AES BIOFLUX

Advances in Environmental Sciences - International Journal of the Bioflux Society

Quantitative measurement of vulnerability of selected coastal communities to hydrometeorological hazards, in Iloilo Province, Central Philippines

[1]Farisal U. Bagsit, [2]Armi M. T. Guzman, [1]Caridad N. Jimenez, [1]Genna D. Serofia

[1]Institute of Fisheries Policy and Development Studies, College of Fisheries and Ocean Sciences, University of the Philippines Visayas, Miagao, Iloilo, Philippines; [2]Institute of Marine Fisheries and Oceanology, College of Fisheries and Ocean Sciences, University of the Philippines Visayas, Miagao, Iloilo, Philippines. Corresponding author: F. U. Bagsit, fubagsit@upv.edu.ph

Abstract. The impact of current climate variability adversely affects countless communities and this was demonstrated by the supertyphoon *Haiyan* that ravaged the Eastern and Central Philippines in 2013. In the coming years, the impacts are expected to be more marked and for some communities, catastrophic. According to Dazé et al (2009), vulnerability to climate variations can differ within countries, communities and even households and therefore, adaptation requires context-specific activities with strategies vital in the planning process for an effective adaptation program in response to these hazards. This study was conducted to assess the vulnerability of selected coastal communities to hydrometeorological hazards (HMHs) in Iloilo Province, Central Philippines, specifically in the municipalities of Oton and Concepcion, as these coastal towns have the highest number of registered affected persons (relative to population) in the aftermath of typhoon Fengshen in 2008 (IPDCC 2008), and supertyphoon Haiyan in 2013 (Municipality of Concepcion, unp. data). Assessment of vulnerability was done by constructing a vulnerability index (VI) and results show that study sites in the municipality of Concepcion are more vulnerable to HMHs, as compared to the sites in the municipality of Oton.
Key Words: risk assessment, community participation, coastal hazards.

Introduction. In 2014, the Philippines was among the top 5 countries that were most often hit by natural disasters worldwide (Guha-Sapir et al 2013) and noticeably, most of the disasters that have occurred in the country were hydrological and meteorological in nature. The Philippines however, is one of the countries that is vulnerable and hard-pressed to adapt to the impacts of hydrometeorological hazards (HMHs) largely due to its geographical location being situated at the nucleus of typhoon activity (CRED 2014). Further, the Philippines is an archipelago and is characterized by long coastlines that is home to thousands of communities that rely on climate-sensitive industries like agriculture and aquaculture. Notably, 54% of its municipalities are coastal (Philippines Environment Monitor 2005). Furthermore, Castro & D'Agnes (2009) reported that majority of Filipinos reside along the coastal zones where rates of fertility, teenage pregnancy and unmet need for family planning exceed national average figures and contribute to high poverty incidence of 44% among fisherfolk.

Extreme natural hazards, particularly HMHs (e.g. supertyphoon, tsunami, etc.), are emerging causes of major concern in the coastal regions. HMHs refer to process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR 2004). It includes tropical cyclones (also known as typhoons and hurricanes), thunderstorms, hailstorms, tornados, blizzards, heavy snowfall, avalanches, coastal storm surges, floods including flash floods, drought, heatwaves and cold spells.

Although scientific knowledge about natural hazards and the technological means of addressing them has expanded greatly over the last decades, vulnerability among communities is continuously growing because weather conditions are intensified by climate change. Consequently, these contribute in up-scaling the scope and cost of disaster events. This has been demonstrated by the catastrophic effects brought by disasters that happened in the Philippines in the past years (typhoon Fengshen in 2008, and supertyphoon Haiyan in 2013). The frequency of these hazards in the past has taken a heavy toll on coastal communities in the Philippines (CRED 2014). According to the IPCC (2001), geographic and economic variability leads to inequity in the vulnerability of coastal communities.

In order to plan for effective adaptations program in response these hazards, analysis of vulnerability and capacity of communities is vital, especially in the planning process. Local leadership must be able to understand who is vulnerable to its impacts, why, and how communities can appropriately respond to HMHs. Hence, this study was conducted to examine the vulnerability of selected coastal barangays in the municipalities of Oton and Concepcion, in the province of Iloilo, Central Philippines (Figure 1).

