangays are along the coast with many informal settlements. The remaining 75 barangays have relatively low sensitivity. These are mainly the upland barangays whose land areas are mostly occupied by the mountains rather than communities. The barangay with the least sensitivity is Barangay 15, located in the highly commercialized downtown area.

## Exposure

Due to their natural and built environments, 21 barangays were highly exposed to climate-related hazards (Figure 5). These barangays scored between 0.05833 to 0.13559, with Barangay 88 scoring the upper limit. This could be attributed to the high susceptibility of these barangays to particular hazards and to the structure of their houses which could not provide protection during disasters. Similarly, 50 barangays were moderately exposed. These are the barangays adjacent to those that were identified to have high exposure score. The remaining 67 barangays have low exposure; mostly in the downtown area with Barangay 16 having the lowest exposure score. Tacloban downtown is a highly built-up, commercialized area and most of Barangay 16 is in the heart of it. Prior to Haiyan, building codes across all development zones and building types were not enforced and standard designs for houses and public infrastructure could only withstand winds of 200 kph. Most public infrastructure and critical facilities used as evacuation centers such as the Astrodome are located in hazard-prone areas.

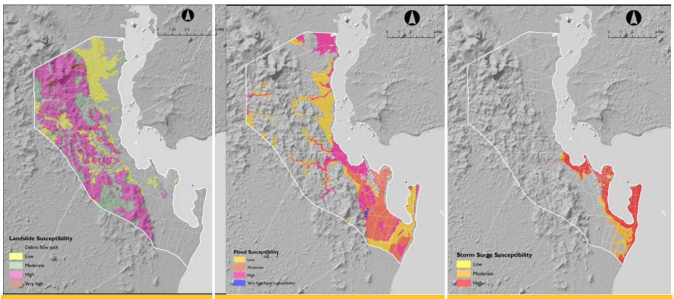

**Figure 5**. Landslide, flood, and storm surge susceptibility maps of Tacloban City.

## Adaptive Capacity

Barangay 88, having 54.37% of its households earning below the poverty threshold, scored an adaptive capacity index of 0.33, recording a large differential value compared to the 9 other barangays with high adaptive capacity index. Barangay 103 got the next highest index with 0.16435, almost half of that of Barangay 88. These barangays were spatially scattered showing that poverty in the city is not concentrated in certain areas. The index for moderate exposure is within 0.04012 to 0.10784, with 43 barangays falling within the range. The remaining 86 barangays whose index is low have the lowest proportions of households with income below the poverty threshold. The barangays with the lowest indices are Barangays 109-A, 77, 80, 109, 17, 62-B, and 16. The land uses among these barangays are mostly commercial and institutional, with only a few residential areas.

## Ormoc City

Typhoon Haiyan did not directly hit Ormoc but still brought strong winds that caused damage and deaths. Ormoc is generally vulnerable to disasters due to its exposure to natural hazards, not to mention that the livelihoods of many residents are dependent on the environment. Although Ormoc (Figure 6) has a higher proportion of barangays (8.18%) with high social vulnerability score (Figure 7), its barangays have lower social vulnerability scores compared to those in Tacloban (Table 7). The highest is that of Naungan with 0.32726 and the differential value between the index of Naungan and that of the second highest (Cogon Combado) is not very significant (Table 8). Those with high overall social vulnerability are those with high sensitivity indices, indicating that population at risk is the main factor contributing to their vulnerability. Bagong Buhay is the only barangay whose sensitivity is high but has moderate overall social vulnerability index. On the other hand, Lao has moderate sensitivity, but has high adaptive capacity and exposure indices, contributing to a high overall social vulnerability.

**Table 7**. Range of values for sensitivity, adaptive capacity, exposure, and overall social vulnerability for Ormoc City.

| | S | AC | E | V |
|---|---|---|---|---|
| Long | 0.00067-0.03649 | 0.00000-0.00766 | 0.00237-0.02432 | 0.00574-0.06546 |
| Moderate | 0.03650-0.09972 | 0.00766-0.02143 | 0.02483-0.05260 | 0.06608-0.16831 |
| High | 0.10481-0.19014 | 0.02265-0.06437 | 0.05325-0.11370 | 0.17656-0.34983 |

The barangays with moderate social vulnerability have indices ranging from 0.06788 to 0.16252. These are 49 barangays whose residents are engaged in small-time commercial fishing and/or subsistence farming, acquiring irrigation from the tributaries of Anilao and Malbasag Rivers. Most of these barangays also have high exposure and high adaptive capacity indices (Figure 8). The 52 barangays that have low social vulnerability indices are mostly the upland barangays that are sparsely occupied and the poblacion (town center) barangays that are commercialized. The least vulnerable among them is Barangay 5, which is a commercial block along Real Street in Ormoc City Proper.

