AN INDEX TO DETERMINE VULNERABILITY OF COMMUNITIES IN A COASTAL ZONE: A CASE STUDY OF BALER, AURORA, PHILIPPINES

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ABSTRACT

A Coastal Community Vulnerability Index (CCVI) was constructed to evaluate the vulnerability of coastal communities (Buhangin, Pingit, Reserva, Sabang and Zabali) in the municipality of Baler, Aurora, Philippines. This index was composed of weighted averages of seven vulnerability factors namely; geographical, economic and livelihood, food security, environmental, policy and institutional, demographic, and capital good. Factor values were computed based on scores that described range of conditions that influence communities' susceptibility to hazard effects. Among the factors evaluated, economic and livelihood, policy and institutional and food security contributed to CCVI across communities. Only small variations on CCVI values (i.e. 0.47 to 0.53) were observed since factor values cancelled-out one another during combination process. Overall, Sabang received the highest CCVI, which was contributed mainly by geographical and demographic factors. This technique to determine factors that influenced communities' vulnerability can provide information for local governments in enhancing policies on risk mitigation and adaptation.

Keywords: vulnerability indicators, coastal communities, Philippines, social survey, geographic information system (GIS)

INTRODUCTION

Many of the causal systems and interrelationships that are relevant in the coastal areas can be described as complex (Nicholls et al. 2007). This complexity stems from the fact that

these areas are in the forefront of change and development (Selman 2000), and are influenced by various factors in global environmental (Boesch et al. 2000; McCarthy et al. 2001) and social systems (Creel 2003). Meteorological events such as hurricanes and tropical cyclones that result in damages from flooding, and shoreline erosion (Sharples 2006), or social events like economic development, population growth, and human-induced vulnerabilities have increased the risks that threaten the well-being of coastal communities (USIOTWSP 2007).

In the environmental system, the interaction of these factors result in a vulnerable condition (Cutter et al. 2003; Brooks et al. 2005) that adversely affects the quality of ecosystem services (Grant et al. 2008). In the coastal areas, these include food, livelihood and good health (Marshall et al. 2010), which when made insufficient results to dramatic social changes (Adger et al. 2005), such as communities with high dependence become vulnerable (Grant et al. 2008). These conditions and processes that increase the susceptibility of a community to the impact of hazards that result from physical, social, economical, environmental factors is regarded as vulnerability within the social systems (UNISDR 2004).

However, despite consequences of any perturbation, communities generally have inherent characteristics, and this uniqueness had permitted them to either counter or intensify any hazard effects. Most characteristics are moderated or enhanced by filters such as experiences and response capacities (Cutter et al. 2003), and the locus is an individual person. When individual characteristics are aggregated, this could provide a distinct vulnerability character for a community (UNEP 2002). A community with people having more capability to cope with extreme events is considered less vulnerable (Buckle et al. 2001). Vulnerability, in this case, can be more described as a potential condition that is expected depending on the character of an

element at risk (individual) with respect to a natural or social hazard (Varnes 1984; Hufschmidt 2011).

To determine this assumption, different social and environmental conditions influencing communities were examined with a composite index for coastal community vulnerability. This index aspired to measure communities' inherent vulnerable characteristics by putting values that quantify individual experiences and trade-offs on different attributes of potential disaster scenarios and societal processes that enhance their susceptibility to hazards. The analysis aims to provide information, which may help local governments to better understand communities' vulnerabilities in order to establish their resilience.

Assessing Vulnerability

Previous studies discussed that to determine vulnerability in a system is oftentimes difficult and intricate (Cutter et al. 2003; Eakin and Luers 2006) and no single approach is yet established (UNEP 2002). Approaches vary according to natures of risk and hazards (Mitchell et al. 1989; Cutter 1996) and systems (Fussel and Klein 2006; Eakin and Luers 2006) being analyzed. These are oftentimes bogged by lack of information about stressors in an appropriate scale (O'Brien et al 2004; Brooks et al. 2005) which result in a tendency of biased evaluation (Birkmann 2006), or issues of inconsistent variables that influence proper conceptualization (Fekete et al. 2009).

One approach for assessing vulnerability is through the indicator method, which is based on the systematic combination of indicators to assess the levels of vulnerability (Fussel 2009). Index levels may be global (Brooks et al. 2005) or national (O'Brien et al. 2004) in scale, and their simplification may vary to the kind of spatial analysis they provide (McLaughlin and

Cooper 2010). However, indices are limited in their application due to considerable subjectivity in selecting variables and their relative weights, availability of data at various scales, and difficulty of testing or validating different metrics (Luers et al. 2003; Fussel 2009).

These concerns, as well as nuances on application of vulnerability in the realm of human-environmental systems (Kumpulainen 2006; Cutter and Finch 2008) were considered in constructing the index for coastal community vulnerability in this study. This index was designed to manage incommensurability associated with different types of data and applicability of approaches (Sullivan and Meigh 2005; Cutter and Finch 2008) and followed a starting point appraisal perspective (Kelly and Adger 2000; O'Brien et al. 2004; Eakin and Luers 2006).

In the starting point appraisal, different environmental, socio-economic and political processes and their potential levels in the communities were considered to determine the state of the human dimension – one that is made vulnerable by multiple factors and mechanisms generated in social systems, with some occurring within the system (Turner et al. 2003). Based on an underlying theoretical vulnerability framework, a composite metric of these processes was developed to provide a single measurement of compounded events (Hiete and Merz 2009), and these measurement were used to categorize and rank overall community vulnerability (UNEP 2002).

The Coastal Community Vulnerability Index

Coastal communities' vulnerability was assessed based on a composite index, termed in this study as Coastal Community Vulnerability Index (CCVI). This index was derived from combination of seven major factors namely; geographical, environmental, economic and livelihood, food security, demographic, policy and institutional, and capital good (Figure 1).

These factors were modified from an indicative framework of factors affecting vulnerability of communities (Buckle et al. 2001) and were described by a set of different indicators and variables (Table 1).