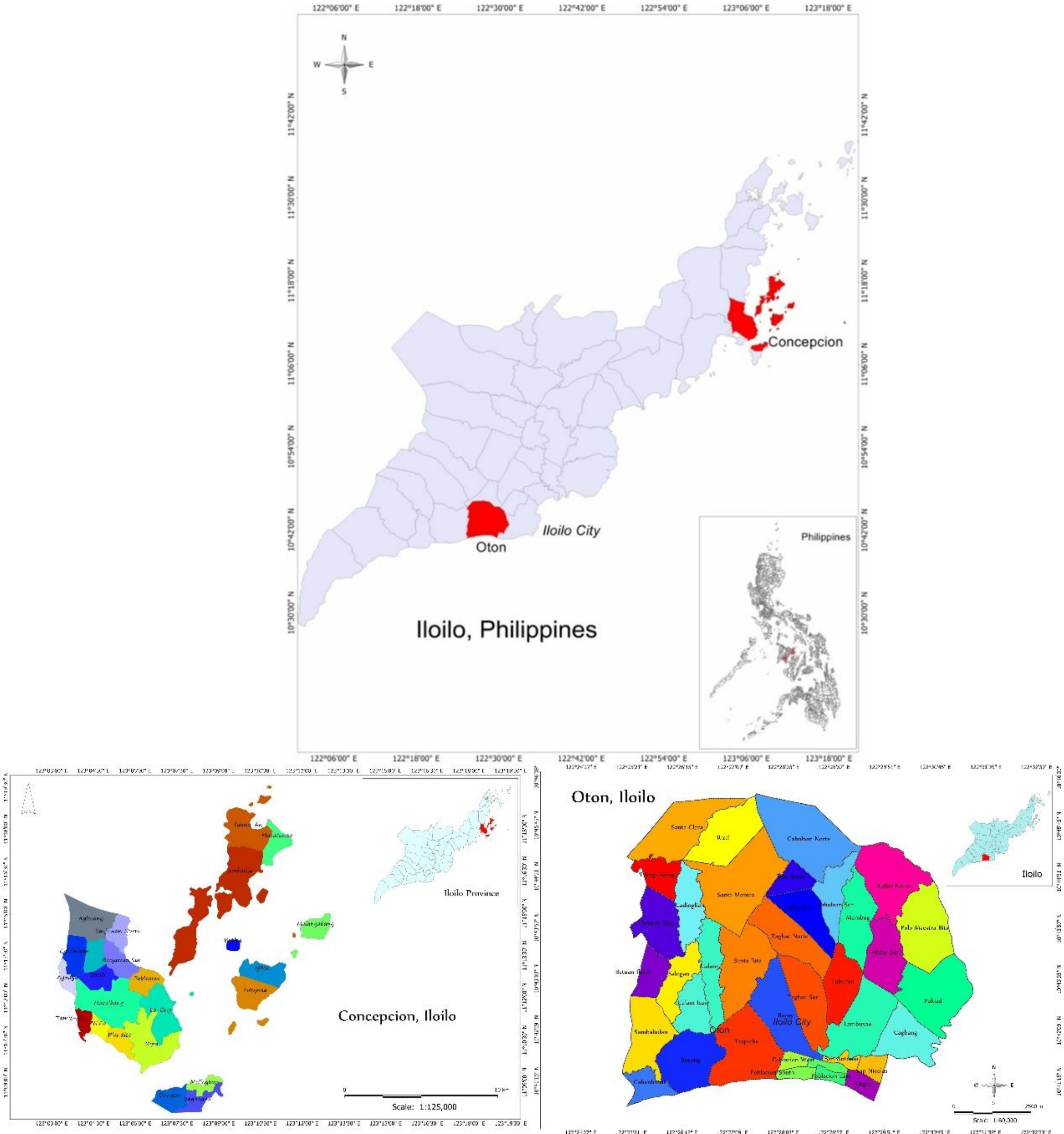

Figure 1. Map showing the study sites (in black box) in the municipalities of Oton and Concepcion in the province of Iloilo, Central Philippines.