**Table 8**. Barangays in Ormoc City with the highest values for sensitivity, adaptive capacity, exposure, and overall social vulnerability.

| | Barangay | Score |
|---|---|---|
| Sensitivity | Cogon Combado | 0.19014 |
| Adaptive Capacity (Lack) | Naungan | 0.06437 |
| Exposure | Naungan | 0.08879 |
| Vulnerability | Naungan | 0.32726 |

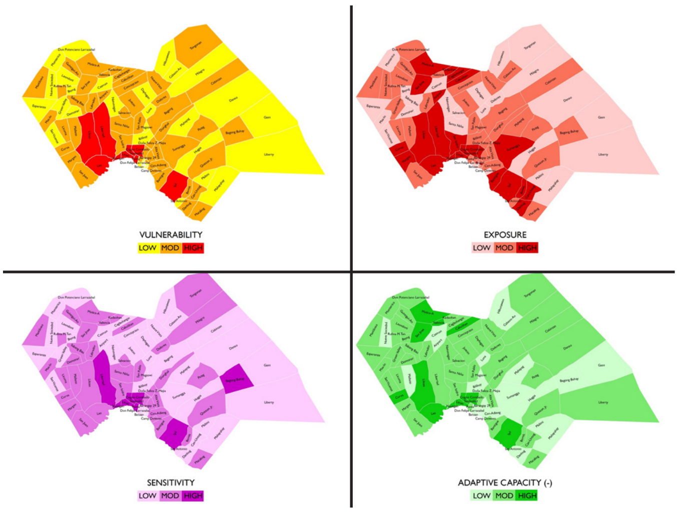


**Figure 6**. Social vulnerability, sensitivity, adaptive capacity, and exposure maps of Ormoc City, per barangay.

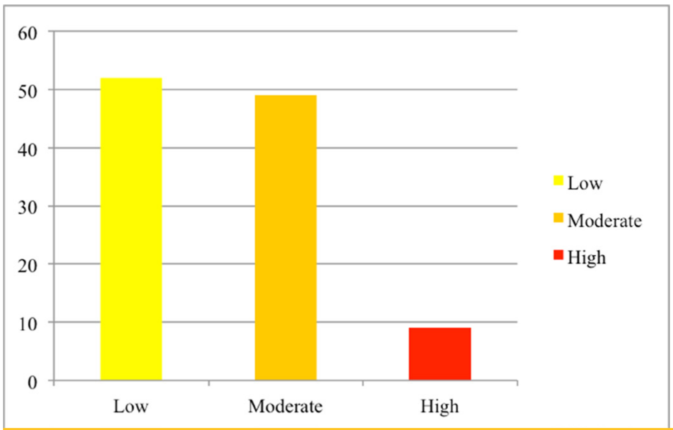


**Figure 7**. Number of barangays in Ormoc City per degree of vulnerability.

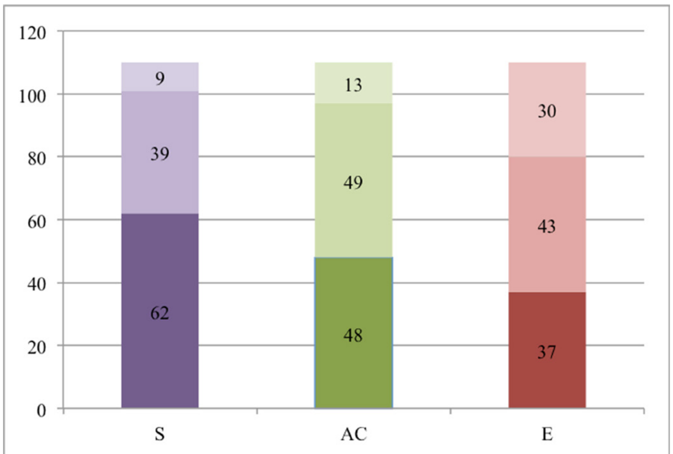


**Figure 8**. Number of barangays in Ormoc City per degree of sensitivity, adaptive capacity, and exposure. Lightest to darkest color denotes low to high index.

## Sensitivity

Out of the 9 barangays with high sensitivity, Barangay Cogon Combado is the area most sensitive to disasters because it is the most densely populated barangay in Ormoc City; it scored 0.19014. The other barangays with high sensitivity are Tambuilid, Naungan, Linao, Ipil, Punta, Libertad, Bagong Buhay, and Liloan, which are either coastal communities or barangays with large population.

There were 39 barangays with moderate sensitivity. Barangay 14 registered the lowest sensitivity sub-index among the 62 barangays which have low sensitivity index. This is likely due to the low numbers of population at risk because Barangay 14 is in the poblacion (town center) district and not a residential area. All the poblacion barangays have low sensitivity.

### Exposure

Past disasters could validate that Ormoc is at risk to natural hazards such as flooding and landslide (Figure 9). Thirty barangays have high exposure, with Barangay Naungan having the highest with 0.08879. As a coastal community also traversed by Jaoban River, it has very high susceptibility to flooding and is most likely to be affected by storm surges. The other barangays with high exposure index are its neighboring barangays and 7 poblacion barangays which are near Anilao River. The remaining 43 barangays have moderate exposure index and the 37 barangays have low.