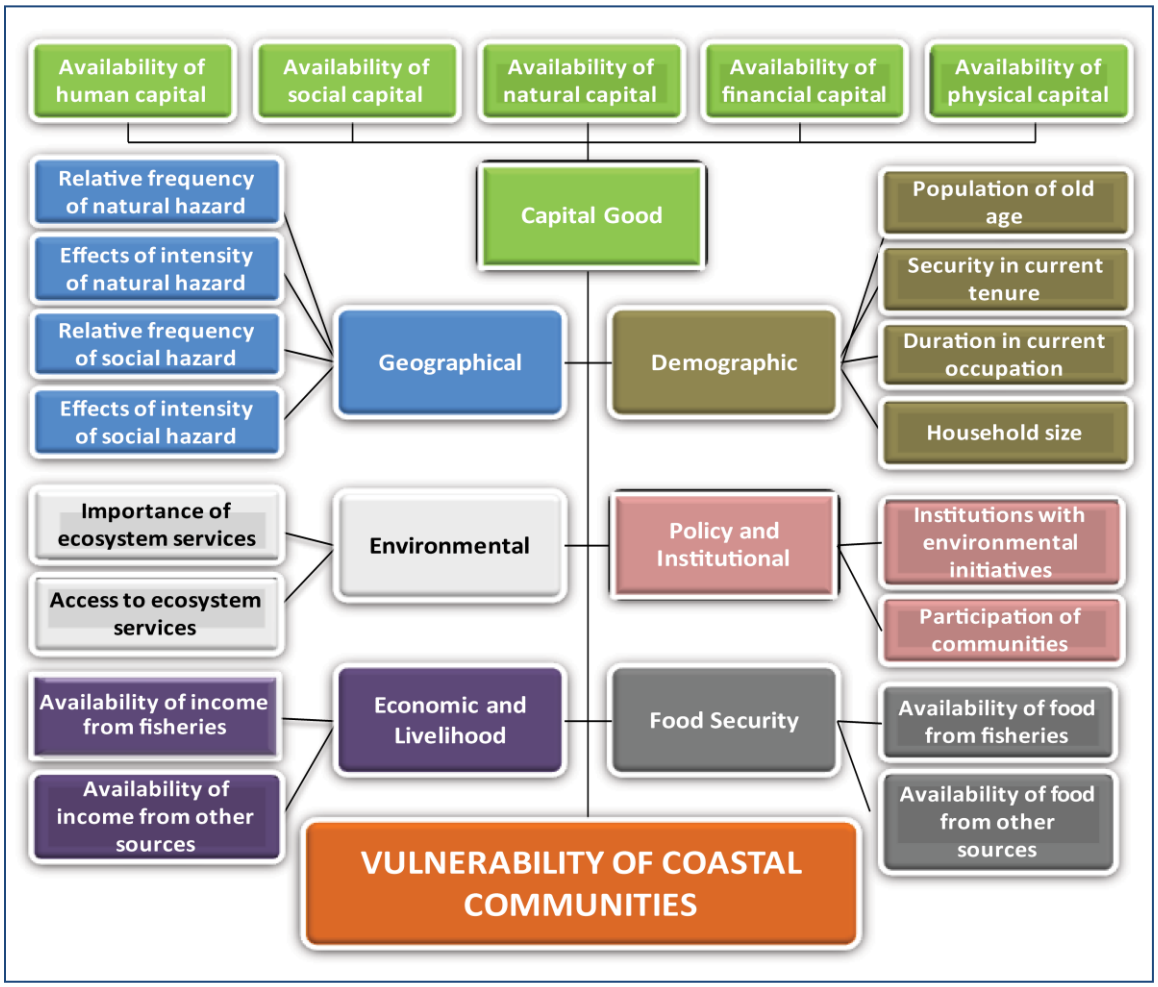

Figure 1. Indicative framework of major factors, and their respective sub-factor indicators that comprised the composite index used for analysis of coastal community vulnerability.

Indicators and variables that described the seven major factors were sourced from related researches encompassing disaster and epidemic, human security, environmental change (UNEP 2002) and sustainable livelihoods (DFID 2000). Variables like technology, infrastructure, institutions and political systems (Kelly and Adger 2000; McCarthy et al. 2001), as well as, age,

income, gender, employment, residence type, household type, health insurance, house insurance, car ownership, disability and debt and savings (Dwyer et al. 2004) were also considered. As a major resource, fisheries was considered as indicator for environmental, food security, and economic and livelihood factors. In environmental factor, communities' perception on importance and capacity for access of this resource was assessed, while communities' dependence for food and livelihood were assessed in food security and economic and livelihood factors, respectively.

All community characteristics were evaluated in relation with their experience on natural disasters, such as flood events, or social incidents, like theft, wherein people that are access deprived, elderly or in poor health are more vulnerable (Birkmann 2006). In describing experiences on hazards, basic information such as location, time, intensity and frequency are given importance (Gravley 2001). A mix of natural and anthropogenic incidents described as socio-natural events (Garatwa and Bolin 2002) were used to define these hazards, as classified from geophysical to human induced with respect to a hazard spectrum (Smith 2000). Human induced hazards that include pollution and illegal environmental practices were considered as variable components of human environmental destruction, an indicator for social hazards.

The methods undertaken to construct the composite index, which included quantification of these factors and their respective indicators are discussed in the following sections. Indicators were scored based on responses of individuals in a social survey that was conducted in a coastal municipality in the Philippines, where use of the index was piloted. The results were then analyzed and used to craft recommendations that may address sources of vulnerability of a coastal community that was ranked most vulnerable.

Table 1. Component descriptions in each index level for analysis of coastal community vulnerability

Major Factors	Sub- factor Indicators	Indicator Variables	Variable Components
Geographical Factors (GF) [1]	Relative occurrence of natural hazards	Total frequency of (3) different natural hazards	Seasonal changes (rain, heat, monsoons)
	Effects of intensity of natural hazards	Total intensity of (3) different natural hazards	Natural disasters (storms, earthquake) Natural calamity (floods, drought, diseases)
	Relative occurrence of social hazards	Total frequency of (4) different social hazards	Human environmental destruction Social conflicts (access and control of resources)
	Effects of intensity of social hazards	Total intensity of (4) different social hazards	Social discrimination (because of age, values, religion) Social security (crimes, war, death)
Environmental Factors (EF) [2]	Importance of ecosystem services	Total importance of (6) different services from coastal ecosystems	Fisheries services (marine resources) Recreation services (beach/ sea capes, nature based tourism) Forestry services (wood and lumber) Quarry services (gravel and sand)
	Access to ecosystem services	Total access to (6) different services from coastal ecosystems	Ornamental services (drift wood, seashells, pebbles) Medicinal services (leaves and roots of some plant and animal species)
Food Security Factors (FF) [2]	Availability of food from fisheries	Total fisheries used for food gathered from (2) main sources	Municipal fisheries production used for food Commercial fisheries production used for food
	Availability of food from other sources	Total availability of (4) food production activities from utilized land	Fish farming Livestock raising Crop production Fruit tree farming

Major Factors	Sub- factor Indicators	Indicator Variables	Variable Components
Economic and Livelihood Factors (ELF) [2]	Availability of income from fisheries	Total income sourced from fisheries gathered from (2) main industry sources	Municipal fisheries production for livelihood and income Commercial fisheries production for livelihood and income
	Availability of alternative income sources	Total engagement in (9) other income sources other than fisheries and fisheries-related work	Agriculture Livestock raising Small business Forestry Handicraft Regular salary Remittance from abroad Pension Daily wages
Policy and Institutional Factors (PIF) [2]	Institutions with environmental initiatives	Total knowledge of respondents on the nature of environmental activities by (5) institutions	Local Government *Barangay/* Village Non Government Organizations National Government Agencies Church/ Religious Sects
	Participation of communities	Total participation of communities in (4) different environmental activities	Establishment of marine protected area Fisheries law enforcement Registration and licensing for fishing activities Habitat enhancement (e.g. Mangrove planting)
Demographic Factors (DF) [2]	Population of old aged people	Total population based on age classification	Age is classified as (young, middle aged, somewhat old aged, old aged)
	Duration in current occupation	Total duration of stay in current employment bracketed in specific year ranges	Description of stay in current employment (very long, long, medium and short)
	Household size	Number of households members based on different classifications	Household size classification (small, medium, large, extended)
	Security in current tenure	Security of tenure based on	Description of duration based on period of time (very long,