These coastal towns registered the highest number of affected persons (relative to population) in the aftermath of typhoon Frank in 2008 (IPDCC 2008) and typhoon Yolanda in 2013 (Municipality of Concepcion, Iloilo, unpublished data).

Material and Method. Vulnerability is defined by the IPCC (2001) as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. It is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. In literature (Mazzi et al 1998; Easter 2000; Moss et al 2001; Dolan & Walker 2003; Vincent 2004), assessment of vulnerability is usually done by constructing a vulnerability index (VI), which is based on a set of indicators that result in a vulnerability of a certain region. The VI produces a single number (between 0 to 1) which can be used to rank and compare different regions. In the present study a total of 23 indicators were included in the construct of the VI (Table 1).

Table 1

List of variables, indicators and sub-indicator

Variable	*Indicator*	*Sub-indicator*	*Code*	*Functional relationship*[c]
Exposure[a]	Typhoon	Number of typhoon occurrence/year	E1	↑
	Flooding	Number of flood occurrence/year	E2	↑
	Tornado	Number of tornado occurrence/year	E3	↑
	Thunderstorm	Number of thunderstorm occurrence/year	E4	↑
	Drought	Number of drought occurrence/10 years	E5	↑
	Storm surge	Average height of storm surge incidence	E6	↑
Sensitivity[b]	Human	Dependency ratio (% population below 15 years old and above 65 years old)	S1	↑
	Socio-economic	% HH w/ Fishing and related activities as major source of income	S2	↑
		% HH w/ Farming as major source of income IPPO	S3	↑
		% HH whose combined monthly income falls below PhP 5,000	S4	↑
		Unemployment rate (% Population 15 years old and over w/out job)	S5	↑
Adaptive	Human capital	% Population 15-64 years old	AC1	↓
		% Population 10 years old and over who can read and understand simple message in Fiipino, English and local dialect	AC2	↓
		% Population who are knowledgeable of possible impacts/effects of the HMHs	AC3	↓
Capacity	Availability of resources	% HH with transportation	AC4	↓
		% HH with cell phones	AC5	↓
		% HH with TV and radio	AC6	↓
	Accessibility	Distance from town proper	AC7	↓
	Communication system	Presence and effectiveness of a community early warning system	AC8	↓
		System of disseminating information within the community about the hazards	AC9	↓
	Social capital	Presence and accessibility of support system in the community (family, neighbors, BLGU)	AC1 0	↓
		Presence and accessibility of support system outside the community (NGOs, private sector, service providers)	AC1 1	↓
		Percent of population who can afford to spend for adaptation cost	AC1 2	↓

[a] Indicators under this variable include only HMHs that are applicable under the Philippine condition and were most frequently cited by the respondents in the study sites; [b] Data are based from the IPPO (2011); [c]↑ indicates increasing relationship with vulnerability whereas ↓ indicates decreasing relationship with vulnerability.

For the purpose of this study, the VI was constructed using set of indicators selected for each of the 3 component of vulnerability following the work of Garcia et al (2011) and Islam Nazrul et al (2013).

Primary data were gathered through workshop following the participatory methods (e.g. historical timeline, vulnerability matrix, seasonal calendar, hazard mapping, etc.) provided in the Climate Vulnerability and Capacity Analysis Manual (Dazé et al 2009) and VAST-Agro: Community-based Vulnerability and Adaptive Capacity Assessment for Agriculture (Garcia et al 2011). Focus group discussions (FGD), key informant interviews (KII) and GIS mapping were also done to complement data obtained from the workshop activities. Non-numeric qualitative data were assigned with equivalent numeric quantitative data. Further, secondary data were gathered from the Barangay Local Government Unit (BLGU), Municipal Planning and Development Coordinator (MPDC), Department of Environment and Natural Resources-Land Management Services (DENR-LMS), Department of Environment and Natural Resources-Mines and Geosciences Bureau (DENR-MGB), Iloilo Provincial Population Office (IPPO), Office of the Civil Defense (OCD) VI, Department of Science and Technology (DOST) VI, Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA) Manila, and Agromet Station in Dumangas, Iloilo.