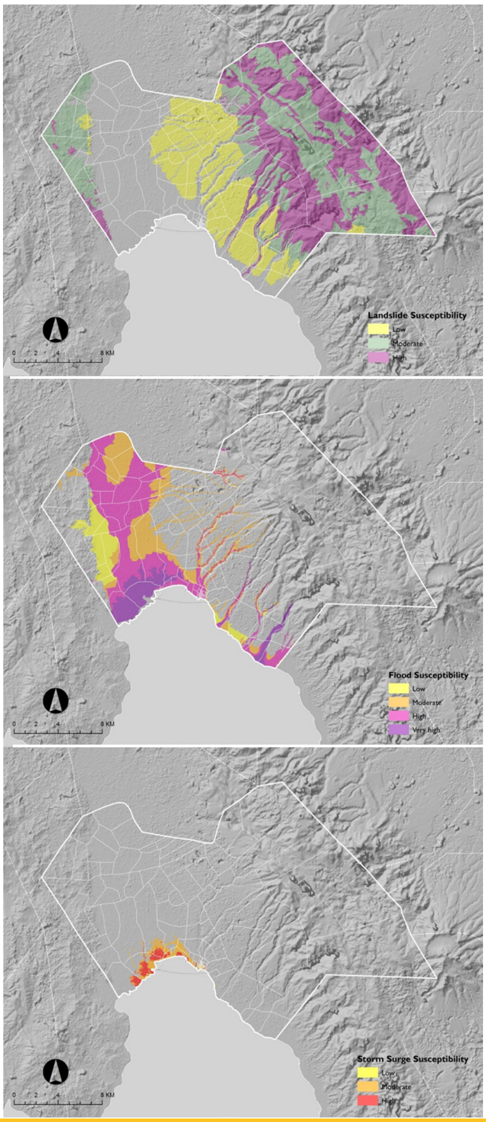


**Figure 9**. Landslide, flood and storm surge susceptibility maps of Ormoc City.

### Adaptive Capacity

Ormoc, though highly urbanized like Tacloban, have more families living below poverty threshold. Therefore, more barangays in Ormoc have high adaptive capacity index. About 13 barangays in Ormoc have high adaptive capacity index (Figure 8). Naungan has the highest adaptive capacity index, perhaps due to the large number of informal settlers in the area. Most of these informal settlers live in stilt houses over the water, while the rest live in houses that are usually submerged during the high tide. The 49 barangays that have moderate adaptive capacities are the rural barangays engaged in fishing and subsistence farming, aside from Barangay 29 which is a poblacion barangay but has residents living under Anilao Bridge. More than half of the remaining 48 barangays that have low adaptive capacity index are located within the poblacion area. These areas are commercialized with only a few residents. Inadequacy in adaptive capacity due to poverty is observed to be higher in Barangay Naungan with index of 0.06437 as compared to the other barangays.

## Conclusion and Recommendation

Typhoon Haiyan highlighted that the combination of exposure to climate-related hazards, underlying socioeconomic conditions, and changing demographic characteristics in Tacloban and Ormoc increases the threats of climate-related hazards to communities. Haiyan's impacts would require the examination of the various causes of vulnerability to facilitate measures to reduce these causes or adapt from the combined factors of disasters.

Barangay 88, said to be the hardest hit barangay in Tacloban City by Typhoon Haiyan, is consistently highest in the city in all factors of vulnerability, recording a large differential vulnerability index relative to other barangays. Tacloban has 9 barangays with high vulnerability index. Unfortunately, there is no official data on the number of deaths per barangay due to Typhoon Haiyan in Tacloban City that can be used to validate the computed vulnerability scores.

In Ormoc City, Barangay Naungan, located in the western seaboard of the City, got the highest vulnerability index. Ormoc has 9 barangays with high social vulnerability scores, which are lower than those of Tacloban. The barangays with high overall social vulnerability are also those with high sensitivity indices, with population at risk as the main factor contributing to their vulnerability. However, no association can be established between the vulnerability score and the impact of Typhoon Haiyan as represented by the number of deaths per barangay (see Annex 1). This could be attributed to other factors not considered by the study such as the use of pairwise index in evaluating the weights of the sub-indicators. Furthermore, Ormoc City is located in the southwestern portion of the Leyte Island and only experienced strong winds, which this study was not able to evaluate. Typhoon Haiyan hit the hardest in Eastern Leyte and passed though the province in a northeast direction.

While Tacloban City and Ormoc City are examples of a looming and varying social vulnerability across barangays, it is important not only to consider short-term structural mitigation measures but also to adopt sustainable and long-term strategies addressing the underlying factors of vulnerability targeted at the community level. This matter will also require basic social services to be more accessible in barangays who score moderate to high vulnerability. Measures to reduce vulnerability should be a local priority and would require political will for community-based climate action, disaster risk reduction and management, and risk-sensitive land use development.

This study provides an approach for assessing social vulnerability using available census and climate-related hazard data to determine areas for intervention targeted at the barangay level. Future related research should consider other key indicators available at the barangay level to capture a more precise vulnerability index.

