



HOKKAIDO UNIVERSITY

Title	Developing and applying composite indicators for assessing and characterizing vulnerability and resilience of coastal communities to environmental and social change
Author(s)	Orencio, Pedcris Miralles
Degree Grantor	北海道大学
Degree Name	博士(環境科学)
Dissertation Number	甲第11531号
Issue Date	2014-09-25
DOI	https://doi.org/10.14943/doctoral.k11531
Doc URL	https://hdl.handle.net/2115/57133
Type	doctoral thesis
File Information	Orencio_Pedcris_Miralles.pdf



**Developing and applying composite indicators for assessing
and characterizing vulnerability and resilience of coastal
communities to environmental and social change**

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Submitted in Partial Fulfillment of the Requirements
For the Degree of Doctor of Philosophy in
Environmental Science

**Course in Global Environmental Management
Graduate School of Environmental Science
Hokkaido University**

Sapporo, Japan 2014

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ABSTRACT

A key concept to achieving sustainable and invulnerable development, especially in the coastal areas, is to manage the sources of risks to disaster-causing hazards. Risk in any system is influenced by multi-dimensional factors affecting vulnerability and resilience. In this dissertation, the causal structures of these components were analyzed by indicators and metrics that measure their occurrences in the coastal areas. Two case studies in analyzing vulnerability and resilience were conducted with five coastal communities and their governing institutions, respectively, following a practical application of social assessment tools and methods in the municipality of Baler, province of Aurora, the Philippines. The first study that looked at the indicators for vulnerability illustrated variations in patterns across communities. This suggests that a vulnerability condition was particularly influenced by communities' inherent characteristics and their interactions with various social and environmental factors. Constructing resilience indicators in the second study, on the other hand, presented a method for formulating direct outcomes and processes that described a resilient coastal community. Such attempts to use an index-based approach to analyze vulnerability and resilience did not only advances pragmatic tools and mechanisms for managing risk from emerging change such as disasters. It also enhanced the strategies for characterizing risks to social and environmental changes through the application of participatory development processes toward a viable disaster- risk reduction system at the local levels.

CHAPTER ONE

ENHANCING LOCAL LEVEL PARTICIPATORY APPROACHES IN ANALYZING RISK OF COASTAL COMMUNITIES TO SOCIAL AND ENVIRONMENTAL HAZARDS

The substantial damages and setbacks to economic growth and development by disaster-causing hazards (e.g., either naturally occurring, such as earthquakes, tropical cyclones or coastal erosion, or man-made, such as water pollution or terrorist attack) have prompted policies that consider the management of integrated risks with sustainable development. This has given birth to prevailing concepts such as risk reduction (Birkmann 2006) and invulnerable development, which looks at the manner to pursue development as to reduce vulnerability (McEntire 2001; Weichselgartner 2002). Blaikie et al. (1994) described vulnerability as a combination of characteristics of a person or group, expressed as an outcome of hazard exposure.

Over time, the complexities of hazard exposure and vulnerability of society have constituted the term disaster-risk. UNEP (2002) suggested that it is important to prioritize risks in order to identify the most vulnerable people and their geographical distribution. With an increasing interest on this context, the UN International Strategy for Disaster Reduction (UNISDR), in 2004, has put forward disaster risk reduction (DRR) as an approach to systematically develop and apply policies, strategies, and practices to minimize vulnerabilities and disaster risks throughout a society, and to avoid or limit the adverse impact of hazards. As such, approaches that facilitate risk analysis had become increasingly important to properly undertake specific risk reduction measures at different levels– the communities included. With this, communities were then enjoined to participate in the assessment and planning of sustainable adaptation policies (e.g., Wisner 2004; Reid et al. 2007).

Corollary to this development, UNISDR (2007) has advocated an approach to build the disaster-resilience capacities of at-risk communities at the local level as one of the important cornerstones of risk reduction. Resilience demonstrates the persistence of relationships within a system as well as its ability to absorb and persist despite changes of

state and driving variables and parameters (Holling 1973; Folke et al. 2002). In the context of DRR, resilience adds greater emphasis on what local communities can do for themselves and how to strengthen their capacities, rather than concentrating on their vulnerability to a disaster or their needs in an emergency (Twigg 2007; Olwig 2012).

1.1. A paradigm shift

Despite the development of policies and approaches supporting risk reduction, such a system that caters for risk management capable of integrating hazard risk assessment, socio-economic factors and decision-making processes into a more integrated, holistic concept is still rare (Mercer et al. 2008). In the local level, for instance, the lack of reliable and locally-based scenarios hamper the development of scientific knowledge and information that facilitate a systematic approach to disaster adaptation and preparedness (Ibid). Likewise, involving most people at-risk and taking in account indigenous knowledge is not that prevalent as most researches adhere to an expert-oriented paternalistic approach (White et al. 2001). This allows participation to come from the top, which in turn do not guarantee a quality knowledge exchange (Krutli et al. 2006).

With a recognition that more stakeholder involvement in the risk determination process, for example interest groups and publics (see Chilvers 2007), could enhance local empowerment in the decision-making on complex issues (Krutli et al. 2010), researchers were prompted to consider participatory techniques as an approach to DRR studies (Mercer et al. 2008). Traditional knowledge is then incorporated to provide locally relevant outcomes that could promote more effective decision-making, planning and management in areas susceptible to hazards (Dolan and Walker 2003). These approaches are also popularized by organizations such as Oxfam and ActionAid in planning and undertaking disaster risk assessments and vulnerability analyses within at-risk-communities (e.g. Trujillo et al. 2000; Abarquez and Murshed 2004).

1.2. Understanding resilience from vulnerability perspectives

Vulnerability research and resilience research are often convergent. Their common elements are the shocks and stresses experienced by a system, the response of a system to a

shock, and the capacity for adaptive action (Adger 2006). Researchers such as Manyena (2006) and Cutter et al. (2008) defined resilience as associated with vulnerability. The former relate it as a concept nested within a vulnerability structure, while the latter described it as a concept linked to vulnerability. In this dissertation, I viewed resilience as a concept emanating from vulnerability.

Resilience includes the ability to absorb shocks, the autonomy of self-organization, and the capability to adapt (Gunderson and Holling 2002; Walker et al. 2006). Within the ecological literature there are two types of resilience, engineering resilience and ecosystem resilience. Engineering resilience emphasizes control, consistency, efficiency and predictability. Engineering resilience retains stability near a steady state or stable condition, while ecosystem resilience focuses on persistence, adaptability, variability and unpredictability (Gunderson and Holling 2002).

In order to quantify resilience concepts from vulnerability factors, the outputs of intuitional learning like return, re-growth and if necessary social action in areas exposed to hazards should be measured. Examples of social action that are necessary for resilience include leadership, trust, and social networking within any given community (Walker et al. 2006). For instance, socioeconomic and institutional differences are major contributors to patterns of differential vulnerability (Kasperson et al. 2005) but these can also be transformed into elements of resilience (Adger 2006).

1.3. At-risk coastal communities

Among the many communities around the world that are found prone to a vulnerable condition are the people from the coastal areas (McCarthy et al., 2001; Monirul and Mirza 2003). Coastal communities, characteristically, are dependent on fisheries and agriculture for livelihood so to deal with these increasing threats to environment and livelihoods as well as safety of households require the skills, assets and other resources necessary to adapt to changes (Lasco et al. 2008). In the Philippines, for instance, potential risks test the adaptive capacity of the people in the coastal areas as income and food security, among others, is threatened by climate variations (Uy et al. 2011). This concern highlights the need to determine the sources of vulnerability that increases community's risk to the increasing

occurrence of hazardous events.

The methods used in analyzing vulnerabilities must consider the value- inputs that best present facts for making quality decisions (Orencio and Fujii 2013a). These values and preferences could determine what should be counted as source of or limiting factor for vulnerability and this knowledge should therefore be collected directly from sources, such as the coastal communities-at-risk (Ibid). Hence, the first objective of this dissertation was to analyze vulnerability and resilience of at- risk- communities using participatory approaches. Frameworks and indices for vulnerability and resilience were constructed and were be quantitatively evaluated using metrics via social assessment tools and methods.