Major Factors	Sub- factor Indicators	Indicator Variables	Variable Components
		duration in current residence and based on the type of ownership of current house and residential land	long, medium, short) Description of different tenure classification (based on 10 house and land ownership schemes)
	Availability of natural capital	Availability of land for cultivation based on ownership Utilization of owned land based on percentage cultivation	Ownership of land other than residential (with and without land) Percentage utilization of owned land (25%, 50%, 75%, 100%)
	Availability of social capital	Total membership recognizing (4) different benefits from organization	Networking assistance Training assistance Monetary assistance Livelihood assistance
Capital Good Factors (CGF) [3]		Total importance and access to different information sources	Description of value according to importance Description of value according to access
	Availability of physical capital	Total availability of (3) types for the (3) kinds of physical assets	Description of physical assets (communication, transportation and livelihood implements)
	Availability of human capital	Total workforce based on physical capacity and health of members	Absence from work due to sickness (once a month, once a semester, once a year, never)
	Availability of financial capital	Total availability of (4) types of liquefiable assets	Bank books Land titles Car ownership and registration Insurance bonds

This table shows the major factors selected and their respective indicators and variables for assessing vulnerability. Factor selection followed the index of vulnerability and its related assessments conducted by different institutions such as [1]United Nations Development Programme, Center for Research on the Epidemiology of Disasters and Red Cross' assessments of disasters and epidemics; [2]Global Environmental Change and Human Security Report 1; and [3]Sustainable Livelihoods Framework.

METHODS

Index Construction

To establish the index, each indicator and variable was quantified using values from scores generated in a social survey. The survey was conducted face-to-face and in random with household heads, and with use of a questionnaire that was scaled and designed at the level of a barangay (a term for village and is the smallest administrative division in Philippines). The determination of this scale was based on considerations gathered from pre-survey assessment activities. This technique to use surveyed information in generating values for indicators made CCVI somewhat different from how other composite indices were constructed.

The pilot study area was Baler, a coastal municipality in province of Aurora, Philippines. The municipality is situated in northern mid-eastern part of Luzon Island, and has a total land area of 9255 hectares divided into 13 barangays, of which five constitutes the coastal barangays of Buhangin, Pingit, Reserva, Sabang and Zabali (Figure 2). A grave threat of potential natural hazards that affected the coastal areas underscored the relative importance in selecting this as study site, and was reinforced by evidences of equally interesting social factors that influenced communities' vulnerabilities.

These conditions are demonstrated by competition on access to important terrestrial and marine priorities (Provincial Land Use Committee 2004), and low community regard on resource management and poor disaster response (Mohanty 2005). These are expected to complicate, as actual proofs of geographic and climatic conditions have increased the occurrence of natural hazards (Technical Working Group 2005).

Index Computations

The process adopted to compute the composite index followed a balanced weighted average approach (Sullivan 2002; Hahn et al. 2009), where major factor values equally contributed to the CCVI value. In this approach, major factors were maintained evenhanded despite difference in quantity of sub-factor indicators for each major factor. The values of sub-factor indicator that determined the major factor values were quantified from the aggregation of their respective variable component values.

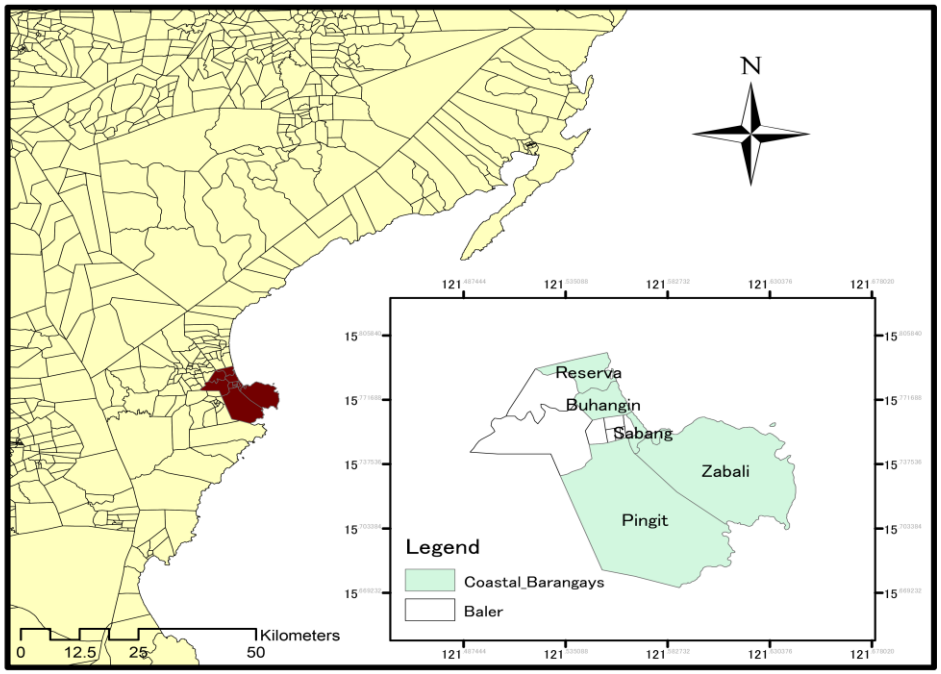

Figure 2. Map of the north-eastern Philippines showing Baler, Aurora with inset map showing the five coastal communities.

A total of 82 variable component values were computed from scored responses of individuals in each community. Responses were treated as individual scores taken from a set of scales ranging from minimum to maximum (Table 2), which were described by level of difficulties that communities have experienced to contribute to their susceptibility to hazard

effects. All individual scores from the same community were used for computing the variable component values for that community. Prior to this, scores were checked with their respective mean values, and were all found significant at $p<0.05$ using the three standard deviation rule, and only a standard error of 0.2.

The computation for each variable component values $\boldsymbol{Index_{V_{com}}}$ followed a process of standardization adopted from computation of life expectancy index of human development index (Hahn et al. 2009). This computation is shown in Equation (1):

$$\boldsymbol{Index_{V_{com}}} = \frac{V_{ave}-V_{min}}{V_{max}-V_{min}}, \qquad (1)$$

where $\boldsymbol{V_{ave}}$ is the computed mean average of all scores collected corresponding to a variable component $\boldsymbol{V_{com}}$, while $\boldsymbol{V_{max}}$ and $V_{\min}$ are respective maximum and minimum scores of respondents, respectively based on the scales set for each $\boldsymbol{V_{com}}$.

For example, to get $\boldsymbol{Index_{V_{com}}}$ of a frequency of a social hazard, all scores of respondents in a community refer to the set of scales: 1= Never; 2= Seldom; 3= Occasional; 4= Often; 5= Very often (Table 2). The mean value of all scored responses gathered, which ranges from 1 to 5 will be the $\boldsymbol{V_{ave}}$. Meanwhile, all resulting $\boldsymbol{Index_{V_{com}}}$ were respectively combined to determine the values of 23 sub-factor variables, 21 sub-factor indicators and seven major factors, with adopted and modified equations from previous studies (e.g. Hahn et al. 2009).