## Annexes

**Annex 1**: Comparisons of vulnerability level, index, exposure and number of deaths per barangay for Ormoc City.

| Barangay | Vulnera-bility Level | Vulnera-bility Index | Highly Exposed to | No. of Deaths due to Hai-yan* |
|---|---|---|---|---|
| Airport | moderate | 0.08785 | riverine flooding | 2 |
| Alegria | moderate | 0.06788 | storm surge & riverine flooding | 0 |
| Alta Vista | moderate | 0.09294 | riverine flooding | 1 |
| Bagong Buhay | moderate | 0.15142 | landslide & flash-flood | 2 |
| Bagong | moderate | 0.07628 | landslide & flash-flood | 1 |
| Bantigue | moderate | 0.15385 | storm surge | 0 |
| Barangay 1 (Pob.) | low | 0.01386 | riverine flooding | 0 |
| Barangay 10 (Pob.) | low | 0.1971 | riverine flooding | 0 |
| Barangay 11 (Pob.) | moderate | 0.07361 | riverine flooding | 0 |
| Barangay 12 (Pob.) | low | 0.02257 | riverine flooding | 0 |
| Barangay 13 (Pob.) | low | 0.04069 | riverine flooding | 0 |
| Barangay 14 (Pob.) | low | 0.02251 | riverine flooding | 0 |
| Barangay 15 (Pob.) | low | 0.05439 | riverine flooding | 0 |
| Barangay 16 (Pob.) | low | 0.03704 | riverine flooding | 0 |
| Barangay 17 (Pob.) | low | 0.02823 | riverine flooding | 0 |
| Barangay 18 (Pob.) | low | 0.01361 | riverine flooding | 0 |
| Barangay 19 (Pob.) | low | 0.01684 | riverine flooding | 0 |
| Barangay 2 (Pob.) | low | 0.02637 | riverine flooding | 0 |
| Barangay 20 (Pob.) | low | 0.03240 | riverine flooding | 0 |
| Barangay 21 (Pob.) | low | 0.04844 | riverine flooding | 0 |
| Barangay 22 (Pob.) | low | 0.05057 | riverine flooding | 0 |
| Barangay 23 (Pob.) | low | 0.05257 | riverine flooding | 0 |
| Barangay 24 (Pob.) | low | 0.04885 | riverine flooding | 0 |
| Barangay 25 (Pob.) | low | 0.05947 | riverine flooding | 0 |
| Barangay 26 (Pob.) | moderate | 0.07102 | riverine flooding | 1 |
| Barangay 27 (Pob.) | low | 0.03519 | riverine flooding | 0 |
| Barangay 28 (Pob.) | moderate | 0.07474 | riverine flooding | 0 |
| Barangay 29 (Pob.) | moderate | 0.13147 | riverine flooding | 0 |
| Barangay 3 (Pob.) | low | 0.00463 | riverine flooding | 0 |
| Barangay 4 (Pob.) | low | 0.02466 | riverine flooding | 0 |
| Barangay 5 (Pob.) | low | 0.00393 | riverine flooding | 0 |
| Barangay 6 (Pob.) | low | 0.00735 | riverine flooding | 0 |
| Barangay 7 (Pob.) | low | 0.00839 | riverine flooding | 0 |
| Barangay 8 (Pob.) | low | 0.00609 | riverine flooding | 0 |
| Barangay 9 (Pob.) | low | 0.00811 | riverine flooding | 0 |
| Batuan | low | 0.02924 | riverine flooding | 0 |
| Bayog | low | 0.05176 | riverine flooding | 0 |
| Biliboy | low | 0.05367 | flooding | 0 |

| Barangay | Vulnera-bility Level | Vulnera-bility Index | Highly Exposed to | No. of Deaths due to Hai-yan* |
|---|---|---|---|---|
| Boroc (Don Carlos Rivilla) | moderate | 0.12073 | | 1 |
| Ca-baon-an | low | 0.04164 | landsline & flash-flood | 0 |
| Cabintan | moderate | 0.08457 | landslide | 0 |
| Cabuli-han | moderate | 0.08533 | landslide & riverine flooding | 0 |
| Cagbu-hangin | moderate | 0.08473 | landslide & riverine flooding | 0 |
| Camp Downes | moderate | 0.08473 | landslide & riverine flooding | 0 |
| Can-adi-eng | moderate | 0.10348 | riverine flooding | 0 |
| Catmon | low | 0.09086 | landslide & riverine flooding | 0 |
| Cogon Combado | high | 0.03343 | riverine flooding | 0 |
| Concep-cion | moderate | 0.28843 | riverine flooding | 0 |
| Curva | moderate | 0.07210 | riverine flooding | 10 |
| Danao | low | 0.13312 | riverine flooding | 0 |
| Danhug | moderate | 0.08139 | storm surge & riverine flooding | 0 |
| Dayha-gan | low | 0.04754 | landslide & riverine flooding | 2 |
| Dolores | moderate | 0.08383 | riverine flooding | 1 |
| Domonar | low | 0.06482 | riverine flooding | 0 |
| Don Felipe Larraza-bal | moderate | 0.08289 | landslide | 0 |
| Dn Po-tenciano Larraza-bal | low | 003793 | landslide & flooding | 0 |
| Doña Feliza Z. Meija | moderate | 0.11771 | riverine flooding | 0 |
| Donghol | moderate | 0.08141 | riverine flooding | 0 |

