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Perceptions of Typhoon Haiyan-affected communities about the resilience and storm protection function of mangrove ecosystems in Leyte and Eastern Samar, Philippines

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Abstract

The destruction caused by Typhoon Haiyan in the coastal areas of central Philippines drew greater international attention to the vulnerability of coastal communities to extreme weather and climate events. Mangrove ecosystems enhance coastal resilience by acting as barriers against storms and its impacts. However, given the strength of and damage brought by Typhoon Haiyan, the extent to which mangroves and coastal vegetation can reduce the impacts of waves caused by storm surge has emerged as a salient issue. Drawing on the results of a survey of 870 households; focus group discussions with community members; and interviews with representatives from government agencies, nongovernment organizations, people's organizations, and communities, the study examines local perceptions on whether or not mangroves played a role in reducing the impacts brought by Typhoon Haiyan in five affected municipalities and cities. It explores how peoples' perception of the coastal protection function of mangroves differed according to the state of mangroves—in terms of area, width, and species richness—validated through vegetation surveys. It also identifies insights on how community participation may help improve coastal rehabilitation and management strategies. In general, the respondents were aware of and appreciated the functions performed by the mangrove forests in protecting their lives and properties from Typhoon Haiyan. However, the participation involvement of local communities in mangrove rehabilitation and management remains low. Community awareness needs to be improved and residents must be encouraged to participate in mangrove rehabilitation and management. This study complements existing studies that show the ability of mangroves and coastal vegetation in attenuating storm surges, the factors that affect the level of protection, the limitations of this function, and the need for further studies that will look more closely into these crucial factors.

Keywords: social perception · resilience · storm protection · mangrove ecosystems · Typhoon Haiyan · coastal communities

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Introduction

Ecosystems contribute to community resilience through their functions in provisioning of services and regulating the impacts of natural disasters (S. Das & Crépin, 2013; A. L. McIvor, Möller, Spencer, & Spalding, 2013; Saikia, Davis, & Ariyabandu, 2013; Zhang et al., 2012). Mangrove ecosystems provide coastal protection as well as diverse benefits that help enhance community resilience, including livelihood options such as tourism, transport, fishing, and other extractive uses (Alongi, 2008; Spalding et al., 2014; Thiaw & Munang, 2013).

The resilience of coastal communities to hazards is therefore extensively dependent on the health of the coastal ecosystem. Any artificial loss or damage could diminish an ecosystem's capacity to carry out its essential resilience-enhancing functions (Saikia et al., 2013). The decline of protective and regulatory functions reduces the ecosystem's capacity to reduce impacts of hazards. Disasters then consequently lead to further decline of ecosystems. The loss of resilience due to degraded ecosystems could, therefore, undermine local development and national economic growth (UNISDR, 2013). Corollary to this, community resilience may be enhanced by the regenerating and absorptive capacity of coastal ecosystems (Adger, 2000).

In the Philippines and around the world, mangrove ecosystems are threatened by human activities such as mismanaged aquaculture, forest extraction, and urban expansion (Primavera & Esteban, 2008). In addition, mangrove ecosystems are exposed to natural events such as typhoons, storm surges, and tsunamis. Pond culture is the major cause of mangrove losses in the Philippines (ASEAN Centre for Biodiversity, 2010). The country's total mangrove area was estimated to be 500,000 ha in the 1900s (Brown and Fisher, 1920 as cited by Melana, Melana, & Mapalo, 2000). It went down to 210,497 ha by 2008 (Department of Environment and Natural Resources, 2009). The total annual loss rate has been estimated at 0.52% between 1990 and 2010 (J. B. Long & Giri, 2011).

In November 2013, Typhoon Haiyan (locally known as Yolanda) wreaked havoc on the central part of the Philippines. Typhoon Haiyan is considered to be one of the most powerful typhoons to have made landfall in recorded history (David, Racoma, Gonzales, & Clutario, 2013; Lagmay et al., 2014). Storm surges, strong winds, and heavy rainfall resulted in over 6,200 deaths, more than 1,000 missing, and almost PhP89.5 billion worth of damages (National Disaster Risk Reduction and Management Council [NDRRMC], 2014).