The computation for sub-factor variable values $\boldsymbol{S_{fv}}$ followed Equation (2):

$$\boldsymbol{S_{fv}i} = \sum_{i=1}^{n} \frac{\boldsymbol{Index_{Vcom}}}{\boldsymbol{n_{Vcom}}}, \qquad (2)$$

where $\boldsymbol{S_{fv}}$ is determined based on the average of all variable components values $\boldsymbol{Index_{V_{com}}}$ of a $\boldsymbol{S_{fv}}$, divided by the total number of variable components $\boldsymbol{n_{v_{com}}}$ that contribute to that $\boldsymbol{S_{fv}}$. All computed sub-factor variable values $\boldsymbol{S_{fv}}$, were then computed to obtain the sub-factor indicator

values $\boldsymbol{S_f}$ with Equation (3):

$$\boldsymbol{S_f i} = \sum_{i=1}^{n} \frac{S_{fv} i}{n_{Sfv}}, \qquad (3)$$

where $\boldsymbol{S_f}$ is determined based on the average of all sub-factor variables $\boldsymbol{S_{fv}}$ of a $\boldsymbol{S_f}$, divided by the total number of sub-factor variables $\boldsymbol{n_{S_{fv}}}$ that contribute to that $\boldsymbol{S_f}$. Every major factor value $\boldsymbol{F_b}$ for each barangay $\boldsymbol{b}$, on the other hand, was obtained with Equation (4):

$$\boldsymbol{F_b i} = \sum_{i=1}^{n} \frac{S_f i}{n_{Sf}}, \qquad (4)$$

where $\boldsymbol{F_b}$ is determined based on the average of all sub-factor indicator values $\boldsymbol{S_f}$ of a $\boldsymbol{F_b}$ divided by the number of sub-factor indicators $\boldsymbol{n_{S_f}}$ that contribute to that $\boldsymbol{F_b}$.

The seven $\boldsymbol{F_b}$ that were assessed for their respective contribution to vulnerability of coastal communities included geographical (GF), environmental (EF), food security (FF), economic and livelihood (ELF), demographic (DF), policy and institutional (PIF), and capital good (CGF). All levels of contribution of $\boldsymbol{F_b}$ were scaled from 0 (low contribution) to 1 (high contribution). All $\boldsymbol{F_b}$ for each barangay $\boldsymbol{b}$ were averaged to establish the Coastal Community Vulnerability Index $\boldsymbol{CCVI_b}$ for that $\boldsymbol{b}$ using Equation (5):

$$\boldsymbol{CCVI_b i} = \sum_{i=1}^{7} \frac{W_{F_b} i F_b i}{\sum_{i=1}^{7} W_{F_b} i}, \qquad (5)$$

where $\boldsymbol{CCVI_b}$ is equal to the weighted average value of seven major factors $\boldsymbol{F_b}$, and their weight $\boldsymbol{W_{F_b}}$ is determined by the number of sub-factor indicator $\boldsymbol{S_f}$ that made up each $\boldsymbol{F_b}$. $\boldsymbol{CCVI_b}$ was measured from a scale of 0 (least vulnerable) to 1 (most vulnerable).

Table 2. Description of scales for ranking variable components of sub-factor indicators. Scales for measuring different indicator variables and their respective components are shown here. Each scale has a specific range from low to high and is respectively quantified to describe responses of individuals in a social survey.

Indicator Variables	Variable Components	Variable Scales	Description of Scales
Total frequency of (3) different natural hazards	Seasonal change Natural disaster Natural calamity Human environmental destruction	5= Very often (4 events or more) 4= Often (3 events) 3= Occasional (only 2 events) 2= Seldom (only 1 event) 1= Never (no event)	Frequency of hazard occurrence refers to the number of times that a hazard has impacted the community's social and/or environmental and/or economic resources in 2009
Total frequency of (4) different social hazards	Social conflict Social discrimination Social security		
Total intensity of (3) different natural hazards	Seasonal change Natural disaster Natural calamity Human environmental destruction	5= Negative (resources destroyed causing negative results to well-being) 4= Moderately negative (some destroyed with some negative results to well-being) 3= No effect (no change in resources and/or benefits) 2= Moderately positive (with some positive benefits) 1= Positive (very positive benefits)	Intensity of occurrence of hazard refers to type of effects that a hazard has impacted the community's social and/or environmental and/or economic resources in 2009
Total intensity of (4) different social hazards	Social conflict Social discrimination Social security		
Total importance of (6) different	Fisheries services	3= Not important (not used for needs of	Ecosystem services encompassing

Indicator Variables	Variable Components	Variable Scales	Description of Scales
services from coastal ecosystems	Recreation services Forestry services Quarry services Ornamental services Medicinal services	individuals) 2= Important (source of needs of individuals) 1= Very important (only source of needs of individuals)	the four types of services (e.g. cultural, provisioning, sustaining and regulating) that are important to the community's social and/or environmental and/or economic needs in 2009
Total access to (6) different services from coastal ecosystems	Fisheries services Recreation services Forestry services Quarry services Ornamental services Medicinal services	4= No access (full restriction to access) 3= Indirect access (access comes from individuals with direct access) 2= Direct but difficult access (regulation impose restrictions for access) 1= Direct and easy access (regulation allows access)	Ecosystem services encompassing the four types of services (e.g. cultural, provisioning, sustaining and regulating) that can be accessed by the community for its social and/or environmental and/or economic needs in 2009
Total fisheries used for food gathered from (2) main industry sources	Municipal fisheries production used for food Commercial fisheries production used for food	3= < 50% (large dependency) 2= > 25% but < 50% (medium dependent) 1= < 25% (less dependent)	Annual fisheries production in 2009 from municipal (within 15km from shoreline) and commercial (outside 15km zone) that is used for entirely for food by communities
Total availability of (4) food production activities from utilized land	Fish farming Livestock raising Crop production Fruit tree farming	4= None (not available at all) 3= Sold commercially outside community (available but with more competition) 2= Sold commercially within community (available with less competition) 1= Personal and family (available with no competition)	Different food sources that are available and accessible to communities, for them to supplement their daily food needs in 2009

Indicator Variables	Variable Components	Variable Scales	Description of Scales
Total income sourced from fisheries gathered from (2) main industry sources	Municipal fisheries production used for livelihood and income Commercial fisheries production used for livelihood and income	3= > 50% (large dependency) 2= > 25% but < 50% (medium dependent) 1= < 25% (less dependent)	Annual fisheries production in 2009 from municipal (within 15km from shoreline) and commercial (outside 15km zone) that is used for entirely for livelihood and income by communities
Total engagement in (9) other income sources other than fisheries and fisheries-related work	Agriculture Livestock raising Small business Forestry Handicraft Regular Salary Remittance from abroad Pension Daily wages	4= Very important (only income source) 3= Important (major income source) 2= Less important (minor income source) 1= Not important (not source of income)	Different income and livelihood sources for communities according to its contribution in supporting their daily needs in 2009
Total knowledge of respondents on the nature of environmental activities by (5) institutions	Local Government Barangay/ Village Non Government Organization National Government Agencies Church/ Religious Sects	3= No programs (inactive) 2= With programs acting as support institution (reactive and supportive) 1= With programs acting as lead institution (autonomous and proactive)	Various institutions in 2009 that have been locally implementing resource management programs and their relative capacity for implementation
Total participation of communities in (4) different environmental activities	Establishment of Marine Protected Area Fisheries law enforcement Registration and licensing for fishing activities Habitat enhancement (Mangrove planting, MPA)	4= None (no participation) 3= Indirect (did not attend any but adheres to the activities) 2= Minimal (participated in two or three activities) 1= Full (participated all process in activities)	Various activities in 2009 that are implemented for coastal resource management that have been participated into by members of the community