Conversely, a second objective was set to determine the factors that contributed to the level of vulnerability or resilience of coastal communities. These factors were expected to vary based on prevailing conditions that operate in certain spatial scales although their effects may also change relative to individuals that comprised the community. Determining the factors was just as important for local development planning, specifically in managing the sources of risks in the communities. Hence, to determine the contribution to policy development and public information, the methods for establishing indicators were assessed. This has finally constituted a third objective, which aims to look at benefits from undertaking the development and use of indicator-based approaches in evaluating at-risk communities.

An application of the composite indicator methods and the processes involved in developing a construct for understanding vulnerability and resilience was provided in the following chapters. A key evaluation criteria for establishing the indices include the level of theoretical understanding, comparability across regions and time, soundness of methods for indicator selection and aggregation, parsimony and transparency, data availability and quality, robustness with respect to uncertain input data and alternative aggregation methods, and level of validation (Gall 2007; Eriksen and Kelly 2007). These steps were then applied to two case studies conducted in the five coastal communities in the Philippines.

1.3.1. The Philippines' disaster-risk in context

Natural disasters occur frequently in the Asia-Pacific region, including in the Philippines, which often experiences large-scale disasters. For example, the Mount Pinatubo

eruption and the northern Luzon mega-earthquake that occurred in the 1990s. Meanwhile, the last two decades have witnessed an increase in strong typhoons that caused massive destruction in various parts of the country. In 2009, the Philippines was listed as the most disaster-stricken country in the world by the Center for Research on the Epidemiology of Disasters (CRED) (Vos et al. 2010).

While the main factor in disasters in the Philippines is the country's geographical location (Yumul et al. 2011), developmental problems such as socio-cultural and technological situations likewise contribute to the transformation of hazards into disasters (Asian Disaster Preparedness Center 2008). A study by the World Bank (1996) reported that two-thirds of poor people in the Philippines are engaged in the agriculture, fishery, and forestry sectors. Templo (2003), in a study commissioned by the Canadian International Development Agency (CIDA), found that the majority of poor communities consisted of indigenous people who have been pushed into the interiors by logging and mining industries, fishermen displaced from their traditional fishing grounds by commercial fishing industries, and farm and non-farm households affected by disasters or by declining industries.

1.3.2. Livelihood insecurity

The National Statistical Coordination Board (NSCB) reported in 2000 that highly urbanized cities (HUCs), such as Metropolitan Manila, had the highest poverty threshold level, while most rural households shared the lowest. The poverty threshold is also linked to a secure source of livelihood. People who are more dependent on climate-sensitive forms of natural capital and less reliant on economic or social forms of capital have greater risk from climate variability (Barnett and Adger 2007). For example, coastal communities in Baler, in the province of Aurora, were found to be more susceptible to the effects of hazards because of their dependence on coastal ecosystems for their food and livelihoods (Orencio and Fujii 2013a). Fishing, a major occupation in that area, is strongly affected by the weather such as monsoon systems that generate large waves and limit fishing operations.

In agricultural communities, extreme drought or chronic flooding have led to hunger in communities or failure to meet other needs. For example, in 1997 to 1998, El Niño conditions resulted in a 6.6% drop in agricultural production (The Philippines' Initial

National Communication on Climate Change 1999). As an immediate solution, some farmers mortgaged their farmland. Over the long term, however, this contributed to instability in agricultural communities as farmers lost their main asset base (Huigen and Jens 2006). Hence, among others, sustaining a livelihood is recognized as the key to managing rural vulnerability (Chambers 1995).

1.3.3. Overview of DRR in the Philippines

In 2009 and 2010, respectively, the Philippines' national frameworks, Climate Change Act (CCA) or the Republic Act 9729 and the Disaster Risk Reduction Management Act (DRRMA) or Republic Act 10121, have outlined the implementation of disaster-risk-free communities. The frameworks aim to systematically address the growing threats of disasters on community lives, and its impact on the environment, as well as, to strengthen and enhance DRR mechanisms and structures at the sub-national levels in the country. This coincides with projects previously implemented by non-government agencies such as the Citizen-Based and Development-Oriented Disaster Response (CBDODR) and Community-based Disaster Risk Management (CBDRM) that transform at-risk communities into disaster-resilient organizations (e.g. ADPC 2008).

Along this line, the National Economic Development Authority et al. (2008) suggested collaborations to be institutionalized that will lead to continued benchmarking and localized vulnerability studies, to achieve a more efficient and cost-effective system for risk information generation. Supporting this initiative was the mandate given to local government in implementing risk reduction systems because of their strategic position to identify and appropriately respond to the cause and effects of disasters. Local governments could readily provide effective leadership for their citizens, as well as, the opportunity to catalyze and sustain behavioral change at individual and community levels, which were necessary elements for establishing community resilience to disaster events.

CHAPTER TWO

SELECTING SOCIAL AND ENVIRONMENTAL INDICATORS TO MEASURE RISK AND VULNERABILITY OF COASTAL COMMUNITIES

Social researches as early as the 1950's have studied the social characteristics of people in specific places. These studies were used to understand how people could cope with sickness, social inequalities, and environmental inequities (Cutter and Emrich 2006). However, to enhance the understanding of the human system in relation to his environment in particular, the study of socio-ecological systems has emerged (Adger 2000). Such an approach to the analysis of this system has evolved into a science which uses a mix of demography, sociology, geography and natural science to understand social vulnerability to the effects of disaster events in a natural system (Cutter et al. 2000, Boruff et al. 2005; Adger 2006).

In the context of vulnerability analysis, indicators have served as an operational representation of a characteristic or a quality of a system to be able to provide information regarding the susceptibility, coping capacity and resilience of a system to an impact of a disaster. Considering that several socio-economic characteristics may directly apply to an individual or household, an aggregation to this effect can be expected as soon as more than one variable or characteristic for vulnerability was selected. To come up with a quantitative value for this effect, each selected indicators must be measurable in order to rank and identify social patterns.

2.1. Indicator typologies

In general, indicators are management tools which describe and operationalize a complex system's characteristics in a quantitative and transparent way. A comprehensive definition given by Gallopin (1997) regard indicators as variables which are an operational representation of an attribute, such as quality or/ and characteristics of a system. King and MacGregor (2000) presented in their paper a review of indicators undertaken by MacGregor and Fenton (1999), where five classes are revealed. The following classes include informative, predictive, problem-oriented, program-evaluation and target delineation, to wit:

- Informative indicators are used to describe the social system and the changes

taking place (e.g. social statistics subject to regular production as a time-series and which can be disaggregated by relevant variables).

- Predictive indicators, on the other hand, include indicators that are informative, which fit into explicit formal models of sub-systems of the social system (e.g. indicators such as family income and urban recreational facility location may be used in a model attempting to predict potential levels of juvenile crime in a neighborhood).
- Problem-oriented indicators point particularly toward policy situations and actions on specific social problems.
- Program evaluation indicators are used to monitor the progress and effectiveness of particular policies; and
- Target delineation indicators include variables describing the demographic, environmental, pathological or service provision characteristics which are useful in identifying geographical areas or population subgroups to which policy is directed.

2.2. Vulnerability indicators and value- inputs

Throughout the last three decades, indicators have been used to assess the vulnerability of communities and populations to various social and environmental hazards. These include socio-economic and demographic characteristics identified by Smith (1994), Blaikie et al. (1994) and Granger (1995). These social characteristics are likely significant as most people's vulnerability are found to be highly associated with them. For instance, specific groups of people that may be identified as vulnerable were the elderly or single parent families, short-time residency in the area of study or instability of livelihood source.

Ideally, this information should be directly linked to household survey data, at least via selecting communities from the same sampling frame but much of these are missing in current standard census (Dercon 2001). Moser (2003) argues that, with effort, it is possible to research this using participatory approach, and to quantify and make it representative. This would involve careful choice of communities and efforts in post-coding of answers in patterns. For example, direct questions of whether individuals were affected by particular

environmental events, where the type of questions were inspired by pilot work involving talking to many individuals in different areas close to the survey sites.