In the aftermath of Typhoon Haiyan, plans to establish coastal greenbelts along the country's coasts have been put forward. The government launched a campaign for the rehabilitation of coastal areas. The case for coastal greenbelt establishment as a natural barrier against storm surge is supported by a number of studies (Badola & Hussain, 2005; Barbier et al., 2011; S. C. Das, Iimura, & Tanaka, 2011; S. Das & Vincent, 2009; A. L. McIvor et al., 2013; Zhang et al., 2012). Vegetation serves as an important source of friction to moving water, slowing down and reducing the size of waves brought by storms as they approach coastlines (Barbier et al., 2011; Liu, Hsu, & Wang, 2003). Others also studied the protection function of coastal vegetation against tsunamis (Bayas et al., 2011; Danielsen et al., 2005). The rule of thumb, according to Zhang et al. (2012), is that for every kilometer of dense mangrove, 0.5 meter is reduced in wave height (A. L. McIvor et al., 2013). Das and Crepin (2013) also established that mangroves can provide substantial protection to properties by attenuating impacts of strong cyclonic winds. However, the coastal protection function also depends on many other factors including the location, bathymetry, forest floor slope, and the properties of the storm itself (Engle, 2011; Koch et al., 2009; Tanaka, 2009).

There is growing understanding of the factors that affect the efficacy of the coastal protection function of mangroves. Improved understanding, based on empirical and scientific evidence, of its effectiveness and more importantly its limitations, will form part of a more holistic ecosystem rehabilitation and management (UNEP, 2014). Success of such initiatives will depend on how communities view or appreciate this function as well as the other services coastal ecosystems provide.

This study examines local communities' perception of the role of mangroves in reducing the impacts brought about by Typhoon Haiyan. It explores how the cause of damage, extent of housing damage, and the state of mangrove ecosystems played a role in the extent by which the mangroves were able to reduce the damages. It also identifies insights on community participation and how these may help inform coastal rehabilitation and management strategies.

Materials and Methods

Study Sites

We conducted the study in the cities of Tacloban and Ormoc, the municipality of Palo in Leyte, and the municipalities of General MacArthur and Quinapondan in Eastern Samar (Figure 1). All of the study sites are within 50-km radius from the storm's track. Leyte and Eastern Samar were among the provinces that suffered major losses and damages due to the impacts of storm surge and intense cyclonic winds.

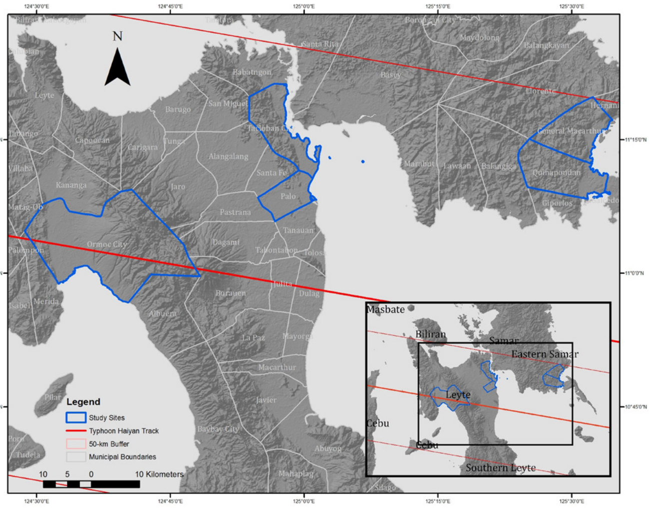

Figure 1. Location map of the selected cities and municipalities as sampling sites of the study.

Of the total area of the Philippines' mangrove forests, Leyte is estimated to have 2.26% and Eastern Samar with 2.18% (based on 256,185 ha total area estimate in 2000 by Long et al., 2014). Table 1 shows the total land area and estimated mangrove area per municipality. Among all the study sites, Ormoc City and Quinapondan have the highest estimated area of mangroves. Most of the communities of General MacArthur and Quinapondan along the Matarinao Bay have mangroves along the coastlines. In Tacloban and Palo, only small patches of mangrove remain along the coastlines (Carlos, Delfino, Juanico, David, & Lasco, 2015).

Table 1. General characteristics of the study sites.

General Characteristics *Location details*	Tacloban	Palo	Ormoc	Gen. Mac-Arthur	Quina-pondan
Total Land area (ha)[a]	20,172	22,127	61,360	8,324	11,729
Mangrove area (ha)[b]	170	125	1,463	1,085	432
Percent mangrove area	0.84	0.56	2.38	13.03	3.68
No. of houses destroyed[c,d]	12,270	11,607	34,228	2,403	11,185
No. of houses partly damaged[c,d]	46,553	3,741	14,983	1,857	

[a]National Statistics Coordination Board. Accessed last 14 Oct. 2014. [b] Estimated from Long et al., 2011 [c] National Disaster Risk Reduction and Management Council (2014) [d] Quinapondan and General MacArthur Post-disaster Needs Assessment

Tacloban and Ormoc are both highly populated coastal cities with 221,174 and 191,200 recorded inhabitants, respectively, while Palo has 62,727 (as of 2010). The population in Quinapondan and General Mac Arthur, on the other hand, are 13,841 and 12,214, respectively (Table 2). Due to its geography and proximity to the eye of the storm, Tacloban City and Palo suffered the highest fatalities during Typhoon Haiyan, reporting 2,678 and 902 deaths respectively, while Ormoc City reported 37 deaths (Lagmay et al., 2014).