Indicator Variables	Variable Components	Variable Scales	Description of Scales
Total population based on age classification	Age of members by different class	4= Above 60 years old (old) 3= 50 to 60 years old (somewhat old) 2= 35 to 50 years old (middle aged) 1= 35 and below (young)	Prevalent age class of individual members of the community
Total duration of stay in current employment bracketed in specific year ranges	Length of stay in current employment	4= less than 3 years (short) 3= 3 years to less than 5 years (medium) 2= 5 years to less than 10 years (long) 1= More than 10 years (very long)	Security of individual members of communities based on the length of stay in current employment
Number of households members based on different size classifications	Household size classification (small, medium, large, extended)	4= more than 8 members (extended) 3= 6-8 members (large) 2= 4-5 members (medium) 1= 3 or less (small)	Measure of household size based on the number of members in each household
Security of tenure based on duration in current residence and based on the type of ownership of current house and residential lot	Type of ownership of current house and residential lot	1= Own or owner-like possession of house and lot 2= Rent house, owned lot 3= Own house, rent lot 4= Own house, rent-free lot with consent of owner 5= Own house, rent-free lot without consent of owner 6= Rent house/room including lot 7= Rent house, rent-free lot with consent of owner 8= Rent house, rent-free lot without consent of owner 9= Rent-free house and lot with consent of owner 10= Rent-free house and lot without consent of owner	Security of individual members of communities based on the type of ownership of current house and lot. Note: Variables were reclassified into different ranges: 3= not secured (from 8 to 10) 2= medium security (from 5 to 7) 1= with security (from 1 to 4)
	Length of stay in current house and residential land	4= 0 month to less than 1 year 3= 1 year to 3 years 2= More than 3 years to 5 years 1= More than 5 years	Security of individual members of communities based on the duration of stay in current house and lot

Indicator Variables	Variable Components	Variable Scales	Description of Scales
Availability of land for cultivation based on ownership	Ownership of land other than residential land	2= No (without land) 1= Yes (with land)	Land was use for assessing the availability of natural capital
Utilization of owned land based on percentage cultivation	Fish farming Livestock raising Crop production Fruit tree farming	5= None 4= <25% 3= >25% but < 50% 2= >50% but <70% 1= 75% to 100%	Land that is cultivated and used for contributing to income and community's sense of well-being in 2009
Total membership recognizing (4) different benefits from organization	Networking assistance Training assistance Monetary assistance Livelihood assistance	4= Not important (no benefits) 3= Less important (with minimal benefits) 2= Important (with some benefits) 1= Very important (highest benefits)	Important benefits in 2009 that can be received by an individual that is a member of a social organization
Total value on importance and access to different information sources	Importance of information sources (e.g. local information board, villager's meeting, printed materials, informant's visiting the area and mass media (TV, radio)	3= Not important (not used for information of individuals) 2= Important (source of information of individuals) 1= Very important (only source of information of individuals)	Different information sources in 2009 that are available and important for communities for their social and/or environmental and/or economic needs
	Access of communities on information sources (e.g. local information board, villager's meeting, printed materials, informant's visiting the area, mass media (TV, radio)	4= No access (lack of access) 3= Indirect access (access is shared by members with direct access) 2= Direct but difficult access (organization impose restrictions on members for access) 1= Direct and easy access (membership allows access)	Different information sources in 2009 that are available and accessible for communities for their social and/or environmental and/or economic needs
Total workforce based on physical capacity and health of members	Health of individual community members	4= Once per month (sick very often) 3= Once per quarter (sick occasionally) 2= Once per semester (sick seldom) 1= None (never sick)	Factor of quality labor from frequency of incidents of absence from work of individual members due to health reasons in 2009 (illness, etc.)

Indicator Variables	Variable Components	Variable Scales	Description of Scales
Total availability of (4) types of liquefiable assets	Bank books Land titles Car ownership and registration Insurance bonds Bicycle (transportation)	2= No (not available) 1= Yes (available)	Reliable sources or inflows of money other than regular salaries or income that individuals use to augment or to support recovery from emergency financial obligations in 2009
Total availability of (3) types for the (3) kinds of physical assets (transportation, communication, livelihood implement)	Motorbike (transportation) Car (transportation) TV (communication) Radio (communication) Phone/ mobile phone (communication) Boat (livelihood implement) Cattle cart (livelihood implement) Farming/ fishing gear (livelihood implement)	2= No (not available) 1= Yes (available)	Comprises the basic infrastructure or goods that support communities for their social and/or environmental and/or economic needs in 2009

Social Survey

With the intention to facilitate first- hand information, the authors designed and developed the survey questionnaires and encouraged local institutions' participation in a social survey. Municipal and barangay governments, local academe and research institutions such as the Aurora State College of Technology (ASCOT) and Aurora Marine Research Development Institute (AMRDI) participated in pre-selection of enumerators from the academe's senior-level forestry students. These students underwent a brief course on data gathering techniques, which included a practicum on the use of questionnaires. These exercises were useful for students in the conduct of actual field data collection.

The survey was conducted on two consecutive Saturdays and Sundays in September 2010, when most household heads were available. A total of 182 households participated or about 35 to 40 persons in each barangay, and their identities were undisclosed in ways to preserve anonymity. The bulk of information collected for each household meant most respondents spent an average duration time of 45 minutes to complete a questionnaire. Household respondents interviewed were predominantly male (67%) and middle-aged, from 35 to 50 years old (50%).

The questionnaire comprised four major sections: household characteristics and tenure, resource use and access, social and environmental trends, and livelihood and economic activities (Orencio 2011). To quantify intensity and frequency of both social and environmental hazards in a community, three questions were asked to respondents, and their responses were used to measure the geographical factor (Table 3).

Table 3. Questions for the poll that was used for deriving variable component scores for geographic factor and sub-factors. The sequence of asking the questions for determining the variable scores are described as– the first question identifies the type of hazards based on the descriptions used, while second and third questions aim to quantify the intensity and frequency of hazards based on what the individuals have experienced in the last year.

Variables Components	Question for the Poll	Sub- factor Indicators	Question for the Poll
Seasonal change Natural disaster Natural calamity Human environmental destruction	1 From the six major types of hazard, which hazards have you and your household members experienced in the last year (2009)?	Relative occurrence of social and natural hazards Effects of intensity of social and natural hazards	2 How often have you and your household members experienced the occurrence of such hazards? 3 What type of effect did such hazards bring to you and your household members?

RESULTS

Vulnerability Factors

Major factors that appeared in high values in all communities were considered highly contributing to their respective vulnerability measurements. These factors were observed to be considerably influenced by their respective high sub-factor indicator values. This direct attribution between sub-factor indicator's contributions resulted in variations in major factor values in all communities. For instance, Sabang's geographical factor, which scored the highest value of 0.58 among communities were contributed primarily by its sub-factor indicators, frequency of social hazards at 0.25 and intensity and frequency of natural hazards at 0.90 and 0.54, respectively (Table 4).

Meanwhile, other communities like Reserva received the highest environmental factor values of 0.58, contributed mainly by inaccessibility to ecosystem services by highly dependent communities with values at 0.55. Buhangin's high values on policy and institutional factor at 0.72, on the other hand, was contributed by values that respectively described the community's lack of knowledge on environmental management activities of institutions at 0.50, which have influenced a low level of community participation on resource management at 0.94.

In terms of economic and livelihood, and food security factors, Zabali had the highest values of 0.70 and 0.80, respectively contributed by values that described communities' dependency on fisheries for income and food at 0.44 and 0.62, and lack of other income and food sources at 0.96 and 0.97. On the demographic factor, Zabali had the lowest value of 0.46 when compared with other communities, since Buhangin and Sabang had the same value at 0.51, while Pingit and Reserva were the same at 0.50.