On the other hand, the essentially categorical data describing the nature of the problems faced can be aggregated in a number of relatively simple indices per community. In example, King and Macgregor (2000) expressed that a community's vulnerability or resilience to natural hazards can also be measured by the attitudes and values of its members. Rapport et al. (1998) state that values can be considered as a set of philosophical, ethical, moral and emotional principles that order an individual or society. However, values and attitudes are significantly different such that a value is a single belief but an attitude is an organization of beliefs about an attitude object (Rockeach 1973).

Despite the difficulties in clearly defining values and attitudes, it is nonetheless commonplace in social science to use attitude statements in questionnaires to determine an individual's value orientation. This can be measured by scales based on techniques designed in such a way people with different points of view could respond differently to questions about attitudes (e.g. Likert 1932). The main purpose of developing a scale in this aspect is to locate a person's attitudes to a particular object on an evaluative continuum, i.e., to determine how positive or negative those attitudes are to the person in question (King and Macgregor 2000).

2.3. Empirical vs. exploratory constructs

Prior to the selection process for an indicator, a particular construct for its purpose should be determined (Neuman 1997). Constructs are concepts or ideas, very often abstract that define or categorize an issue or situation. The construct is very often theoretical and most likely presented as a model that aims to express a relationship, or a process or an issue. Therefore, indicator constructs tend to bridge the gap between theoretical concepts of complex systems and decision-making (Hiete and Merz 2009). In this dissertation, the construct of interest is the vulnerability and the resilience of communities to disaster-causing hazards, respectively.

There are two basic premises for undertaking the constructs; either based on empirical analysis or for exploratory purposes. The difference between the two is that empirical

analysis follows studies that revealed the complex mosaics of vulnerability to describe patterns and to establish trends at other areas and other scales (UNEP 2002), while exploratory delves more deeply and more intricately into complex and changing situations by first establishing an issue to be explored, which is based on scenario-analysis (Buckle et al. 2001). In both premises, the initial step is to decide how to divide up the components to be cross-referenced (Ibid). It is important that indicators do refer relevantly and directly to the components being examined and that they minimize ambiguity as to their cause or to what they represent. On the other hand, the components should have some substantial and relevant reference to the interest or purpose they address.

2.4. Developing a composite criteria index

According to Alwang et al. (2001), developing a composite index of vulnerability that reduces all indicators to one number, that is comparable temporally and spatially, can be used for a vulnerability assessment. In this case, it is more useful to use composite indicators rather than relying on a single indicator variable for a specific construct, which means construct validity can be improved by aggregating several indicator variables together, thereby yielding a composite indicator for a specific construct of interest (King and MacGregor 2000). As the methods allow for any quality to be assessed and given a rank score of each indicator, they may then be combined, aggregated or considered in tandem to give a ranking for a broader area or social unit (Buckle et al. 2001).

Adger et al. (2004) outlined four different approaches to developing composite indices, namely:

- Constructing a single index by aggregating all relevant proxies;
- Constructing a single index by defining geographical groupings;
- Separating indices that represent different elements of vulnerability, and
- Establishing vulnerability profiles for each geographical entity.

The composite index can also diminish the importance of a single vulnerability factor by the process of averaging indicators, thereby suggesting that the area is not vulnerable when, in fact, it is extremely vulnerable on a single critical factor (Rygel et al. 2006). This further enables a comparative analysis, benchmarking and support decision-makers in

complex decision situations (e.g., in crisis management and emergency planning) (Hiete and Merz 2009).

CHAPTER THREE

DEVELOPING AN INDEX FOR COASTAL COMMUNITY VULNERABILITY: A CASE STUDY OF BALER, AURORA, PHILIPPINES

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.

3.1. 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).

3.2. 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 3.1). 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 3.1).

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.

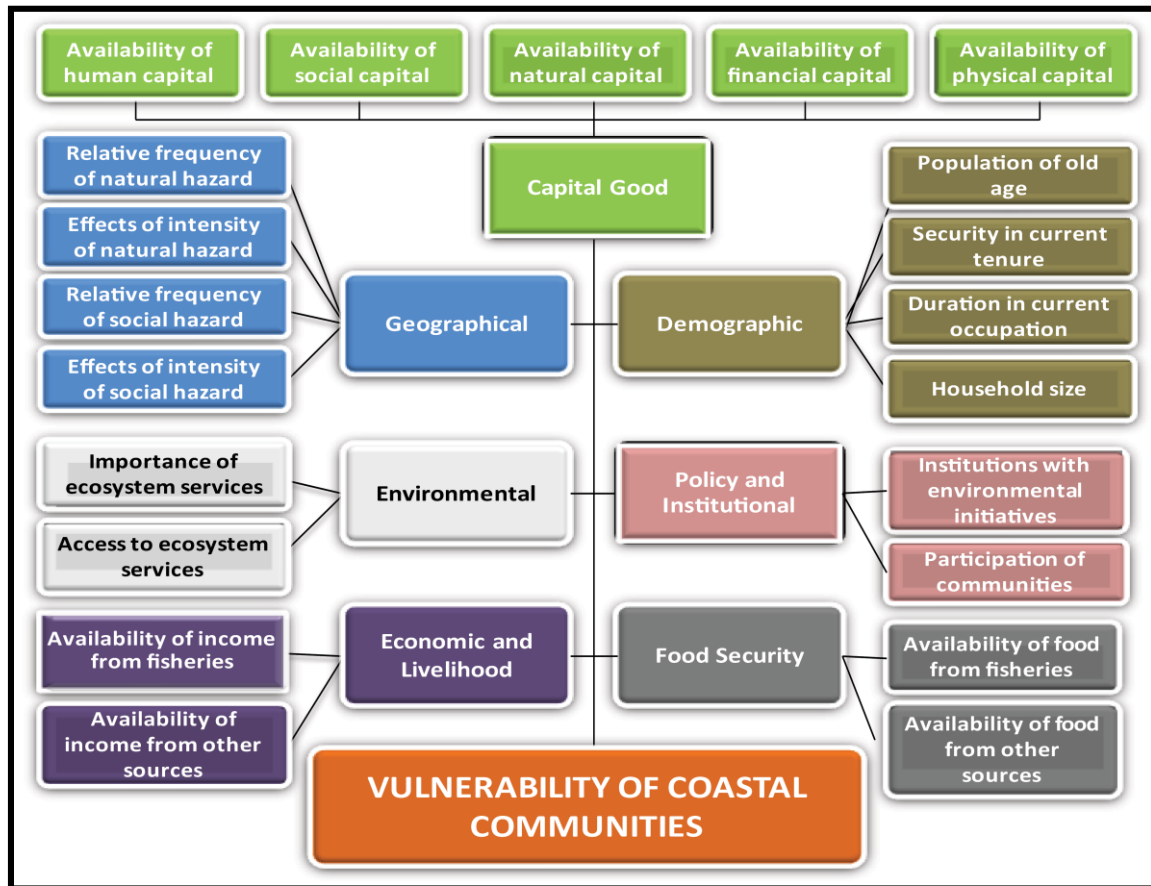


Figure 3.1. Indicative framework of major factors, and their respective sub-factor indicators that comprised the composite index used for analysis of coastal community vulnerability.

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.

Table 3.1. 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) Social discrimination (because of age, values, religion) Social security (crimes, war, death)
	Effects of intensity of social hazards	Total intensity of (4) different social hazards	
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) Ornamental services (drift wood, seashells, pebbles) Medicinal services (leaves and roots of some plant and animal species)
	Access to ecosystem services	Total access to (6) different services from coastal ecosystems	
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-Governmental 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)

Major Factors	Sub- factor Indicators	Indicator Variables	Variable Components
Capital Good Factors (CGF) ³	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 duration in current residence and based on the type of ownership of current house and residential land	Description of duration based on period of time (very long, 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	Ownership of land other than residential (with and without land)
		Utilization of owned land based on percentage cultivation	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
	Availability of physical capital	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 ¹United Nations Development Programme, Center for Research on the Epidemiology of Disasters and Red Cross' assessments of disasters and epidemics; ²Global Environmental Change and Human Security Report 1; and ³Sustainable Livelihoods Framework.