Table 2. Population of the study sites and number of affected families by Typhoon Haiyan.

Study Site	Population[a]	No. of Affected Families[b]	No. of Casualties [c]
Tacloban	221,174	58,823	2,678
Palo	62.727	15,481	902
Ormoc	191,200	64,637	37
Quinapondan	13,841	3,723	10
Gen. MacArthur	12,214	3,858	0

[a]National Statistics Office, 2010. [b]NDRRMC, 2014. [c]Lagmay et al., 2014

Interviews, Vegetation Survey and Analysis

Key informant interviews (KIIs), focus group discussions (FGDs), and household surveys were conducted to determine the perception of the people living along the coastlines about the presence of mangroves, extent of damage, and sense of security and well-being afforded by mangroves.

Semi-structured interviews with key officials from local government units (LGUs), national government agencies (Department of Natural Resources and the Department of Agriculture's Bureau of Fisheries and Aquatic Resources), and field offices (regional, provincial, and community level) were done to get an overview of the state of ecosystems as well as rehabilitation and management efforts in the study sites. A series of FGDs with local stakeholder groups i.e., LGUs at the municipal and village level (barangay, the smallest administrative unit in the Philippines), people's organizations (farmers and fisher folks associations; women, youth and elderly groups), local basic service providers (coastal and security patrols/volunteers), and nongovernment organizations in selected villages for each municipality were done to collect community level information and perception on mangroves and coastal ecosystems.

Semi-structured interviews were also done with residents of coastal communities. There were 26 villages selected in Tacloban, 6 in Palo, 31 in Ormoc, 5 in General MacArthur and 4 in Quinapondan with a 95% confidence level and different margins of error (Figure 2). These villages were chosen based on their coastal location, presence and/or absence of mangroves, the proximity of houses to water bodies and mangrove areas, and population exposed to hazards. Field enumerators selected households through a randomized field walk; assessing 1 household out of every 5 in the villages they were assigned. Households were assessed based on the criteria set until the target sample size for the municipality had been reached. The total sample size of 870 individuals from 5 municipalities and selected villages (Table 3) were interviewed. The questionnaire's themes revolved around the respondents' awareness and perceptions prior, during, and after the typhoon. The respondents, most of whom are household heads and permanent residents, were asked about their socioeconomic profile, the perceived protection functions of mangroves/coastal vegetation, and the activities and strategies conducted by the community, government and other organizations.

We tried to compare the extent of damage caused by Typhoon Haiyan in areas with and without mangrove forests. Firsthand information was collected by asking the respondents about the cause of damages and the extent of damage to their houses due to Typhoon Haiyan.