Whilst, sub-factor indicators that contributed to the demographic factor values among communities were found to vary substantially from one to another. In Buhangin, the quantity of aged people and household members to support, valued at 0.58 and 0.60 respectively influenced to its demographic factor values. In Sabang, values that described individuals with the least security in current occupation (0.84) were its highest contributing sub-factor.

On the other hand, Reserva had different contributing sources from Pingit, as this was influenced by high values that described individuals in a least secured tenure with current residence (0.24). Pingit had no specific highest sub-factor indicator values but it exhibited similarity with Reserva because its values that described the number of aged people to support (0.52), and the number of individuals with least security in current occupation at (0.83), were not far from highest values respectively received by Buhangin and Sabang.

Table 4. Computed values in each index level for five coastal communities. The resulting values in each index level are shown. Sub-factor and major factors are scaled from 0 to 1, where 1 is described with the highest contribution, while the measure of vulnerability through the CCVI is scaled from 0 to 1, with 1 as the most vulnerable.

Index Levels	**Descriptions**	**Coastal Communities**				
		Buhangin	**Pingit**	**Reserva**	**Sabang**	**Zabali**
Sub-factor	Relative frequency of natural hazards	0.39	0.27	0.30	0.54	0.25
	Effects of intensity of natural hazards	0.89	0.70	0.63	0.90	0.26
	Relative frequency of social hazards	0.18	0.05	0.22	0.25	0.01
	Effects of intensity of social hazards	0.65	0.53	0.72	0.62	0.44
	Importance of ecosystem services	0.63	0.86	0.61	0.65	0.83
	Access to ecosystem services	0.37	0.22	0.55	0.42	0.17
	Availability of food from fisheries	0.22	0.44	0.32	0.51	0.62
	Availability of food from other sources	0.91	0.95	0.90	0.97	0.97
	Availability of income from fisheries	0.32	0.36	0.25	0.35	0.44
	Availability of alternative income sources	0.81	0.95	0.75	0.88	0.96
	Institutions with environmental activities	0.50	0.34	0.38	0.39	0.31
	Participation of communities	0.94	0.90	0.94	0.82	0.74
	Population of old aged people	0.58	0.55	0.56	0.55	0.47
	Security in current tenure	0.18	0.10	0.24	0.15	0.08
	Duration in current occupation	0.69	0.83	0.73	0.84	0.76
	Household size	0.60	0.52	0.45	0.50	0.51
	Availability of natural capital	0.37	0.45	0.39	0.52	0.52
	Availability of social capital	0.39	0.41	0.35	0.33	0.30
	Availability of human capital	0.44	0.34	0.35	0.38	0.61
	Availability of financial capital	0.36	0.34	0.32	0.34	0.23
	Availability of physical capital	0.33	0.40	0.43	0.30	0.38
Major factors	Geographic factors (GF)	0.52	0.39	0.47	0.58	0.24

Index Levels	Descriptions	Coastal Communities				
		Buhangin	**Pingit**	**Reserva**	**Sabang**	**Zabali**
	Environmental factors (EF)	0.50	0.54	0.58	0.54	0.50
	Food security factors (FF)	0.57	0.70	0.61	0.74	0.80
	Economic and livelihood factors (ELF)	0.56	0.65	0.50	0.62	0.70
	Policy and institutional factors (PIF)	0.72	0.62	0.66	0.60	0.52
	Demographic factors (DF)	0.51	0.50	0.50	0.51	0.46
	Capital good factors (CGF)	0.38	0.39	0.37	0.37	0.41
Vulnerability	Coastal Community Vulnerability Index (CCVI)	0.51	0.50	0.50	0.53	0.47

Despite these notable variations on major factor values across communities, there were no large variations on CCVI values because of the cancelling effect between factors with low values and factors with high values during the process of combination. For example, Sabang's low values on capital good factor at 0.37 cancelled out its high values on geographical factor at 0.58, and demographic factor at 0.51, which resulted in a CCVI value of 0.53, the highest among communities. In Zabali, its low geographic factor values of 0.24 cancelled out its high values on food security factor at 0.80, economic and livelihood factor at 0.70, and capital good factor at 0.41. It received the lowest CCVI value of 0.47 despite the high factor values being surprisingly higher than other communities.

DISCUSSION

Factors and CCVI Relationships

Observations on variations in major factors with high values that directly contributed to CCVI measurements for coastal communities supported the idea that inherent conditions exist between communities, and their variations distinctively contributed to their level of vulnerability (Table 4). To illustrate major factors' relationships to CCVI, the Pearson's correlation coefficient of determination (R^2), which expressed the percent of CCVI explained, was computed.

Factors that exhibited significant R^2 with CCVI at $p<0.05$ included geographical and demographic at 0.93 and 0.83, respectively. This relationship was considered probable since in both major factors and CCVI, Sabang was evaluated highest among communities, despite most of its factors being evaluated as low. It can be assumed therefore that considerable negative

effects experienced by communities on occurring hazards, and the quantity of socially-disadvantaged individuals, could likely influence a vulnerable coastal community.

On the other hand, when mean values of similar major factors of communities were computed, food security, policy and institutional, and economic and livelihood factors were evaluated highest at 0.68, 0.63 and 0.61, respectively (Figure 3). This suggests that vulnerabilities of most communities were caused by their high level of dependency on fisheries for food and income, as well as their poor knowledge and participation on environmental management activities of institutions.