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. For example, to quantify geographical factors, both frequency and intensity of natural and social hazards were used and these were all evaluated based on the experiences of the individuals on the hazards in question. 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.

3.2.1. 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 3.2). 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).

3.2.2. 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.

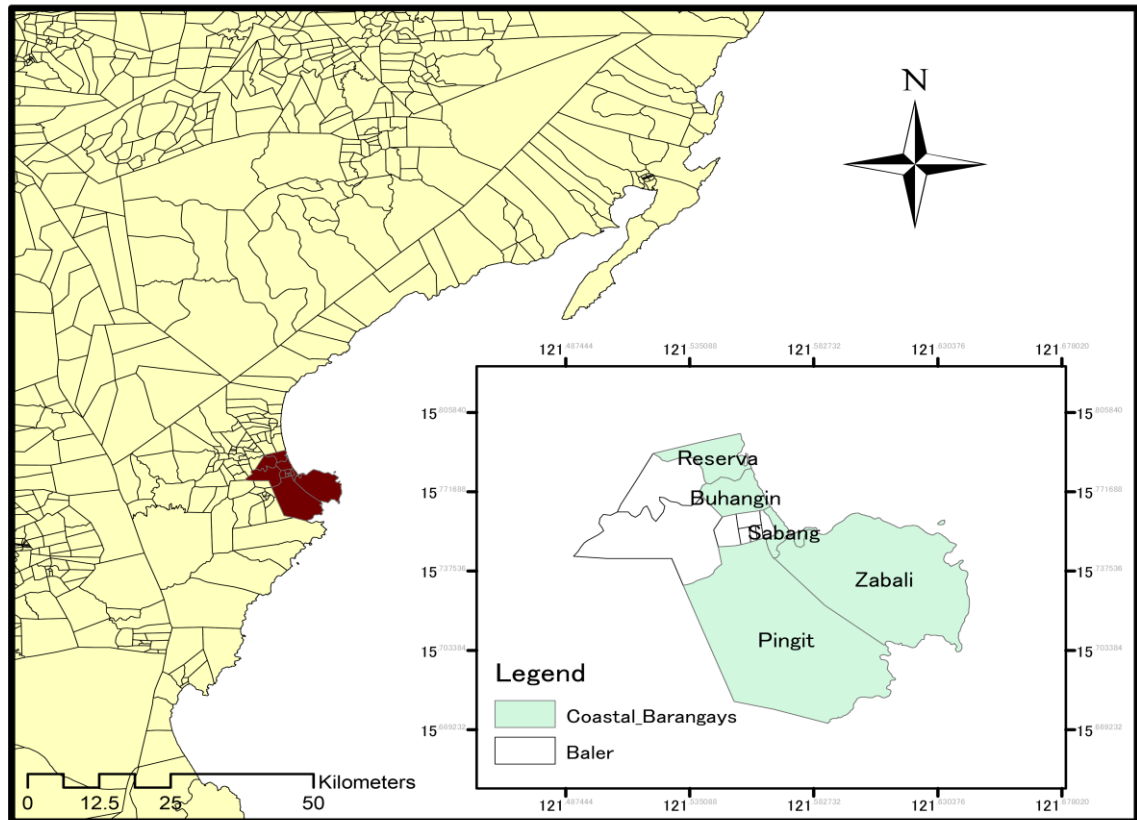


Figure 3.2. Map of the north-eastern Philippines showing Baler, Aurora with inset map showing the five coastal communities.

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 3.2), which were described by level of difficulties that communities have experienced to contribute to their susceptibility to hazard effects that occur only at their locality during the previous year from the time of the assessment. 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.

Table 3.2. 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	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	Human environmental destruction Social conflict Social discrimination Social security		
Total intensity of (3) different natural hazards	Seasonal change Natural disaster Natural calamity	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	Human environmental destruction Social conflict Social discrimination Social security		
Total importance of (6) different services from coastal ecosystems	Fisheries services Recreation services Forestry services Quarry services Ornamental services Medicinal services	3= Not important (not used for needs of individuals) 2= Important (source of needs of individuals) 1= Very important (only source of needs of individuals)	Ecosystem services encompassing 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

Indicator Variables	Variable Components	Variable Scales	Description of Scales
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
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

Indicator Variables	Variable Components	Variable Scales	Description of Scales
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
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

Indicator Variables	Variable Components	Variable Scales	Description of Scales
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
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

Indicator Variables	Variable Components	Variable Scales	Description of Scales
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	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
	Land titles		
	Car ownership and registration		
	Insurance bonds		
Total availability of (3) types for the (3) kinds of physical assets (transportation, communication, livelihood implement)	Bicycle (transportation)	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
	Motorbike (transportation)		
	Car (transportation)		
	TV (communication)		
	Radio (communication)		
	Phone/ mobile phone (communication)		
	Boat (livelihood implement)		
	Cattle cart (livelihood implement)		
	Farming/ fishing gear (livelihood implement)		

The computation for each variable component values $Index_{V_{com}}$ 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 (3.1):

$$Index_{V_{com}} = \frac{V_{ave} - V_{min}}{V_{max} - V_{min}}, \quad (\text{Eq. 3.1})$$

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

For example, to get $Index_{V_{com}}$ 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 3.2). The mean value of all scored responses gathered, which ranges from 1 to 5 will be the V_{ave} . Meanwhile, all resulting $Index_{V_{com}}$ 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 S_{fv} followed Equation (3.2):

$$S_{fv}i = \frac{\sum_{i=1}^n Index_{V_{com}}}{n_{V_{com}}}, \quad (\text{Eq. 3.2})$$

where S_{fv} is determined based on the average of all variable components values $Index_{V_{com}}$ of a S_{fv} , divided by the total number of variable components $n_{V_{com}}$ that contribute to that S_{fv} . All computed sub-factor variable values S_{fv} , were then computed to obtain the sub-factor indicator values S_f with Equation (3.3):

$$S_fi = \frac{\sum_{i=1}^n S_{fv}i}{n_{S_{fv}}}, \quad (\text{Eq. 3.3})$$

where S_f is determined based on the average of all sub-factor variables S_{fv} of a S_f , divided by the total number of sub-factor variables $n_{S_{fv}}$ that contribute to that S_f . Every major factor value F_b for each barangay b , on the other hand, was obtained with Equation (3.4):

$$F_b i = \frac{\sum_{i=1}^n S_f i}{n_{S_f}}, \quad (\text{Eq. 3.4})$$

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

The seven 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 F_b were scaled from 0 (low contribution) to 1 (high contribution). All F_b for each barangay b were averaged to establish the Coastal Community Vulnerability Index $CCVI_b$ for that b using Equation (3.5):

$$CCVI_b = \frac{\sum_{i=1}^n W_{F_b i} F_{b i}}{\sum_{i=1}^n W_{F_b i}}, \quad (\text{Eq. 3.5})$$

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

3.3. 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 3.3).

Table 3.3. 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	1 From the seven 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	2 How often have you and your household members experienced the occurrence of such hazards?
Natural change			
Natural calamity			
Human environmental destruction			
Social conflict		Effects of intensity of social and natural hazards	3 What type of effect did such hazards bring to you and your household members?
Social discrimination			
Social security			

3.4. Resulting 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 3.4).

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.

3.5. Resulting CCVI

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.

3.6. 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 3.4). 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 3.3). 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.

3.7. 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 3.4).