| Barangay | Vulnera-bility Level | Vulnera-bility Index | Highly Exposed to | No. of Deaths due to Hai-yan* |
|---|---|---|---|---|
| Esper-anza | low | 0.01924 | landslide | 0 |
| Gaas | low | 0.02217 | landslide & flash-flood | 0 |
| Green Valley | low | 0.05977 | riverine flooding | 1 |
| Guin-tigui-an | moderate | 0.09171 | riverine flooding | 0 |
| Hibun-awon | low | 0.04108 | landslide & flash-flood | 0 |
| Hugpa | low | 0.02699 | NA | 0 |
| Ipil | high | 0.24413 | storm surge | 0 |
| Juaton | moderate | 0.07426 | riverine flooding | 0 |
| Kadao-han | moderate | 0.09428 | landslide & riverine flooding | 0 |
| Labrador (Balion) | moderate | 0.08146 | riverine flooding | 0 |
| Lao | high | 0.18155 | storm surge | 0 |
| Leondoni | low | 0.04938 | riverine flooding | 0 |
| Libertad | high | 0.18857 | storm surge | 1 |
| Liberty | low | 0.03215 | landslide & flash-flood | 0 |
| Licuma | moderate | 0.07499 | riverine flooding | 0 |
| Liloan | high | 0.18401 | storm surge | 2 |
| Linao | high | 0.25736 | storm surge | 1 |
| Luna | low | 0.04415 | riverine flooding | 0 |
| Mabato | moderate | 0.1000 | riverine flooding | 0 |
| Mabini | low | 0.05082 | landslide & flash-flood | 0 |
| Macabug | moderate | 0.10435 | storm surge | 0 |
| Magaswe | low | 0.03606 | riverine flooding | 0 |
| Mahayag | low | 0.04022 | riverine flooding | 0 |
| Mahaya-hay | low | 0.03115 | landslide & flash-food | 0 |

| Barangay | Vulnerability Level | Vulnerability Index | Highly Exposed to | No. of Deaths due to Haiyan* |
|---|---|---|---|---|
| Manlilinao | moderate | 0.07316 | landslide | 0 |
| Margen | moderate | 0.12990 | landslide & riverine flooding | 1 |
| Mas-in | moderate | 0.06948 | landslide | 0 |
| Matica-a | moderate | 0.12063 | landslide & riverine flooding | 1 |
| Milagro | low | 0.06632 | landslide & flash-flood | 0 |
| Monterico | low | 0.03772 | landslide | 0 |
| Nasunogan | low | 0.05052 | riverine flooding | 1 |
| Naungan | high | 0.32726 | strom surge & riverine flooding | 1 |
| Nueva Sociedad | low | 0.04133 | NA | 0 |
| Nueva Vista | moderate | 0.06979 | riverine flooding | 2 |
| Patag | moderate | 0.10018 | NA | 1 |
| Punta | high | 0.19365 | storm surge & riverine flooding | 0 |
| Quezon, Jr. | moderate | 0.08708 | riverine flooding | 0 |
| Rufina M. Tan | moderate | 0.08743 | landslide & riverine flooding | 0 |
| Sabang Bao | moderate | 0.07681 | riverine flooding | 0 |
| Salvacion | moderate | 0.09689 | riverine flooding | 0 |
| San Antonio | low | 0.05364 | storm surge & riverine flooding | 0 |
| San Isidro | moderate | 0.13146 | riverine flooding | 0 |
| San Jose | moderate | 0.15853 | landslide & riverine flooding | 0 |
| San Juan | moderate | 0.07650 | storm surge & riverine flooding | 0 |
| San Pablo (Simangan) | moderate | 0.13378 | riverine flooding | 0 |

| Barangay | Vulnerability Level | Vulnerability Index | Highly Exposdd to | No. of Deaths due to Haiyan* |
|---|---|---|---|---|
| San Vicenter | low | 0.04400 | landslide | 0 |
| Santo Niño | moderate | 0.09484 | riverine flooding | 0 |
| Sumangga | moderate | 0.08423 | riverine flooding | 0 |
| Tambulilid | low | 0.28127 | storm surge & riverine flooding | 2 |
| Tongonan | moderate | 0.07163 | landslide | 0 |
| Valencia | moderate | 0.16252 | riverine flooding | 0 |

[a]City Health Office-Health Emergency Management Staff (CHO-HEMS), Ormoc City

**Annex 2**:Vulnerability level, vulnerability index, and exposure level per barangay for Tacloban City

| Barangay | Vulnerability Level | Vulnerability Index | Exposure Level |
|---|---|---|---|
| Barangay 2 | low | 0.03711 | moderate |
| Barangay 5 | low | 0.02299 | low |
| Barangay 5-A | low | 0.01646 | low |
| Barangay 6 | low | 0.06986 | low |
| Barangay 6-A | low | 0.08478 | low |
| Barangay 7 | low | 0.01922 | low |
| Barangay 8 | low | 0.01827 | low |
| Barangay 8-A | low | 0.01549 | low |
| Barangay 100 | moderate | 0.21673 | moderate |
| Barangay 101 | moderate | 0.10727 | high |
| Barangay 102 | low | 0.06355 | low |
| Barangay 103 | high | 0.26579 | moderate |
| Barangay 103-A | low | 0.09772 | moderate |
| Barangay 104 | moderate | 0.18604 | moderate |
| Barangay 105 | moderate | 0.14059 | moderate |
| Barangay 106 | moderate | 0.12677 | high |
| Barangay 107 | moderate | 0.11479 | moderate |
| Barangay 108 | moderate | 0.1134 | moderate |
| Barangay 109 | moderate | 0.11885 | low |
| Barangay 109-A | moderate | 0.19379 | moderate |
| Barangay 110 | high | 0.29659 | moderate |
| Barangay 12 | moderate | 0.14724 | moderate |
| Barangay 13 | low | 0.04870 | moderate |
| Barangay 14 | low | 0.02080 | low |
| Barangay 15 | low | 0.01010 | low |
| Barangay 16 | low | 0.00749 | low |