Data processing and analysis. After obtaining all the raw data for the different indicators, data are arranged in rectangular matrix with rows representing the coastal barangays and columns representing indicators. The raw data are then normalized using functional relationship following Islam Nazrul et al (2013), using Microsoft Excel program. Since data obtained are of different scales and units, normalization is necessary to free the values from their respective units and scales, and to bring all of the variables into proportion with one another. Further, functional relationship of indicators to vulnerability (Table 1, Column 5) was taken into account to ensure that the resulting index is not misleading.

In particular, indicators of exposure and sensitivity have increasing (↑) functional relationship with vulnerability, such that vulnerability increases as the values of the indicators increase. The values are normalized following the equation 1 below:

$$x_{ij} = \frac{X_{ij} - \underset{i}{Min}\{X_{ij}\}}{\underset{i}{Max}\{X_{ij}\} - \underset{i}{Min}\{X_{ij}\}}$$

Whereas indicators of adaptive capacity have decreasing (↓) functional relationship with vulnerability such that vulnerability decreases as the values of the indicators increase, hence, values are normalized using the equation 2 below:

$$y_{ij} = \frac{\underset{i}{Max}\{X_{ij}\} - X_{ij}}{\underset{i}{Max}\{X_{ij}\} - Min\{X_{ij}\}}$$

After raw data have been normalized, simple average of scores (methods with equal weights) was done and the resulting VI was used for ranking the study sites. Qualitative interpretation of the different levels of vulnerability was also done following the fractile intervals by Iyenger & Sudarshan (1982). The qualitative interpretation was then translated to vulnerability map for easy understanding and better appreciation of the people from the study sites.

Table 2

Levels of vulnerability (Iyenger & Sudarshan 1982)

Vulnerability index	*Qualitative interpretation*
0.0-0.20	Less vulnerable
0.21-0.40	Vulnerable
0.41-0.60	Moderately vulnerable
0.61-0.80	Highly vulnerable
0.81-1.0	Extremely vulnerable

Results and Discussion. The coastal barangays included in this study (Barangays Cabanbanan and Poblacion South in Oton, and Barangays Lo-ong and Botlog in Concepcion) were selected as per recommendation of the Municipal Disaster Risk Reduction Officer - Oton and Environmental Management Specialist - Concepcion. These barangays were among the hardest hit areas in the wake of typhoon Fengshen in 2008 and supertyphoon Haiyan, in 2013.

Cabanbanan is the last barangay of Oton going to Tigbauan, Iloilo (Figure 1). It has a total area of 101 has and a population of 2,717. A creek serves as a boundary to the next municipality and the coastal area and the rest of the barangay is traversed by the national road. Fishing and farming are the primary sources of livelihood.

Poblacion South is a lowland coastal barangay that has a total area of 57 has and is situated in the Oton town proper. It is one of the most densely populated barangays in the municipality, consisting of 5,402 inhabitants. Due to its close proximity to the city, most of the residents are engaged in commercial, service and industrial activities, aside from fishing and farming.

Lo-ong is a coastal barangay with a land area of about 574 ha and population of 3,384. It is located in the mainland of Concepcion, Iloilo. Its coastal area is flat lowland while the rest of the barangay is situated in the mountainous area. The barangay depends on fishing and farming as main sources of livelihood. Major resources in the area include rice, coconut and livestock.

Botlog is an island barangay located 9 km away from the mainland. It has a total land area of 58 ha and a population of 481. This island barangay is characterized by lowland coastal area which develops into a steep rocky, mountainous area. The only source of livelihood for the residents is fishing and subsistence farming. The Table 3 shows the summarized profile of the 4 barangays.

The exposure component of the VI is composed of 6 HMHs, namely: typhoon, flooding, tornado, thunderstorm, drought and storm surge. These are the most common cited hazards by the respondents across the study sites, in terms of frequency of occurrence. Results show that Lo-ong has the highest exposure to the identified hazards, while Botlog incurred the lowest score (Figure 2). The physical features of Botlog, being an island barangay, contributed to its low exposure. Unlike the other study sites, it did not experience flooding (E2) and drought (E5) primarily because 81% of its total land area is rocky and mountainous.