Table 3.4. The computed values in each index level for five coastal communities 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

Index Levels	Descriptions	Coastal Communities				
		Buhangin	Pingit	Reserva	Sabang	Zabali
Major factors	Geographic factors (GF)	0.52	0.39	0.47	0.58	0.24
	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

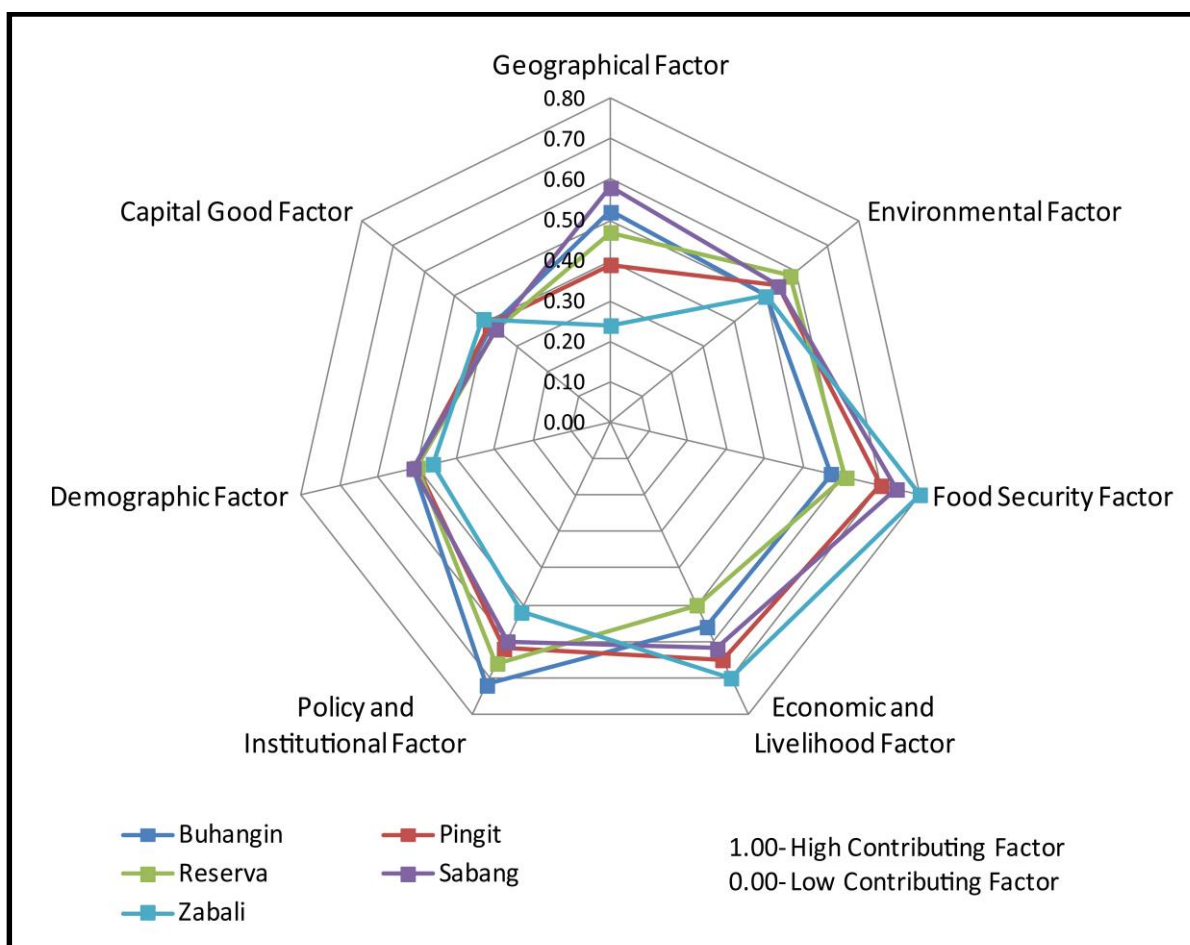


Figure 3.3. Major factor values and their level of contribution to overall vulnerability scaled from 0 (least contribution) to 1 (most contribution) as aggregated from their respective sub-factor indicator values for each community.

3.7.1. 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.

The analysis made in this activity was entirely independent and did not in any way influence the survey results (Figure 3.5). 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.

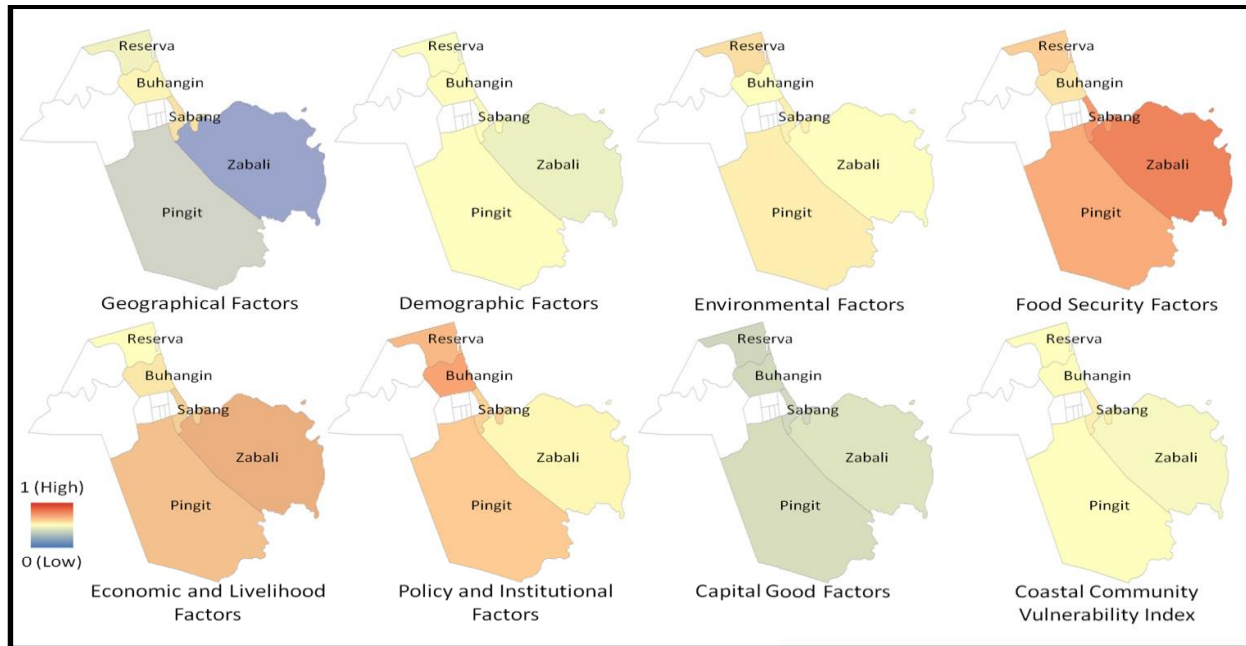


Figure 3.4. Normalized major factor and CCVI maps prepared with minimum-maximum method, scaled from 0 (least) and 1 (highest). All major factor maps show their relative contribution to vulnerability across communities, while CCVI map show the overall vulnerability for each community.

3.8. 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.