| Barangay | Vulnerability Level | Vulnerability Index | Exposure Level |
|---|---|---|---|
| Barangay 17 | low | 0.01211 | low |
| Barangay 18 | low | 0.01391 | low |
| Barangay 19 | low | 0.01750 | low |
| Barangay 20 | low | 0.02621 | low |
| Barangay 21 | low | 0.01259 | low |
| Barangay 21- A | low | 0.01260 | low |
| Barangay 22 | low | 0.01500 | low |
| Barangay 23 | low | 0.02670 | low |
| Barangay 23-A | low | 0.03406 | low |
| Barangay 24 | low | 0.03739 | low |
| Barangay 25 | low | 0.09707 | moderate |
| Barangay 26 | low | 0.02575 | low |
| Barangay 27 | low | 0.01580 | low |
| Barangay 28 | low | 0.02083 | low |
| Barangay 29 | low | 0.01325 | low |
| Barangay 30 | low | 0.00903 | low |
| Barangay 31 | low | 0.05402 | low |
| Barangay 32 | low | 0.01648 | low |
| Barangay 33 | low | 0.01327 | low |
| Barangay 34 | low | 0.02129 | low |
| Barangay 35 | low | 0.01706 | low |
| Barangay 35-A | low | 0.07173 | low |
| Barangay 36 | low | 0.06522 | moderate |
| Barangay 36-A | low | 0.03831 | low |
| Barangay 37 | low | 0.28076 | moderate |
| Barangay 37-A | moderate | 0.11399 | moderate |
| Barangay 38 | low | 0.02877 | low |
| Barangay 39 | moderate | 0.18749 | moderate |
| Baragay 40 | low | 0.01479 | low |
| Barangay 41 | low | 0.01716 | low |
| Barangay 42 | low | 0.06566 | low |
| Barangay 42-A | moderate | 0.11472 | low |
| Barangay 43 | low | 0.03159 | low |
| Barangay 43-A | low | 0.06915 | low |
| Barangay 43-B | moderate | 0.13364 | moderate |
| Barangay 44 | low | 0.02740 | low |
| Barangay 44-A | low | 0.01278 | low |
| Barangay 45 | low | 0.04316 | moderate |
| Barangay 46 | low | 0.03581 | low |
| Barangay 47 | low | 0.03517 | low |
| Barangay 48 | low | 0.02361 | low |

| Barangay | Vulnerability Level | Vulnerability Index | Exposure Level |
|---|---|---|---|
| Barangay 48-A | low | 0.05200 | low |
| Barangay 48-B | low | 0.04867 | low |
| Barangay 49 | moderate | 0.10501 | moderate |
| Barangay 50 | low | 0.04541 | moderate |
| Barangay 50-A | low | 0.06230 | moderate |
| Barangay 50-B | low | 0.06625 | moderate |
| Barangay 51 | low | 0.03752 | low |
| Barangay 51-A | low | 0.03478 | low |
| Barangay 52 | moderate | 0.13886 | high |
| Barangay 53 | low | 0.04306 | low |
| Barangay 54 | low | 0.08507 | moderate |
| Barangay 54-A | low | 0.09310 | moderate |
| Barangay 56 | low | 0.08555 | moderate |
| Barangay 56-A | low | 0.06237 | moderate |
| Barangay 57 | low | 0.7275 | low |
| Barangay 58 | low | 0.06525 | low |
| Barangay 59 | moderate | 0.13905 | low |
| Barangay 59-A | moderate | 0.17042 | low |
| Barangay 59-B | low | 0.04785 | low |
| Barangay 60 | low | 0.04741 | low |
| Barangay 60-A | moderate | 0.11937 | low |
| Barangay 61 | low | 0.07855 | low |
| Barangay 62 | moderate | 0.11849 | low |
| Barangay 62-A | moderate | 0.21872 | low |
| Barangay 62-B | low | 0.06849 | low |
| Barangay 63 | moderate | 0.16040 | moderate |
| Barangay 64 | moderate | 0.11326 | moderate |
| Barangay 65 | low | 0.08539 | low |
| Barangay 66 | moderate | 0.11216 | moderate |
| Barangay 66 | moderate | 0.11216 | moderate |
| Barangay 66-A | moderate | 0.11326 | moderate |
| Barangay 67 | moderate | 0.15057 | high |
| Barangay 68 | moderate | 0.20725 | high |
| Barangay 69 | moderate | 0.20741 | high |
| Barangay 70 | moderate | 0.13941 | high |
| Barangay 71 | moderate | 0.23353 | high |
| Barangay 72 | low | 0.08595 | high |
| Barangay 73 | low | 0.08052 | high |