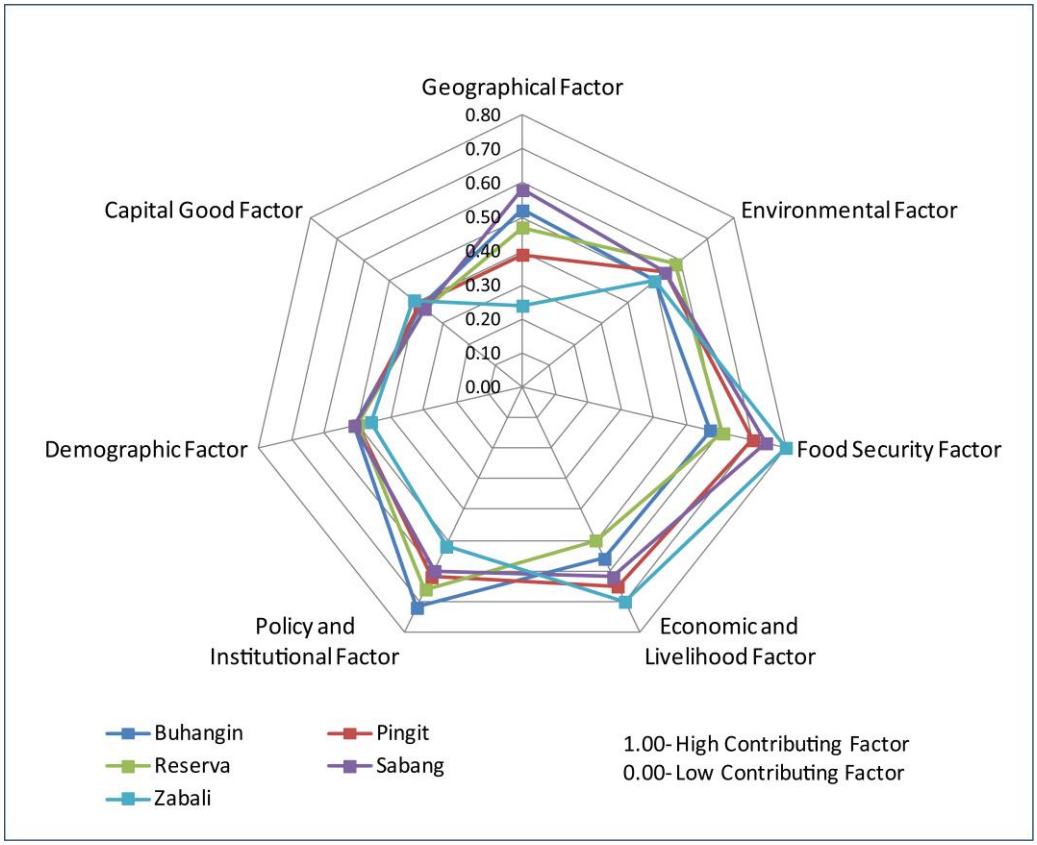

Figure 3. Major factor values and their level of contribution to overall vulnerability scaled from 0 (least contribution) to 1 (most contribution) as aggregated from their respective sub-factor indicator values for each community.

Mapping CCVI and Factor Values

Further analysis of all major factor and CCVI values of all communities was undertaken with Geographic Information System (GIS) software, ArcGIS 9.3.1. The procedure followed a normalized raster computation to produce maps with a minimum-maximum method based on a range of 0 (least vulnerable) to 1 (most vulnerable) for CCVI, and 0 (least contributing factor) and 1 (most contributing factor) for major factor values. These maps showed that communities were distinctively affected by various factors that make them vulnerable (i.e. geographical and demographic factors in Sabang). Most communities however were observed as vulnerable due to food security, policy and institutional, and economic and livelihood factors (Figure 4).

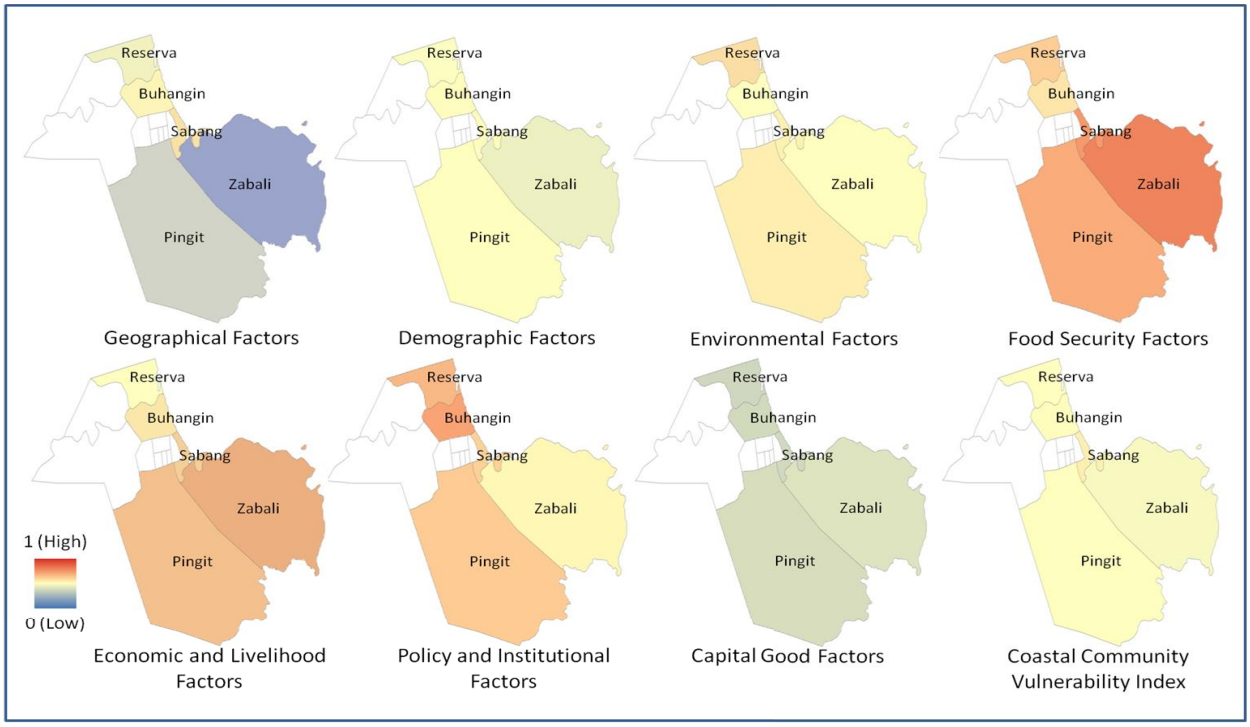

Figure 4. Normalized major factor and CCVI maps prepared with minimum-maximum method, scaled from 0 (least) and 1 (highest). All major factor maps show their relative contribution to vulnerability across communities, while CCVI map show the overall vulnerability for each community.

Spatial Assessment

A resource mapping activity in March 2011 was conducted with selected communities, following the method that assesses risks using qualitative and field based information on livelihood and food economy zones (Save the Children Fund 1997). In this workshop, participants plotted in a topographic map the location of environmental resources and major livelihood activities, and these were then digitized spatially using ArcGIS 9.3.1.

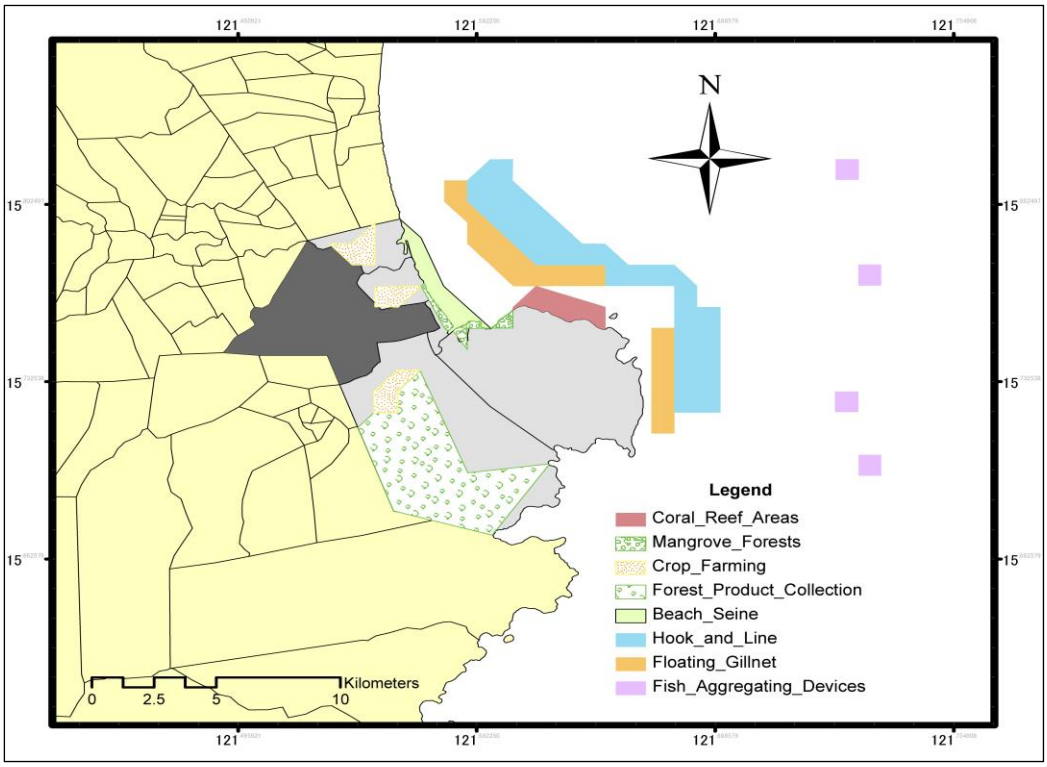

Figure 5. Map of important livelihood and food sources and environmental resources in the coastal barangays of Baler, Aurora, Philippines estimated based on research validation activities conducted in this study.