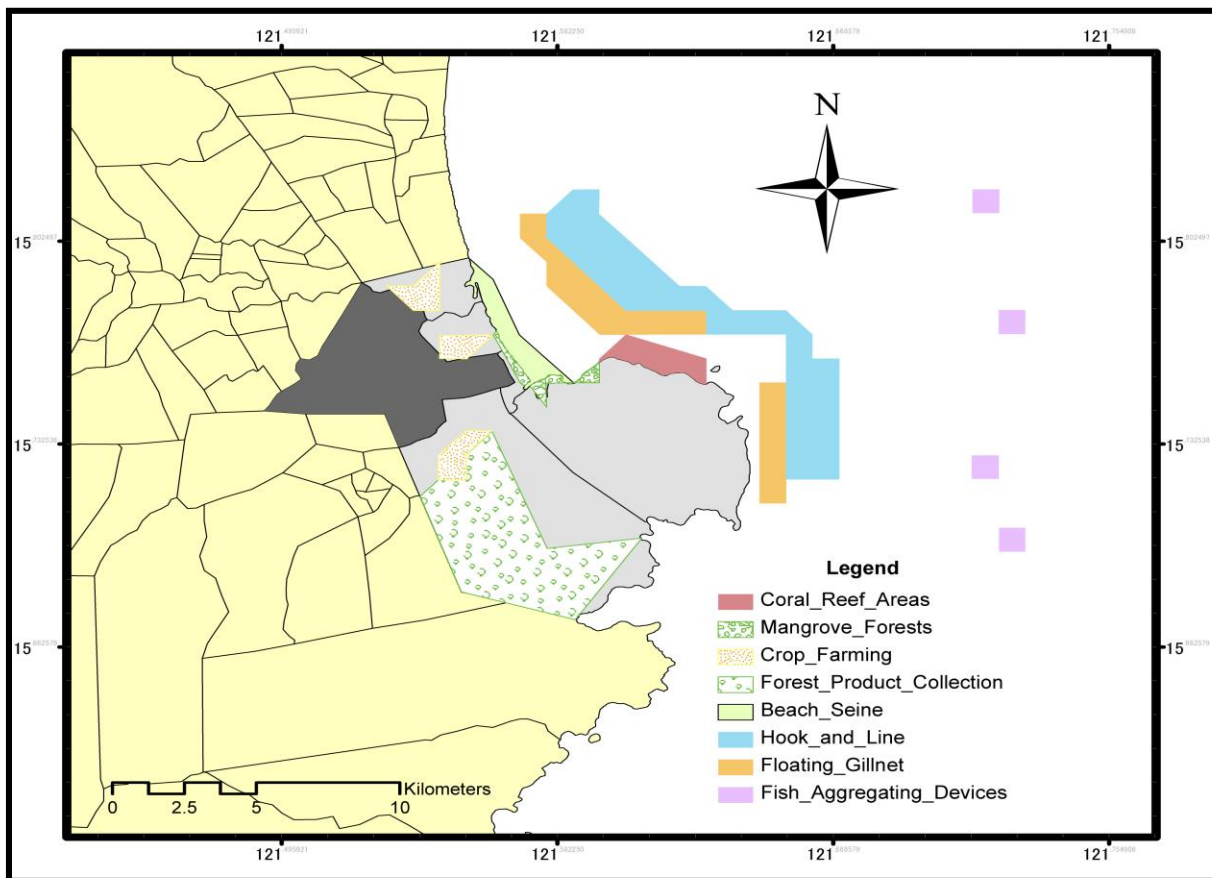


Figure 3.5. Map of important livelihood and food sources and environmental resources in the coastal barangays of Baler, Aurora, Philippines estimated based on research validation activities conducted in this study.

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.

3.9. 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. Conversely, following the starting point appraisal, the questionnaires were constructed based only on a previous year's perception and experience of respondents, hence, it can only cover experience on hazards that occur in that year.

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.

3.10. 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.

CHAPTER FOUR

DEVELOPING AN INDEX FOR COASTAL COMMUNITY DISASTER-RESILIENCE BASED ON AN ANALYTIC HIERARCHY PROCESS (AHP)

The number of people affected by disasters has increased considerably over the last 30 years. Droughts, floods, and tropical storms accounted for approximately 100 thousand fatalities and US \$250 billion of damage in 2005 (Goklany 2007; Stolton et al. 2008) and for 80% of life-threatening natural hazards worldwide (Bhavnani et al. 2008). Based on distribution, developing countries experienced the greatest impact and loss (UNISDR 2004), accounting for 97% of the affected communities worldwide (SIWI 2005). Because coastal zones within 200 km of the oceans are home to about half of the global population (Creel 2003) and are more prone to hazards (Boesch et al. 2000; IPCC 2007), a large number of people are at risk. This population is often composed of communities that lack the capacity to effectively plan for and respond to hazards (USIOTWSP 2007).

If vulnerable people and property are not considered, hazards can be regarded as simply natural environmental processes (Blaikie et al. 1994). Based on this view, hazard-risk management and disaster solutions have shifted from the typical technical solutions provided by hard science toward understanding conditions associated with the human aspects of disaster occurrences (Cannon 1994). This includes the application of systems that increase security through social and ecological resilience (Adger 2005). Likewise, factors that diminish the adverse hazard effects must be understood, as these may improve the capacity of a community to respond to and recover from subsequent hazard events (Cutter et al. 2010). By strengthening their local capacity, it is possible to develop invulnerable communities (McEntire 2001).

Resilient communities experience less damage and tend to recover quickly from disasters (Buckle et al. 2001). These communities absorb stress either through resistance or adaptation, manage and maintain basic functions despite effects, and can recover with specific behavioral strategies for risk reduction (Twigg 2007). To determine and to measure the factors to enhancing resilience of coastal communities in the face of disasters, I performed a case study of local indicators of a disaster-resilient coastal community in the Philippines.

4.1. Disasters and local coping mechanisms in the Philippines

The Philippines lie between the Pacific and Eurasian plates along the Western Pacific basin, a location frequented by climatic conditions such as typhoons, sea surges, and volcanic eruptions. According to the Center for Research on the Epidemiology of Disasters (CRED), the country was the most disaster-stricken nation in the world in 2009 (Voz et al. 2010), with a total of 191 natural and human-induced disasters reported to have killed 903 persons and affecting more than 2.8 million families (CDRC 2009).

Meanwhile, a huge gap between recognition and active implementation of disaster-management programs exists in the Philippines, which is often attributed to the failure of the government to provide adequate resources, education, and awareness related to mitigating various hazard threats (ADPC 2008). Destruction in different parts of the country had clearly manifested in poor disaster prediction and forecasting failures, especially in the local levels. Local capability to undertake risk mitigation is lacking and local governments rarely performed risk assessments without external support (ADPC 2008; NEDA et al. 2008). Expected investments of funds in local risk-management policies also posed a significant challenge in terms of political support, which often resulted in a biased implementation and community participation in disaster-management programs (ADPC 2008; NEDA et al. 2008).

Within these situations, disasters are caused not only by natural events but also by the dysfunctional social institutions and inherently vulnerable nature of the community (Cannon 1994). In the coastal areas, for instance, where 60% of the Philippines' population resides, a large portion of people and property must make adjustments when disasters occur (World Bank 2005), including many fishery-dependent communities that were constantly affected by poverty and a lack of social services (Israel et al. 2004; World Bank 2005).

Nonetheless, unique local mechanisms or indigenous response systems become typical in some disaster-prone areas in the country (ADPC 2008; Heijmans and Victoria 2001). An example of this is the flood-prone communities in the municipality of Bula, Camarines Sur, which established management teams and implemented systems for response and recovery from disasters (Luna 2000). Projects such as the Citizen-Based and Development-Oriented Disaster Response (CBDODR) and Community-based Disaster Risk Management (CBDRM), implemented by non-government organizations, have added to this context, as they transformed at-risk communities into disaster-resilient organizations (ADPC 2008).

NEDA et al. (2008) has incorporated some activities of these projects in an approach that mainstreamed disaster-risk reduction (DRR) to the sub-national level. A tool to assess the factors that could enhance local resilience from disasters, however, would significantly contribute for a localized DRR approach.

4.2. Local-level disaster-risk reduction

UNISDR (2007) highly recognized the capacity of local communities as cornerstones to the overall global movement for disaster-risk reduction. Practically, this means putting greater emphasis on what people can do for themselves and how to strengthen their capacity for resilience, rather than concentrating on their vulnerability to disaster or their needs in an emergency (Twigg 2007). This concept recognizes that, by focusing on the capability and ability to adapt, people and communities affected by disasters are not just passive victims but capable agents (Olwig 2012).

In this dissertation, I adopted the term resilience from ecosystem resilience concepts (Holling et al. 1973) within the ecological literature. This type of resilience occurs after a disturbance and is related to the system's ability to adapt, reorganize, undergo change, and still maintain its basic structure, function, identity and feedbacks (Walker et al. 2006). The concept can be explained broadly as the capacity of a community, a group or an organization exposed to a hazard to maintain functional level, withstand loss or damage or to recover from the impact of a disaster and reorganize for future protection (UNISDR 2004).

Community resilience is increasingly being seen as a key step towards disaster risk reduction, and the ability to measure it is largely considered by researchers (Cutter et al. 2010). How researchers were viewing resilience, however, influenced the proposed measurements, for instance, as a process in the ecological perspective (Manyena 2006) or as an outcome in the social perspective (Adger 2000). Moreover, tool development has remained to be a challenge despite numerous theoretical underpinnings that tackle this concept in various scales. Only few procedures within the existing literature (e.g., Cutter et al. 2008; Peacock et al. 2010; Sherrieb et al. 2010), however, suggested how the concept could be quantified and be used to categorize or to compare communities.