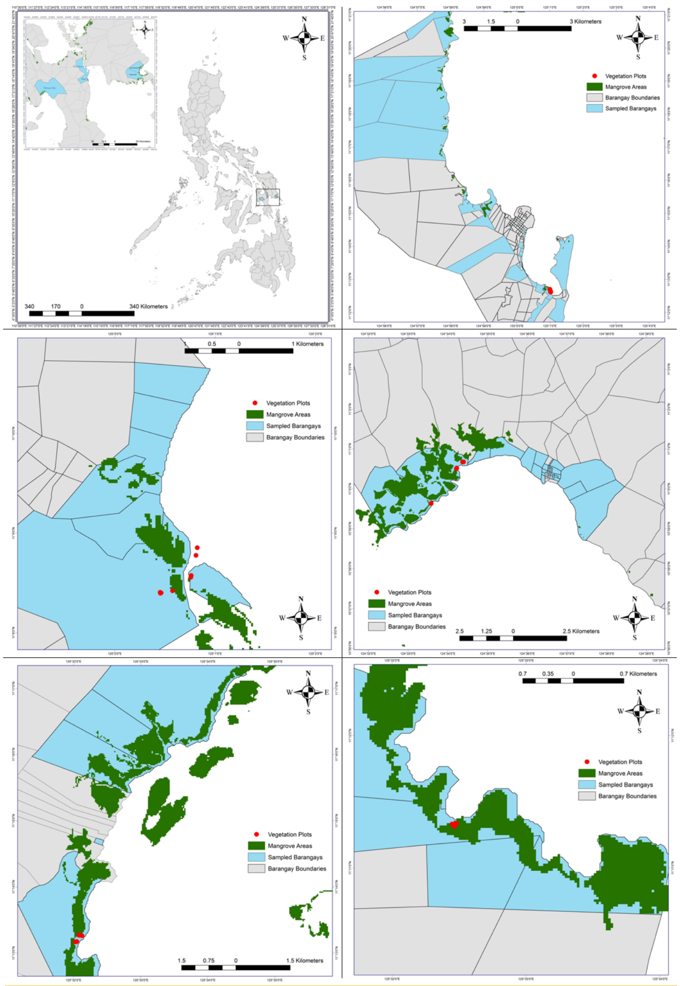

Figure 2. Figure 2. Maps showing location map (top left); and sampled barangays, location of vegetation plots in each of the study sites: Tacloban (top right), Palo (middle left), Ormoc (middle right): General MacArthur (bottom left), and Quinapondan (bottom right).

Table 3. Household samples per municipality.

City/ Municipality	Total # of Households	# of Selected Villages	# of Households in Selected Villages	# of Sample Households	Sampling Rate (%)
Tacloban	45,522	26	12,560	320	2.56
Palo	11,342	6	3,592	100	2.78
Ormoc	38,299	31	17,294	250	1.44
Gen. MacArthur	12,214	5	850	100	11.76
Quinapondan	13,841	4	545	100	18.35

Observations on the characteristics of the mangrove trees and seedlings were also considered. In addition, 36 circular plots at 3-m radius were established on the selected Typhoon Haiyan-affected natural growth mangroves in Tacloban City and Ormoc City in Leyte, mangroves and beach forest in Palo, and General MacArthur and Quinapondan along the Matarinao Bay coastline in Eastern Samar (see Figure 2 above). The plots were distributed and selected to consider variations in inundation levels within the mangrove areas as well as its proximity to the settlements. At least 8 plots were selected per city/municipality.

Data were analyzed using geographical information system software (ArcGIS) and Microsoft Access for cross-tabulating the results of the interviews with that of the vegetation survey. Awareness of the benefits and protection provided by mangroves as well as participation in rehabilitation and protection programs were measured categorically (yes/no) by asking respondents whether they think the mangroves can be beneficial, provided them a sense of security, and if they participated in the programs. The results were cross-tabulated with their characteristics: age, gender, resources taken, and level of housing damage due to Typhoon Haiyan. The percentage of surveyed residents that perceived that mangroves provided coastal protection were mapped and compared with the estimated mangrove area in hectares, estimated width of mangroves in meters and species richness in the study sites. The estimated mangrove area per hectare was based from Long et al. (2014). The estimated width and species richness were based from the on-the-ground vegetation surveys.

Results and Discussion

Table 4 shows the characteristics of the respondents of each site: average age, average number of years of residence, sources of income, and type of housing structures. The average age of residents is generally concentrated between 40 to 50 years old. Majority of the respondents are either small business owners or employed. Most lived in houses made of light materials, with only 14% living in permanent type of structures.

Table 4. General characteristics of the respondents.

General Characteristics	Tacloban	Palo	Ormoc	Gen. MacArthur	Quinapondan
Demographic characteristics					
Ave age of respondents	45.21	42.77	47.56	46.74	46.1
Ave # of years of residence	25.79	27.73	31.1	24.05	30.51
Source of Income (n)					
Business/ employemnt/others	250	70	193	38	39
Farming/livestock	15	7	9	23	21
Fishing	15	4	26	23	25
Multiple sources	32	18	8	4	10
Type of house (n)					
Light materials	112	39	103	69	61
Mixed materials	164	48	112	23	19
Permanent	44	13	35	8	15

Damage Attributed to Wind and Storm Surge

Majority (85%) of households reported that wind was one of the main causes of housing damage, followedby storm surge (37%) and flooding (18%) (Figure 3). Ormoc has the highest number of respondents (95%) that reported wind as the major cause of damage. The citywas along the track of the eye of the storm. General MacArthur (69%) and Quinapondan (82%), both within the 50-km distance from the storm track, also recorded high rates of damage due to wind. Storm surge and flooding were seen at almost equal rates with wind as the major causes of damage in Palo and Tacloban where waves were recorded to be high. Houses along the typhoon track and within 25-50 km distance are usually exposed to winds at their maximum speed while such speed decreases by moving further from the storm track.