| Barangay | Vulnerability Level | Vulnerability Index | Exposure Level |
|---|---|---|---|
| Barangay 74 | high | 0.36425 | high |
| Barangay 75 | low | 0.09240 | high |
| Barangay 76 | low | 0.05999 | moderate |
| Barangay 77 | moderate | 0.10745 | moderate |
| Barangay 78 | moderate | 0.10824 | moderate |
| Barangay 79 | moderate | 0.16567 | high |
| Barangay 80 | low | 0.05063 | moderate |
| Barangay 81 | low | 0.07812 | moderate |
| Barangay 82 | low | 0.06379 | low |
| Barangay 83 | moderate | 0.12186 | moderate |
| Barangay 83-A | moderate | 0.10225 | moderate |
| Barangay 83-B | moderate | 0.18425 | moderate |
| Barangay 83-C | moderate | 0.18361 | moderate |
| Barangay 84 | high | 0.27474 | high |
| Barangay 85 | moderate | 0.11136 | moderate |
| Barangay 86 | moderate | 0.10646 | moderate |
| Barangay 87 | moderate | 0.13132 | moderate |
| Barangay 88 | high | 0.66792 | high |
| Barangay 89 | high | 0.34450 | high |
| Barangay 90 | moderate | 0.13461 | high |
| Barangay 91 | moderate | 0.18401 | moderate |
| Barangay 92 | moderate | 0.22149 | high |
| Barangay 93 | high | 0.26810 | moderate |
| Barangay 94 | moderate | 0.17355 | moderate |
| Barangay 94-A | moderate | 0.16367 | high |
| Barangay 95 | moderate | 0.18215 | moderate |
| Barangay 95-A | moderate | 0.24304 | high |
| Barangay 96 | moderate | 0.22288 | moderate |
| Barangay 97 | moderate | 0.19934 | moderate |
| Barangay 98 | moderate | 0.13117 | low |
| Barangay 99 | high | 0.39874 | high |
| El Reposo | low | 0.03813 | low |
| Barangay | Vulnerability Level | Vulnerability Index | Exposure Level |
| Libertad | low | 0.09325 | moderate |
| Nula-tula | moderate | 0.00000 | moderate |

## References


Asuero, M. P., Nelson, G. L. M., Espaldon, M. V. O., Acosta, L. A., Macandog, D. M., Lalican, N. M., Talubo, J. P. P. (2012). Social characteristics and vulnerabilities of disaster-prone communities in Infanta, Quezon, Philippines. *Journal of Environmental Science and Management*, 15(2), 19–34.

Balica, S. F., Wright, N. G., & Meulen, F. van der. (2012). A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Natural Hazards*, 64(1), 73–105. http://doi.org/10.1007/s11069-012-0234-1

Bolin, R., & Bolton, P. (1986). Race, religion, and ethnicity in disaster recovery (Disaster Recovery, Program on Environment and Behavior Monograph No. 42). Boulder, CO: Institute of Behavioral Science, University of Colorado.

Bolin, R., & Stanford, L. (1991). Shelter, Housing and Recovery: A Comparison of U.S. *Disasters. Disasters*, 15(1), 24–34. http://doi.org/10.1111/j.1467-7717 .1991.tb00424.x

Burton, I., Kates, R. W., & White, G. F. (1993). *The Environment As Hazard* (Second Edition). New York: The Guilford Press.

Cannon, T. (1994). Vulnerability analysis and the explanation of "natural" disasters. In *A. Varley (Ed.), Disasters, Development and Environment* (pp. 13–30). Chichester: Wiley.

Community-Based Monitoring System Network. (2011a). *Ormoc City CBMS*. Manila, Philippines: De La Salle University - Angelo King Institute for Economic and Business Studies.

Community-Based Monitoring System Network. (2011b). T*acloban City CBMS: The Many Faces of Tacloban*. Manila, Philippines: De La Salle University - Angelo King Institute for Economic and Business Studies.

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social Science Quarterly,* 84(2), 242–261. http://doi.org/10.1111/1540-6237.8402002

Cutter, S. L., & Corendea, C. (2013). *From social vulnerability to resilience: measuring progress toward disaster risk reduction*. UNU- EHS. Retrieved from http://collections.unu.edu/view/UNU:1885

Cutter, S. L., Emrich, C. T., Webb, J. J., & Morath,D. (2009). Social vulnerability to climate variability hazards: A review of the literature. *Final Report to Oxfam America, 5*. Retrieved from http://www.mfpp.org/Climate_Solutions_University/pluginfile.php/171/mod_resource/content/0/Literature_Review.pdf

Cutter, S. L., & Finch, C. (2008). Temporal and spatial changes in social vulnerability to natural hazards. *Proceedings of the National Academy of Sciences*, 105(7), 2301–2306. http://doi.org/10.1073/pnas.0710375105

Cutter, S. L., Johnson, L. A., Finch, C., & Berry, M. (2007). The U.S. hurricane coasts: Increasingly vulnerable? *Environment: Science and Policy for Sustainable Development*, 49(7), 8–21. http://doi.org/10.3200/ENVT.49.7.8-21

Cutter, S. L., Mitchell, J. T., & Scott, M. S. (2000). Revealing the Vulnerability of People and Places: A Case Study of Georgetown County, South Carolina. *Annals of the Association of American Geographers*, 90(4), 713–737. http://doi.org/10.1111/0004-5608.00219

Godschalk, D. R., Brower, D. J., & Beatley, T. (1989). *Catastrophic Coastal Storms: Hazard Mitigation and Development Management.* Duke University Press.