The analysis made in this activity was entirely independent and did not in any way influence the survey results (Figure 5). Rather, this was used to explain some significant factor's results. For instance, proximity to ecosystems could be a reason for Buhangin and Reserva's limited knowledge and participation on resource management, since nearer communities like

Sabang and Zabali have higher participation rates. However, this proximity also encouraged high dependence rates on coastal resources for food and livelihood. In Zabali, this rate was considered higher because of having the least difficult access on resources. Meanwhile, Buhangin, Pingit and Reserva were found less dependent on coastal resources because of availability of land for agriculture-related activities.

Sabang's Vulnerability

Among the communities assessed, Sabang was observed to be most vulnerable given its highest CCVI values. Major factors that contributed highly to this value included geographical and demographic values at 0.58 and 0.51, respectively. Conditions that triggered occurrence of these factors should be identified to address them effectively and to establish resilient communities in Sabang.

For example, Sabang's vulnerability due to demographic factors was caused by a large population density of resource-dependent individuals despite its small shoreline (Technical Working Group 2005). This limited availability of resources for a population that consisted mostly of socially-disadvantaged groups requires the implementation of equity and economic based measures. Securing quality standard of living by provision of basic services (e.g. easy access to systems for health, information and transportation) and enhancing a network of individuals to act as quasi-support mechanisms may also assist.

As argued by Mohanty (2005), with its geographic condition, Sabang must take into account potential risks from impending natural hazards by establishing an early warning system, recognized and monitored by communities, based on indicators of an imminent disaster. When designed based on timing, degree of effects and preparedness of communities, they may benefit

from this especially when embodied in a larger community-based emergency response system within available and accessible technologies, knowledge and manpower.

Further worth noticing was the unique social problem in Sabang brought by the influx of local and foreign immigrants due to tourism development. Tourism led to incidences of intermittent urban sprawl that have had considerable impact on the patterns and demands on food and livelihoods (Provincial Land Use Committee 2004). The local government could consider facilitating zonal activities in order to minimize overdevelopment. Although this has been recognized in the Baler Comprehensive Land Use Plan (Technical Working Group 2005), which anticipated that such approaches might also address overexploitation, there were no significant improvements made. Communities were even made vulnerable due to social inequities promoted by competitive and over-exploitative situations that damage important ecosystems.

Limitations in Index Design

The development of any index is in itself vulnerable to constraints from techniques and data sources used. Since social survey was used in this respect, concerns on the development of scales posed some limitations in this study. One of this is the use of a five-point scale versus a three-point scale in measuring variables. Although scores were not affected since these were standardized regardless of the scale's ranges, the five-point scale might have provided better graduated choices for respondents.

Other concerns also included scales that were set in the lowest measure, which could have defeated the determination of presumed inherent vulnerability. While scales that measure variables from lowest to highest, such as in assessing frequency of hazards, where "Never" instead of "Very Seldom" to counter "Very Often" was used, might have created

misrepresentations on variable scales that could likewise lead to a tendency to skew responses to higher scales.

In this case, the scaling system for variables may be established to provide an effective categorization of factors that contributed to their vulnerability. This and the cancelling out of values during aggregation of sub-factor indicators and major factors can be made effective with an indicator specific weighting system – an important step, that could further distinguish the character and contributions of each individual component in the process of measuring vulnerability.

To practically address some limitations on data gathering techniques and assumptions used in the context of rapid appraisal, some measures were undertaken. For instance, pre-survey assessment for a site that is evidently vulnerable based on social conditions was found helpful before administering survey to the wider communities. These provided the presumptions on communities' potential vulnerability that assisted survey design, which include questionnaires for assessing chosen indicators and variables.

Without pre-survey activities, data gathering might not be purposive, to the extent that reliability of collected data may be compromised. Moreover, participation of local institutions during training and data gathering were observed to encourage informed decision-making that likewise enhanced local ownership of research activity. On the other hand, post activities like feedback sessions with local representatives on survey results, and cross-assessment activities with communities may be conducted to counter evaluate results that might be prone to biased approaches.

Research Contributions

Managing vulnerability is part and parcel of the precautionary approach that allows policy makers to make discretionary decisions in situations where there is possibility of harm, especially to general public, based on their capacity to apply the approach. However, when there is limited information such as on sources of vulnerability, this may compromise the ability of governments to take proactive measures. In the local setting, it poses great problems because of threats that communities might face in times of extreme or uncertain change.

The starting point interpretation for vulnerability analysis has contributed to this aspect by providing significant understanding of how various components and mechanisms influence a social system. In the context of complex environment, this has led to observable levels of vulnerability that can be described by indicators, disaggregated by variables and measured in metrics. In a social survey, these indicators and variables were explained in various events and conditions that were recognized by individuals based on their experiences and perceptions.

While a pragmatic application of the index at hand was found useful in local scale analysis, calibration is still recommended prior to its use in other communities. Different sets of variables may be required for each factor that is constructed based on specific community-level scenarios. Nevertheless, results of the assessments can be considered more as baseline rather than a measure of cumulative effects of events, since causation and net impact were not part of the design. This however may be considered in future studies.

CONCLUSION

Vulnerability is difficult to determine because it involves the analysis of complex systems. The Coastal Community Vulnerability Index (CCVI) provides a way to reduce this complexity

by undertaking a simplified measurement of plausible conditions using the social survey. The results, however, should not be treated as an outcome but rather a state of being, wherein changes in social equities, resource distribution and access, opportunities in human security, livelihood patterns, and institutional management structures have influenced the conditions that make communities susceptible to any potential hazard effects.

As observed, there were slight differences in the CCVI values among communities due to the cancelling-out of factor values during the process of aggregation. Among seven factors assessed, food security, economic and livelihood and policy and institutional were found dominant as attributed to their highly rated indicator values. These results explain that communities were made vulnerable by their high dependence on fisheries resources for food and income, and poor knowledge and participation on environmental management activities of institutions. Overall, Sabang ranked as most vulnerable barangay in Baler, Aurora, Philippines with its highest CCVI, influenced by communities' negative experiences on occurring hazards, coupled with an increase of socially-disadvantaged individuals.

This site specific assessment of local vulnerable conditions was achieved based on quantified views of individuals. This process helped not only to integrate relevant critical factors and depict theoretical coherences, but also to present results in a transparent and traceable way, which is particularly important for decision-making towards managing sources of vulnerabilities. Whilst the distinct vulnerability character of a community was determined, the process can be improved by standardizing the scales used for scoring the variables, and by adopting an indicator-weighting system. With this, factors and indicator variables' distinct effects to a communities' potential vulnerability will be more relatively evaluated.

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