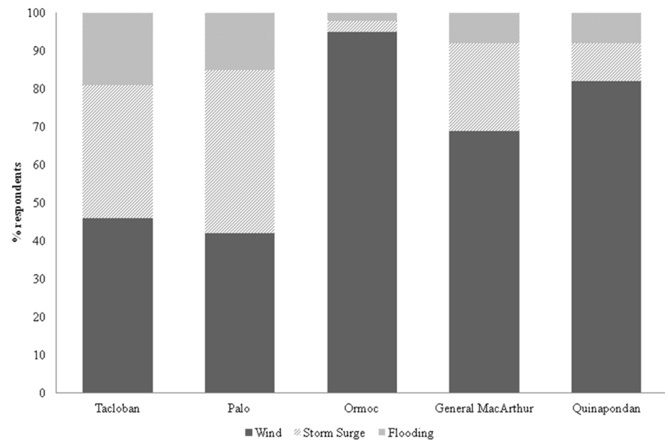

Figure 3. Major causes of housing damage as identified by the respondents.

Other studies performed on the ground were consistent with the impacts and damages reported by the respondents. The high wind speed and storm surge of Typhoon Haiyan brought most of the damage to properties in most of the study sites. At the onset of the storm, the predicted storm tide for Typhoon Haiyan was 4.5 m for Tacloban, Leyte (along San Juanico Strait) and 5.3 m for Matarinao Bay, Eastern Samar. The storm surge inundation levels (flood depths) that were observed in Tacloban reached 4-6 m and3-5 m in municipalities along the Matarinao Bay, including Quinapondan, General MacArthur, Hernani and Salcedo (Lagmay et al., 2014). In another study by Mori and team (2014), storm surge with estimated heights of 5-6 meters were observed in Tacloban City. Bricker, et al. (2014) also studied the site-specific mechanisms that caused the structural damages between Tacloban and Eastern Samar.

Extent of Housing Damage

The household survey results comparing housing damage between sites with and without mangroves showed that coastal communities with mangroves suffered less damage compared to respondents living in areas without mangroves. This is particularly evident in Tacloban, where the number of respondents in areas without mangroves (n=81) that reported total damage is higher than those with mangroves (n=52) (Figure 4). In Ormoc, however, where most houses were made of light materials, damage was higher in areas where there are mangroves.

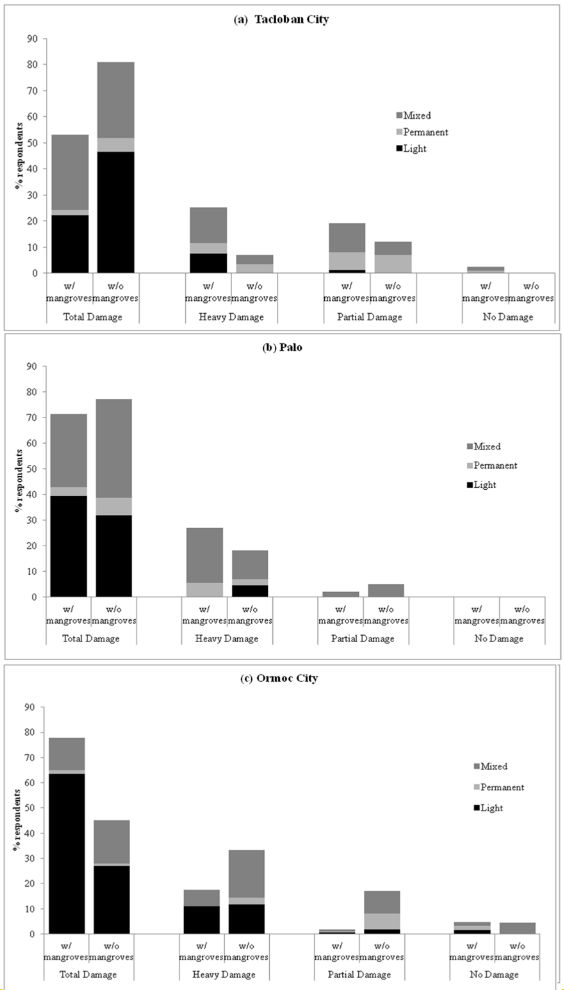

Figure 4. Comparison of the damages in housing to sites with and without mangroves in Leyte.

While Das and Crépin (2013) showed that mangroves provide substantial protection from damage caused by cyclonic winds, the wind protection value of mangroves in reducing housing damage based on type of housing materials and exposure to winds was not considered in this study.

State of Mangroves

Leyte and Eastern Samar used to have natural mangrove stands. During the last few decades, mangroves from these areas were destroyed or degraded due to the rising urban population and higher demand for fisheries. Consequently, coastal communities became more exposed to the relentless power of storms originating from the Pacific. Results of the household survey where respondents said that mangroves were thick and healthy or otherwise were confirmed by the results of the vegetation surveys.