Table 3

Profile of the study sites (BLGU 2014)

	Cabanbanan	*Poblacion South*	*Lo-ong*	*Botlog*
Ecosystem	Coastal, lowland, upland	Coastal, lowland	Coastal, lowland, upland	Coastal, lowland, upland
Land area (ha)	101	57	574	58
Physical feature	Coastal (with river, creek)	Low flat land	Low flat land to mountainous	Low flat land to mountainous
Total population	2,717	5,402	3,384	481
Total no. of households	581	1,066	751	94
Public means of transportation	Jeepney, private, motorcycle	Jeepney, private, motorcycle	Single motorcycle, tricycle, private, boat	Pump boat, banca
Source of income	Employment, business, farming, fishing	Employment, business, farming, fishing	Fishing, farming, business, employment	Fishing, farming, sari-sari
Water supply	Community water system, deep well w/ pump, dug well, spring, MIWD*	Community water system, deep well w/ pump, dug well, spring, MIWD*	LOWA**, water system	Spring, deep well w/ pump, dug well
Power supply	ILECO*** I	ILECO*** I	ILECO*** III, generator, solar, kerosene	Generator, solar panels
Communication	Cell phone, landline	Cell phone, landline	Cell phone, radio handset	Cell phone, radio handset

*Metro Iloilo Water District, **Lo-ong Water Association, **Iloilo Electric Cooperative.

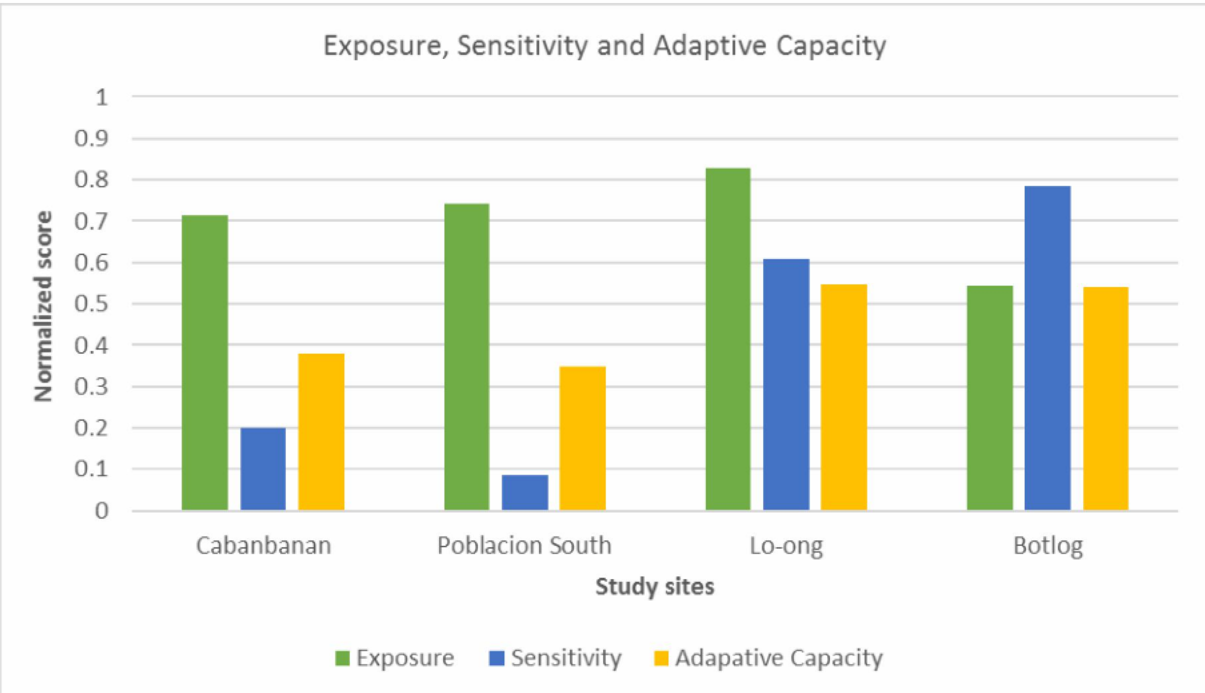

Figure 2. Exposure, sensitivity and adaptive capacity of the study sites.