4.3. Disaster-resilient components based on Analytic Hierarchy Process

This study proposed a novel approach to developing a tool for quantifying disaster

resilience in the Philippines by synthesizing national-level disaster resilience components using the Analytic Hierarchy Process (AHP). The AHP is a methodological approach to decision making that can be applied to resolve highly complex problems involving multiple scenarios, criteria, and actors (Satty 1980). This approach has been used in various studies that aimed to enhance development in different sectors such as tourism (Filipovic 2007; Ok et al. 2011), environmental and natural resources (Schmoldt et al. 2001), forestry (Samari et al. 2012), coastal management (Ryu et al. 2011), and disaster and risk management (Carreno et al. 2007; Chen et al. 2009).

As a decision system, the AHP is valuable for using human cognition in determining the relative importance among a collection of alternatives using paired comparisons (Satty 2001). Corollary, the important alternatives can be used to develop an evaluation tool for assessing performance of business firms (Yang and Shi 2002) or to select the best design concept in product development (Ariff et al. 2008). On the other hand, it is found effective when assigning weights for indicators of disaster risks and vulnerability indices (Cardona and Carreno 2011) or when ranking risk factors in a flood risk assessment model (Yang et al. 2012). With the AHP, important household attributes can also be selected to serve as indicators that measure and categorize household vulnerability to climatic risk (Eakin and Tapia 2008).

In this study, the AHP was used to determine the criteria and elements that best described a disaster-resilient coastal community at the local level by subjecting the components of a risk management and vulnerability reduction system in the Philippines (Twigg 2007; NEDA et al. 2008) in a process of prioritization. An outcome framework for disaster-resilient coastal communities was designed based on priority components and were used to determine the outcome indicators of a composite index for a disaster resilient coastal community. The development of an index, with participation of selected members from a low vulnerability coastal community, was primary in the country. This tool can then be used to evaluate the resilience of local coastal communities from disasters.

4.3.1. Development of the AHP model

The components that best described a disaster-resilient coastal community were presented on a three-tier hierarchy representing relevant aspects of community resilience in an AHP model (Figure 4.1), wherein the top tier represented a goal related to the problem. The second tier consisted of seven criteria determined based on resilience components in Twigg (2007). These

included Environmental and Natural Resource Management (ENRM), Human Health and Well Being (HWB), Sustainable Livelihoods (SL), Social Protection (SP), Financial Instruments (FI), Physical Protection and Structural and Technical Measures (PPST), and Planning Regimes (PR).

Finally, attribute elements for each criterion characterizing disaster-resilient communities represented by C and risk-reduction-enabling environments represented by E formed the bottom tier. For example, the elements that characterized disaster-resilient communities for the criterion ENRM were ENRMC1, ENRMC2..., and ENRMC5, while the elements that characterized risk-reduction-enabling environment were ENRME1, ENRME2..., and ENRME5, wherein the numbers 1,2,... n correspond to a specific attribute element (Table 4.1).

In each tier, the number of criteria and their elements compared were maintained within the suggested limits in a comparison scheme where seven is the maximum (Satty 2001). With this consideration, decision makers reduced attribute elements of the PPST and SL criteria to seven components based on their relevance and applicability in the local context.

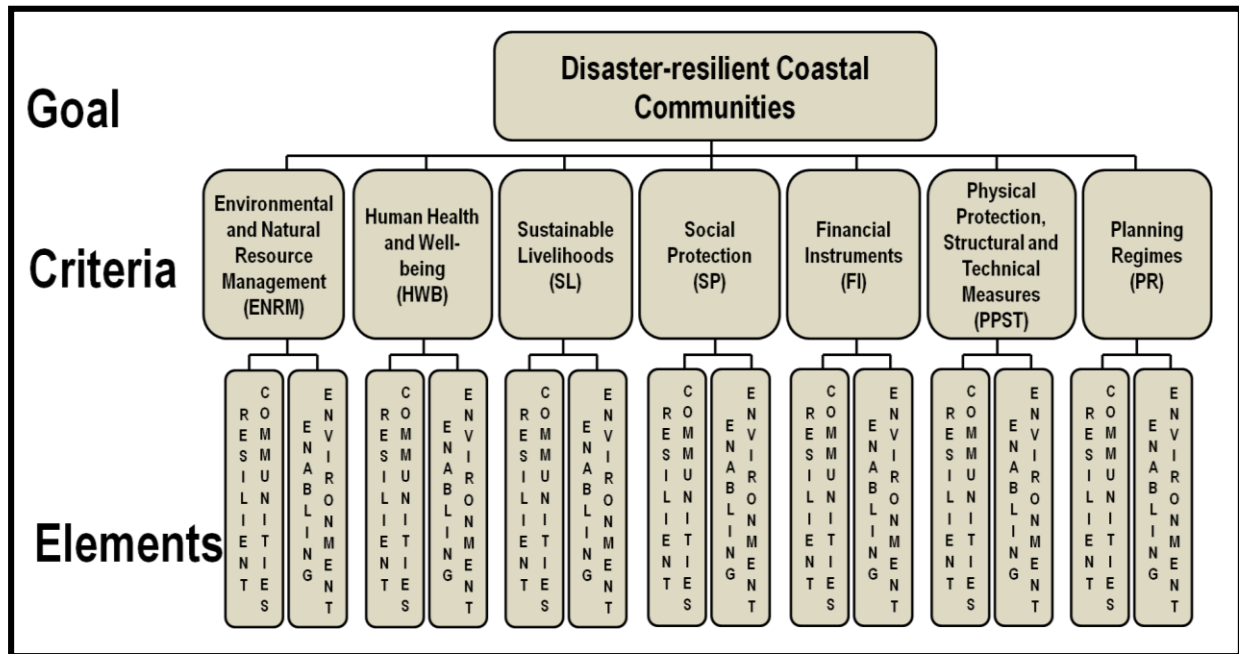


Figure 4.1. AHP model used in the process of prioritizing criteria for a disaster-resilient coastal community

4.3.2. Local decision makers

The process of prioritization for components of a disaster-resilient coastal community was

conducted in March 2012 in the municipality of Baler, province of Aurora, the Philippines (Figure 3.2). In this municipality, Zabali was considered the least vulnerable coastal community in an assessment that measured their susceptibility to various hazards (Orencio and Fujii 2013a).

The familiarity and experience of communities in Zabali in mitigating the sources of vulnerability were the major reasons for considering them as local experts. These community members, along with service providers on coastal management and disaster planning from academia and local governments, were considered decision makers during the prioritization. They were all selected based on their experience, skills, knowledge and practices related to different aspects of addressing vulnerable communities.

4.4. Weights of alternatives in a consistent matrix

With reference to the AHP model, important alternative criteria and elements associated with achieving a disaster-resilient coastal community were identified using paired comparisons and ratio-scale measurement. This is described by the formula:

$$n \cdot (n - 1)/2, \quad (\text{Eq. 4.1})$$

where n is the number of alternative criteria or elements ($a_1, a_2, \dots, a_n$) in a judgment of prioritization (Satty et al. 1991; Satty 2001). In this case, there were 21 comparisons involved in a matrix for seven alternative criteria, while comparisons of attribute elements for each criterion varied from three to 21 and were composed of three to seven alternatives.

Each product of a paired comparison was considered an expression of the decision maker's relative preferences for one alternative over another based on a set of fundamental scales (Table 4.2) composed of values ranging from 1 to 9 (Satty 1980; Satty et al. 1991). Coyle (2004) explained that when a decision maker decided that alternative i was equally important to another alternative j , a comparison represented by $a_{ij} = a_{ji} = 1$ was expected.