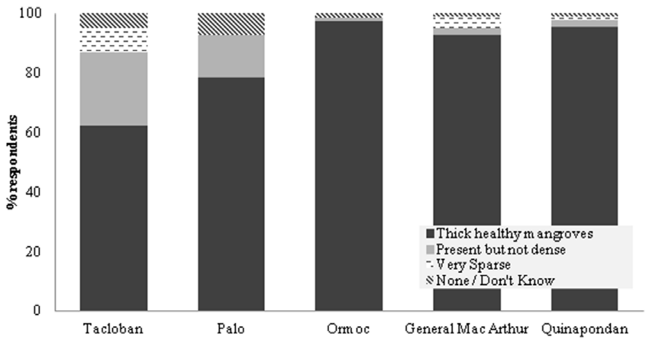

Figure 5. State of mangroves before Typhoon Haiyan according to the respondents per study site.

The mangroves of Tacloban are dominated by planted stands of *Rhizophora* along the seafront and natural stands of *Sonneratia* and *Avicennia* with sightings of *Acanthus sp.*, *Aegiceras sp.*, *Exoecaria agallocha,* and nipa plantations. The vegetation of Palo, Leyte is predominantly abundant with beach forest species rather than true mangrove species. Beach forest vegetation included *Cocos nucifera* (coconut), *Thespesia populnea* (banalo/portia tree), *Talipariti tiliaceum* (malubago/ beach hibiscus), and *Ipomoea pes-caprae* (bagasua), among others. Mangroves also occur but come in very small patches along the coast. Dead or damaged stands of *Rhizophora* and *Sonneratia* were observed during the survey while *Avicennia* stands showed signs of faster regeneration. Plantations of nipa account to the majority of mangrove species found in Palo, Leyte.

The mangrove forests in Ormoc City cover a large expanse of about 726 ha but many portions of the mangroves had been converted to fish ponds. *Sonneratia* and *Avicennia* species dominate the mangroves with sightings of planted *Rhizophora sp.*, *Lumnitzera*, *Exoecaria*, and other beach forest species. On nearby villages, plantations of *Nypa fruticans* are utilized by the local communities for forest products.

The Quinapondan mangroves had 20 mangrove species observed with *Avicennia*, *Bruguiera,* and *Xylocarpus* species being dominant from seaward to landward, respectively. Also sighted is the endangered *Camptosthenom philippinense*. In General MacArthur, there were also 20 sightings of mangrove species with natural stands of *Rhizophora* and *Sonneratia* species dominating the seafront with sandy soil substrate. *Bruguiera* and *Xylocarpus* species dominate the landward portion of the mangrove forest.

The mangroves in Quinapondan and General MacArthur in Eastern Samar had the highest values in terms of species richness, diversity index (H'), and evenness. Tacloban City had the lowest species richness with 8 mangrove species observed. However, Palo had 0 values for H' and evenness as the areas sampled were situated mainly in the nipa plantations although 9 species were recorded on small mangrove patches. Table 4 summarizes the mangrove biodiversity indices from the study sites.

Table 4. Biodiversity indices and parameters in the study site.

Site	Area (ha)	Species Richness	Shannon-Weiner (H')	Density (trees/ha)	Height (m)	DBM (m)
Tacloban	125	8	0.944396	3760	4.16	0.0659
Palo	33	9	0	1327	5.70	0.1320
Ormoc	1,463	13	1.2350663	3096	10.32	0.1238
Quinapondan	1,085	20	1.969263	3229	5.07	0.0769
Gen. MacArthur	432	20	1.748424	3539	4.79	0.0860

Given that biodiversity indices are good indicators of ecological integrity, the mangroves of Quinapondan and General MacArthur have a higher standing in terms of mangrove biodiversity followed by Ormoc, Palo and Tacloban. These two municipalities provide a long stretch of intact mangrove cover along the coastline of Matarinao Bay. Ormoc has a wide stretch of mangroves, although fishpond conversions may have compromised the ecological integrity of these areas. Palo and Tacloban have the least biodiversity as mangroves in these sites come in small patches. Furthermore, human interventions continue to threaten the mangroves.

Mangroves are considered more effective in dissipating the energy of waves brought by storms (S. Das & Vincent, 2009; A. McIvor, Spencer, Möller, & Spalding, 2012; Zhang et al., 2012). The wave energy absorbed by mangroves strongly depends on a few biotic and abiotic factors. The biotic factors include forest density and the diameter of stems and roots. The abiotic consideration encompassed physical characteristics, such as forest floor slope, bathymetry and spectral characteristics of the incident waves, and the tidal stage at which the wave enters the forest (Tanaka, 2009). Carlos et al. (2015) described the vegetation resistance based on forest density of the study sites.