However, Botlog appears to have the highest sensitivity to HMHs based on the 5 indicators (Table 1) under this component. Specifically, Botlog has the highest scores in terms of percentage of households whose major source of income come from fishing and related activities (S2; 75.57%) and percentage of households (with at least 4 family members) whose average monthly income is PhP 5,000 (~106 USD) and below (S4;

49.46%), which is below poverty line. Further, this barangay has the highest unemployment rate of 40.63% (S5).

In contrast, lowest sensitivity is observed in Poblacion South, which can be attributed to its lowest scores incurred in terms of dependency ratio (S1; 34%), percentage of households whose major source of income come from fishing and related activities (S2; 1.41%) and farming (S3; 0.66%).

In terms of adaptive capacity, Poblacion South incurred the highest scores in 5 (AC1, AC2, AC7, AC9 and AC11) out of 12 indicators under this component (Table 1).

Overall, computations for the VI show that barangays Lo-ong (0.600) and Botlog (0.5926), in Concepcion rank 1st and 2nd, while barangays Cabanbanan (0.399) and Poblacion South (0.3665), in Oton rank 3rd and 4th, respectively (Table 4).

Table 4

Computed vulnerability index of the study sites

Barangay	*Score*	*Vulnerability index*	*Rank*
Cabanbanan	9.565	0.399	3
Poblacion South	8.797	0.367	4
Lo-ong	14.410	0.600	1
Botlog	14.222	0.593	2