H. John Heinz III Center for Science, Economics, and the Environment. (2000). *The Hidden Costs of Coastal Hazards: Implications For Risk Assessment And Mitigation*. Washington, D.C.: Island Press.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global Environmental Change*, 19(1), 74–88. http://doi.org/10.1016/j.gloenvcha.2008.11.002

Hammill, A., Bizikova, L., Dekens, J., & McCandless, M. (2013). *Comparative analysis of climate change vulnerability assessments: Lessons from Tunisia and Indonesia*. Eschborn, Germany: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://gc21.giz.de/ibt/var/app/wp342deP/1443/wp-content/uploads/filebase/va/vulnerability-guides-manuals-reports/Comperative-analysis-of-climate-change-vulnerability-assessments.pdf

Hewitt, K. (1997). *Regions of Risk: A Geographical Introduction to Disasters. Routledge*

IPCC. (2007). Climate Change 2007: *Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (Core Writing Team, R. K. Pachauri, & A. Reisinger, Eds.). IPCC, Geneva, Switzerland: Intergovernmental Panel on Climate Change.

Mileti, D. (1999). *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Joseph Henry Press.

Mitchell, J. K., Abdel-Ghaffar, A. M., Gentry, R. C., Leatherman, S. P., & Sparks, P. (1986). *Hurricane Diana, North Carolina*: September 10-14, 1984. National Research Council. Retrieved from http://hdl.handle.net/2027/uiug.30112104066565

Morrow, B. H. (1999). Identifying and mapping community vulnerability. *Disasters*, 23(1), 1–18. http://doi.org/10.1111/1467-7717.00102

National Disaster Risk Reduction and Management Council. (2014). *NDRRMC Update, SitRep No. 108, Effect of Typhoon "Yolanda" (Haiyan)*. Quezon City, Philippines. Retrieved from http://www.ndrrmc.gov.ph/attachments/article/1329/Effects_of_Typhoon_YOLANDA_(HAIYAN)_SitRep_No_108_03APR2014.pdf

National Statistical Coordination Board. (2010). Poverty Statistics. Makati City, Philippines.

National Statistical Coordination Board. (2012). Poverty Statistics. Makati City, Philippines.

National Statistics Office. (2007). Population Data. Quezon City, Philippines.

National Statistics Office. (2010). Population Data. Quezon City, Philippines.

Ngo, E. B. (2001). When disasters and age collide: reviewing vulnerability of the elderly. *Natural Hazards Review*, 2(2), 80–89. http://doi.org/10.1061/(ASCE)1527-6988(2001)2:2(80)

O'Brien, P., & Mileti, D. (1992). Citizen participation in emergency response following the Loma Prieta earthquake. *International Journal of Mass Emergencies and Disasters*, 10(1), 71–89.

Peacock, W. G., Gladwin, H., & Morrow, B. H. (1997). *Hurricane Andrew: Ethnicity, Gender and the Sociology of Disasters*. Routledge.

Platt, R. H. (1991). Lifelines: An emergency management priority for the United States in the 1990s. *Disasters*, 15(2), 172–176. http://doi.org/10.1111/j.1467-7717.1991.tb00446.x

Puente, S. (1999). Social vulnerability to disasters in Mexico City: An assessment method. In J. K. Mitchell (Ed.), *Crucibles of hazard: Mega-cities and disasters in transition* (p. 535). Tokyo: UNU Press. Retrieved from http://collections.unu.edu/eserv/UNU:2385/nLib9280809873.pdf

Sullivan, C. A., Meigh, J. R., & Fediw, T. S. (2002). *Derivation and Testing of the Water Poverty Index Phase 1*. Final Report May 2002 (Report to Department for International Development, Centre for Ecology and Hydrology, Wallingford, UK.).

Thomas, D. S. K., Philipps, B. D., Lovekamp, W. E., & Fothergill, A. (Eds.). (2013). *Social Vulnerability to Disasters, Second Edition* (Second Edition). Boca Raton: CRC Press.

Tobin, G., & Ollenburger, J. (1992). *Natural hazards and the elderly*. Natural Hazards Research and Applications Information Center, University of Colorado. Retrieved from http://scholarcommons.usf.edu/fmhi_pub/16

Uitto, J. I. (1998). The geography of disaster vulnerability in megacities: A theoretical framework. *Applied Geography*, (1), 7–16. http://doi.org/10.1016/S0143-6228(97)00041-6

United Nations Development Programme. (2014). *Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience* (Human Development Report 2014.).

United Nations International Strategy for Disaster Reduction. (2009). *2009 UNISDR terminology on disaster risk reduction*.

White, G., & Haas, J. E. (1975). *Assessment of Research on Natural Hazards*. Cambridge, Mass: The MIT Press.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). *At Risk: Natural Hazards, People's Vulnerability, and Disaster* (Second Edition). London: Routledge.

WWF & BPI. (2013). *Business Risk Assessment and the Management of Climate Change Impacts*. Retrieved from http://wwf.org.ph/wwf3/downloads/publications/Business%20Risk%20Assessment%20and%20the%20Management%20of%20Climate%20Change%20Impacts%20-%2012%20Cities.pdf

Yusuf, A. A., & Francisco, H. (2009). Climate Change *Vulnerability Mapping for Southeast Asia* (EEPSEA Special and Technical Paper No. tp200901s1). Economy and Environment Program for Southeast Asia (EEPSEA). Retrieved from https://ideas.repec.org/p/eep/tpaper/tp200901s1.html

Zahran, S., Brody, S. D., Peacock, W. G., Vedlitz, A., & Grover, H. (2008). Social vulnerability and the natural and built environment: a model of flood casualties in Texas. *Disasters*, 32(4), 537–560. http://doi.org/10.1111/j.1467-7717.2008.01054.x