However, previous studies showed that at high tide, there will be a 50% decline in wave energy for *Rhizophora*-dominated forest (Brinkman et al., 1997 as cited by A. L. McIvor, Möller, Spencer, & Spalding, 2012) within 150 m and *Sonneratia* forest within 100 m off the coast, respectively (Mazda, Magi, Ikeda, Kurokawa, & Asano, 2006). It is unclear how other variables such as distance from the coast and topography affect this protective function.

Perception of Local Communities

Findings from the household survey showed that the peoples' perception on the coastal protection function of mangroves differed according to the state of mangroves, as shown in Figure 6 in terms of area, width, and species richness. The least number of respondents that agreed to the protective functions of mangroves were from Palo and Tacloban where area, width, and species richness were the lowest among all the study sites. On the other hand, the areas with the highest mangrove area, width, and species richness were also the sites where most respondents agreed to the protective role that mangroves play (Ormoc City, General MacArthur, and Quinapondan).

Undeniably, mangroves and coastal vegetation were found to be an important resource for the communities (Table 5). Across all study sites in Leyte, the mangroves are found to be very beneficial to the community as they serve as a source of seafood, fuel wood for cooking, housing materials, and livelihood opportunities through mud crab and nipa shingles production. When respondents were asked if it will be beneficial to plant mangroves in the community, an overwhelming majority (90%) acknowledged the benefits of planting mangroves along the coast lines. In particular, residents of Quinapondan and General MacArthur of Eastern Samar perceive great benefits from the mangroves, which they use as sources of food and fuel wood. In some areas, mangroves are still utilized for housing structure such as stilts and fences. A number of respondents also recognized that mangroves play a substantial role in supporting recovery from disasters, because some residents utilized wood and other resources for survival and reconstruction after Typhoon Haiyan. Of those who perceived that mangroves are beneficial, 55% percent were using resources such as fishes, crabs, shrimp, shells or a combination of many resources. Majority of the respondents with ages 25-34 years old recognized the benefits of the mangroves. Also, the appreciation of the benefits provided by mangroves were apparent across different income groups: business and employment, fishing, and farming. Despite having their houses totally destroyed by Typhoon Haiyan, 49% of the respondents still perceived that they were protected by the mangroves.

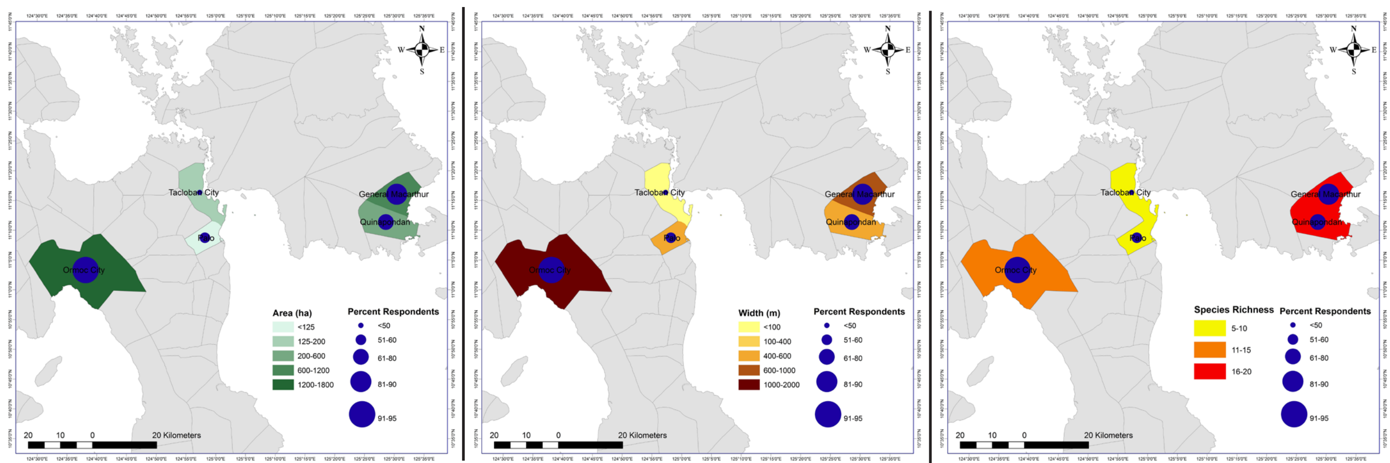

Figure 6. Percentage of surveyed residents that perceived mangroves provided coastal protection compared with the estimated mangrove area in hectares (left), estimated (average) width of mangroves in meters (middle) and species richness (right) in the study sites.

However, in spite of understanding the significance of mangroves, only 29% of the respondents participated in the programs and activities to rehabilitate, conserve and protect the mangroves after Typhoon Haiyan.

Table 5. Respondents' characteristics and perception on the benefits of, protection of mangroves, and participation on activities to rehabilitate, conserve, and protect mangroves.