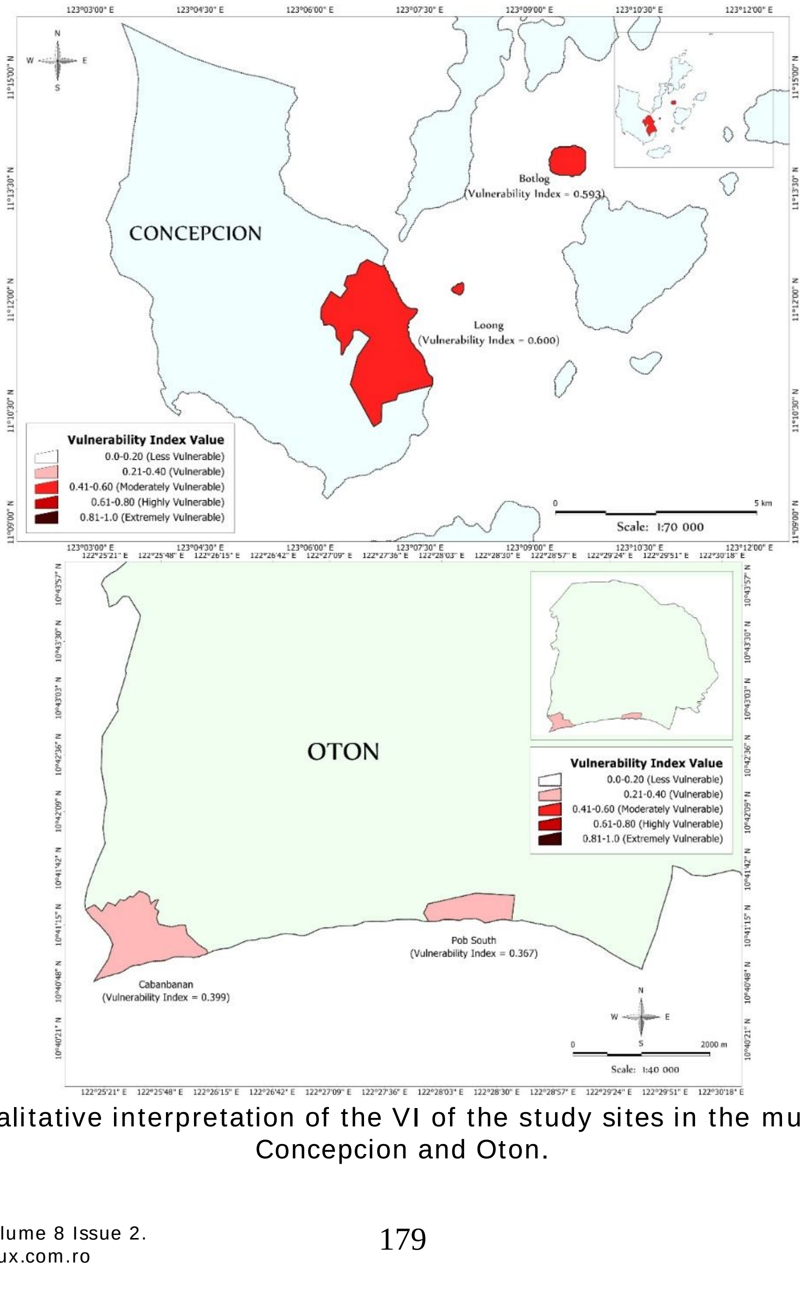

Figure 3. Qualitative interpretation of the VI of the study sites in the municipalities of Concepcion and Oton.

The VI of the study sites can be attributed to their different levels of exposure, sensitivity and adaptive capacity to HMHs, as discussed earlier. Poblacion South in particular, incurred the lowest score for sensitivity while attaining the highest score in terms of adaptive capacity to HMHs, hence, it has the lowest vulnerability. In contrast, Lo-ong incurred the highest exposure and lowest adaptive capacity, hence, appears to be highly vulnerable to HMHs.
Qualitative interpretations of the VI across the study sites are shown in Figure 3. Barangays Cabanbanan and Poblacion South appear to be both vulnerable, while Lo-ong and Botlog are moderately vulnerable.

Conclusions and Recommendations. Quantitative assessment of vulnerability shows that Barangays Lo-ong and Botlog, in Concepcion Iloilo rank 1st and 2nd, while barangays Cabanbanan and Poblacion South, in Oton, Iloilo rank 3rd and 4th, respectively, in terms relative to HMHs. Further, qualitative interpretation of the VI shows that study sites in Oton are vulnerable to HMHs, whereas study sites in Concepcion are moderately vulnerable.

This study advocates that local communities should have adequate understanding of the hazards (e.g. familiarity with the hazards and their corresponding impacts to particular sectors in the community) to which they are exposed for them to be able to respond appropriately. This will translate to better planning and development of adaptive programs that are more attuned to specific needs and vulnerabilities at the local level. The results of this study can serve as an invaluable input for the LGUs concerned, especially in prioritizing programs for coastal barangays that need urgent assistance.

This study further recognizes that vulnerability assessment studies like this could have produced better output if done on a bigger scale (e.g. covering the entire costal barangays in a municipality) for more practical and useful results. Although the study was conceptualized with such intent, funding largely dictated the scope of the research, hence, the few study sites. It is therefore recommended that similar study should be conducted, perhaps in partnership with the LGUs to defray cost, to expand the coverage for a more meaningful assessment.

It is further recommended that yearly survey of relevant demographic data at the barangay level should be conducted for easy reference. The Barangay Disaster Risk and Reduction Management Offices (BDRRMO) in all the cities and municipalities in the Philippines can have a template survey form for this purpose, to ensure homogeneity of data, in terms of content and year, as these information are very important in vulnerability assessment.

Acknowledgements. The research team would like to thank the UP Visayas in-house funding for the financial support for this research, and also to the women and men respondents in the communities we worked with during the conduct of this study. The team is also grateful to the different government agencies, both in the regional and national level, for sharing their data with this research.

References

Mazzi S., Atkins J., Ramlogan C., 1998 A study on the vulnerability of developing and island states: a composite index. The Commonwealth Secretariat, London, UK.

Castro J. R. L., D'Agnes L. A., 2009 Promoting family planning within the context of environmental management yields higher MDG achievement: evidence from the Philippines. Accessed at http://www.pfpi.org/abstract_fpmdg.htm, 29 Jan 2016.

Dazé A., Ambrose K., Ehrhart C., 2009 Climate vulnerability and capacity analysis handbook. CARE, 52 pp., available online at: http://www.careclimatechange.org/files/adaptation/CARE_CVCAHandbook.pdf

Dolan A. H., Walker I. J., 2003 Understanding vulnerability of coastal communities to climate change related risks. Journal of Coastal Research SI 39, available online at: http://coastalcommunities.ns.ca/documents/dolan.pdf

Easter C., 2000 The common wealth vulnerability index. Ministerial Conference on Environment and Development in Asia and the Pacific, Kitakyushu, Japan.
Garcia J. N. M., Wagan A. M., Medina S. M., 2011 Vulnerability and adaptive capacity assessment in different agroecosystems (VAS-Agro). Agricultural Cluster, University of the Philippines Los Baños.
Guha-Sapir D., Hoyois P., Below R., 2013 Annual Disaster Statistical Review 2012: The Numbers and Trends. Brussels: CRED, 50 pp.
Islam Nazrul A. K. M., Deb U. K., Al Amin M., Jahan N., Ahmed I., Tabassum S., Ahamad M. G., Nabi A., Singh N. P., Byjesh K., Bantilan C., 2013 Vulnerability to climate change: adaptation strategies and layers of resilience – quantifying vulnerability to climate change in Bangladesh. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 36 pp.
Iyenger N. S., Sudarshan P., 1982 A method of classifying regions from multivariate data. Economic and Political Weekly 8(51):2047-2052.
Moss R. H., Brenkert A. L., Malone E. L., 2001 Vulnerability to climate change: a quantitative approach. Department of Energy, USA.
Vincent K., 2004 Creating an index for social vulnerability to climate change for Africa. Tyndall Centre for Climate Change Research, Working Paper 56.
*** BLGU, 2014 Barangay Local Government Units of Cabanbanan, Poblacion South, Lo-ong and Botlog, Province of Iloilo, Barangay Profiles.
*** CRED (Centre for Research on the Epidemiology of Disasters), 2014 Disaster Data: A Balanced Perspective. CRED CRUNCH. Issue No. 34, January 2014. 2p.
*** IPCC (Intergovernmental Panel Climate Change), 2001 Climate Change 2001: Impacts, Adaptation and Vulnerability. [Online] URL: http://www.grida.no/publications/other/ipcctar/?src=/climate/ipcctar/ Accessed: April 20, 2014.
*** IPDCC (Iloilo Province Disaster Coordinating Council), 2008 Typhoon "Frank" Damage Assessment Report. Accessed at http://www.iloilo.gov.ph/index.php?option=com_ content&task=view&id=495&Itemid=1, March 11, 2010.
*** IPPO (Iloilo Provincial Population Office), 2011 2011 Household Survey Result. Comprehensive Population Data Banking and Management Project.
*** Municipality of Concepcion, Iloilo. Unp. data. Masterlist of all households affected by Typhoon Yolanda. Office of the Municipal Social Welfare and Development
*** Philippine Environment Monitor, 2005. 6p. Accessed online http://siteresources.worldbank.org/INTPHILIPPINES/Resources/PEM05-ch1.pdf, 29 Jan 2016.
*** UNISDR (United Nations International Strategy for Disaster Reduction), 2004 Living with risk. A global review of disaster reduction initiatives. 2004 Version – Volume I., 457 pp.

Rceived: 14 February 2016. Accepted: 26 March 2016. Published online: 27 March 2016.
Authors:
Farisal Ungkakay Bagsit, University of the Philippines Visayas, College of Fisheries and Ocean Sciences, Institute of Fisheries Policy and Development Studies, Philippines, Iloilo, 5023 Miagao, e-mail: fubagsit@upv.edu.ph
Armi May Torrechilla Guzman, University of the Philippines Visayas, College of Fisheries and Ocean Sciences, Institute of Marine Fisheries and Oceanology, Philippines, Iloilo, 5023 Miagao, e-mail: armi_may26@yahoo.com
Caridad Novio Jimenez, University of the Philippines Visayas, College of Fisheries and Ocean Sciences, Institute of Fisheries Policy and Development Studies, Philippines, Iloilo, 5023 Miagao, e-mail: jimenez.cindy@gmail.com
Genna Diaz Serofia, University of the Philippines Visayas, College of Fisheries and Ocean Sciences, Institute of Fisheries Policy and Development Studies, Philippines, Iloilo, 5023 Miagao, e-mail: gdserofia@gmail.com

How to cite this article:
Bagsit F. U., Guzman A. M. T., Jimenez C. N., Serofia G. D., 2016 Quantitative measurement of vulnerability of selected coastal communities to hydrometeorological hazards, in Iloilo Province, Central Philippines. AES Bioflux 8(2):173-181.