Characteristics of respondents	Survey category and response					
	Benefits		Sense of security		Participation	
	Yes	No	Yes	No	Yes	No
Gender						
Female	66	7	62	11	21	53
Male	24	3	22	5	8	17
Age Group						
15-19	3	1	2	0	2	2
20-24	14	2	12	3	5	9
25-29	25	2	18	2	8	13
30-34	26	3	22	4	6	18
35-39	14	2	15	2	3	13
>60	18	3	15	4	7	15
Source of income						
Business/ employment/others	58	4	48	12	16	42
Farming/ livestock	8	4	11	1	4	8
Fishing	11	1	14	2	3	11
Multiple source	7	1	7	1	4	5
Taking resources from mangroves						
Yes	55	5	59	7	20	46
No	35	5	26	9	10	24
Level of housing						
Totally destroyed	54	8	49	9	18	43
Heavily damaged	21	1	21	4	8	16
Slightlydamaged	11	1	11	3	3	0
Not damaged	1	0	1	0	0	0

The current level of awareness and appreciation by the local people of the functions performed by the mangroves can be used as a good starting point and opportunity for the rehabilitation and management of these ecosystems. In order to ensure the sustainable use of the ecosystem goods and services provided by mangroves, it is important to increase the understanding and appreciation of coastal communities on the functions of mangrove forests. Community awareness in coastal areas on the importance of mangroves in disaster mitigation and risk reduction remains inadequate and needs to be raised further. More importantly, the local community must be motivated enough to be actively involved in the rehabilitation, conservation, and protection programs. The presence and visibility of institutions and organizations (such as DENR, NGOs and people's organization) can also encourage active involvement among the residents. Stakeholders should be easier to motivate if they understand how their efforts would eventually pay off regardless of how far into the future will it happen.

Conclusion and Recommendations

We highlight that the resilience of coastal communities to tropical cyclones are, to some extent, reduced by the removal of mangroves. The study results showed that the appreciation of the protective function of mangroves is lower in areas where mangrove cover is low compared to the study sites with thicker mangrove cover (Table 6). Although only indicative and based on social perception, we show that the housing damage attributed to either wind and storm surge was more extensive in sites where there are no or very little patches of mangroves. While this study attempted to provide evidence on whether mangroves can attenuate impacts of storm surges and provide protection, continuous collection of empirical data and conduct of more in-depth studies could help enhance understanding on the roles of mangroves in reducing the vulnerability of Philippine coastlines to typhoons and its associated hazards such storm surges.

It is conceivable that this observation would have been different if other factors such as distance, bathymetry, and properties of the typhoon were considered in the study. A more sophisticated analysis on the combined role of storm surge, flooding, and wind on the property damages could shed more light on the effectiveness or limitations of the coastal protection function of mangroves. Understanding the interactions among the hazards associated with the typhoon (e.g., storm surge, wind, duration, depth and extent of inundation) and the state of the mangroves and other physical factors such as those mentioned above may provide additional evidence to show that to be effective against storm surges with magnitude similar to that of Typhoon Haiyan, buffer zones or coastal greenbelts would need to be far wider than the existing mangrove areas and even those currently proposed (40-m buffer).

Table 6. Summary of conclusion and recommendations per study site.

Site	Perception	Recommendations
Tacloban	Protective function of mangroves and community participation were perceived to be low	Mangrove rehabilitation efforts should be supported by extensive communication campaigns
Palo	Protective function of mangroves and community participation were perceived to be low	Residents with claims on mangrove areas should contribute to mangrove protection; extensive communication campaign needed
Ormoc	High awareness on the ecosystem services provided by mangroves; community involvement is higher as compared to other study sites	Sustain community participation and protection activities by supporting the existing people's organization (PO)
Gen. MacArthur	High awareness on the ecosystem services provided by mangroves; high community involvement as compared to other sites	Establishment of PO or a network of POs to enhance mangrove protection in the community
Quinapondan	High awareness on the ecosystem services but involvement of community in mangrove rehabilitation/ protection remains to be low	Interventions should cater to the enforcement of ordinances and non-destructive livelihood options

If implemented properly, the establishment of coastal greenbelts may not only provide protection against damages caused by storms, it may also provide ecosystem services including the provision of food and fuel wood, source of income and housing materials, erosion control, and possibly enhanced biodiversity and tourism that could help build the resilience of coastal communities. The observations in this study highlight the multi-functionality of mangrove ecosystems that could justify investments in coastal rehabilitation and management. Additionally, this study generated information that could be used in raising the level of awareness and participation of all stakeholders in mangrove ecosystem rehabilitation and management.

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