Nonetheless, when alternative i was considered extremely important compared with alternative j , the calculation matrix score was based on $a_{ij} = 9$ and $a_{ji} = 1/9$. The distribution of these scores in a square matrix resulted in a reciprocal matrix (Alonso and Lamata 2006), represented as:

Table 4.1. Components of risk-management and vulnerability-reduction systems (Twigg 2007, NEDA et al. 2008)

Criteria		Elements of Disaster-resilient Communities		Elements of Risk-reduction-enabling Environment	
ENRM	Environmental and natural resource management	ENRMC1	Understanding of functioning environment and ecosystems	ENRME1	Supportive policy and institutional structure
		ENRMC2	Environmental practices that reduce hazard risk	ENRME2	Prevention of unsustainable land use
		ENRMC3	Preservation of biodiversity for equitable distribution system	ENRME3	Policy linking environmental management and risk reduction
		ENRMC4	Application of indigenous knowledge and technologies	ENRME4	DRR policies and strategies integrated with climate change
		ENRMC5	Access to community-managed common property resources	ENRME5	Availability of local experts and extension workers
HWB	Health and well-being	HWBC1	High physical ability to labor and good health	HBWE1	Public health structures integrated into disaster emergency plans
		HWBC2	High level of personal security and freedom psychological threats	HBWE2	Community structures integrated into public health systems
		HWBC3	Secured food supply and nutritional status during crisis	HBWE3	Health education programs relevant to crisis
		HWBC4	Access to water for domestic needs during crises	HBWE4	Policy for food security through market and nonmarket interventions
		HWBC5	Awareness of means and possession of skills of staying healthy	HBWE5	Multi-sector engagement for managing food and health crises
		HWBC6	Management of psychological consequences of disasters	HBWE6	Emergency plans provide buffer stocks of food, medicines, etc.
		HWBC7	Trained workers to respond to physical and mental consequences of disasters		
SL	Sustainable livelihoods	SLC1	High level of local economic and employment stability	SLE1	Equitable economic development
		SLC2	Equitable distribution of wealth and livelihood in community	SLE2	Diversification of national and sub-national economies

Criteria		Elements of Disaster-resilient Communities		Elements of Risk-reduction-enabling Environment	
		SLC3	Livelihood diversification in rural areas	SLE3	Poverty-reduction targets vulnerable groups
		SLC4	Fewer people engaged in unsafe livelihood	SLE4	DRR reflected as integral part of policy for economic development
		SLC5	Adoption of hazard-resistant agriculture	SLE5	Adequate and fair wages guaranteed by law
		SLC6	Small enterprises with protection and business continuity/ recovery plans	SLE6	Supportive policy on equitable use and access to common resources
		SLC7	Local market and trade links protected from hazards	SLE7	Incentives to reduce vulnerable livelihood
		SPC1	Social support and network systems on DRR activities	SPE1	Social protection and safety nets for vulnerable groups
		SPC2	Cooperation with local community for DRR activities	SPE2	Coherent policy and networks for social protection and safety nets
SP	Social protection	SPC3	Community access to basic social services	SPE3	Comprehensive partnership with external agencies on DRR
		SPC4	Established social information and communication channels		
		SPC5	Collective knowledge and experience of management of previous events		
FI	Financial Instruments	FIC1	Enough household and community asset bases to support crisis-coping	FIE1	Government and private sector support for financial mitigation
		FIC2	Costs and risks of disasters shared through collective ownership of assets	FIE2	Economic incentives for DRR actions
		FIC3	Access to savings and credit schemes, and microfinance services	FIE3	Microfinance, cash aid, credit loan guarantees made available
		FIC4	Community access to affordable insurance from viable institutions		
		FIC5	Community disaster fund to implement DRR activities		

Criteria		Elements of Disaster-resilient Communities		Elements of Risk-reduction-enabling Environment	
		FIC6	Access to money transfers and remittances from members abroad		
PPST	Physical protection; structural and technical measures	PPSTC1	Decisions and plans on built environment consider hazard risks	PPSTE1	Compliance with international standards that consider hazard risks
		PPSTC2	Security of land ownership/tenancy rights	PPSTE2	Compliance of public infrastructure with standards
		PPSTC3	Adoption of hazard-resilient construction and maintenance practices	PPSTE3	Carry out vulnerability assessment for all infrastructure system
		PPSTC4	Community capacities and skills to build, retrofit, maintain structures	PPSTE4	Retrofitting critical public facilities and infrastructure in high risk areas
		PPSTC5	Infrastructure and public facilities to support emergency management needs	PPSTE5	Security of access to public health and other emergency facilities
		PPSTC6	Resilient and accessible critical emergency facilities	PPSTE6	Legal systems protect land access and ownership and tenancy rights
		PPSTC7	Resilient transport/ service infrastructure and connections	PPSTE7	Legal and economic systems respond to population patterns
PR	Planning regimes	PRC1	Community decision making takes on land use and hazards	PRE1	Compliance with standard international planning
		PRC2	Local disaster plans feed into local development and land use planning	PRE2	Land use planning takes hazard risks into account
		PRC3	Local community participates in all stages of DRR planning	PRE3	Effective inspection and enforcement regimes
				PRE4	Land use plan schemes based on risks assessments

$$A = [a_{ij}] = \begin{Bmatrix} 1 & a_{1j} & \dots & a_{1n} \\ 1/a_{1j} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{Bmatrix}, \quad (\text{Eq. 4.2})$$

where $A = [a_{ij}]$ is a representation of the intensity of the decision maker's preference for one over another compared alternative a_{ij} and for all comparisons $i, j = 1, 2, \dots, n$. Decision makers facilitated the comparisons of alternative criteria or elements in two rounds until the scores were considered stable. Stability was reached when a certain consensus on a sum of scores was achieved.

Table 4.2. Rating scale for judging preferences used for the pair-wise comparison of various criteria and attribute elements of a disaster-resilient coastal community

Scale	Judgment of Preference	Description
1	Equally important	Two factors contribute equally to the objective
3	Moderately important	Experience and judgment slightly favor one over the other
5	Strongly important	Experience and judgment strongly favor one over the other
7	Very strongly important	Experience and judgment very strongly favor one over the other, as demonstrated in practice
9	Extremely important	The evidence favoring one over the other is of the highest possible validity
2, 4, 6, 8	Intermediate preferences between adjacent scales	When compromise is needed

Multiplying together the comparison scores of alternative criteria or elements in each row of the reciprocal matrix and then taking the n^{th} root of that product generated a good approximation of the element weights for each alternative (Coyle 2004), as follows:

$$\text{Element weight} = \sqrt[n]{a_{1j} \cdot a_{nj} \cdot \dots \cdot a_{nn}}. \quad (\text{Eq. 4.3})$$

The weights in a column were summed, and that sum was used to obtain the normalized eigenvector w_{ij} for that alternative, as shown by the formula:

$$w_{ij} = \frac{\text{Element weight}}{\sum \text{Element weights in column}}. \quad (\text{Eq. 4.4})$$

When matrix A was multiplied by the vector w_{ij} , the operation resulted in a new priority vector nw_{ij} . A similar nw_{ij} value was obtained when w_{ij} was multiplied by the maximum eigen value λ_{max} (Satty 1990). The importance of criteria and elements in achieving a disaster-resilient coastal community was determined by a high nw_{ij} value for each criterion or element. This vector is the

sum of products of elements in each row and the normalized w_{ij} in each column (Coyle 2004), as follows:

$$nw_{ij} = \sum_{i,j=1,2}^n a_{ij}w_{ij}. \quad (\text{Eq. 4.5})$$

In a consistent matrix, nw_{ij} values for each criterion or element became weights, from which the rank of each of the other alternatives in the respective set of components was determined.

4.4.1. Consensus building

A consensus on the final scores of every paired comparison of criteria or elements was reached in a process involving the Delphi technique (Kaynak and Macaulay 1984; Richey et al. 1985). The final scores were computed based on a geometric mean of all scores given by decision makers for each paired comparison (Aczel and Satty 1983). Once a consensus was reached, a summary of final scores for each paired comparison was entered into a matrix or decision table.

The scores, as well as their nw_{ij} values, were accepted when they reached a certain level of consistency, as determined by a consistency index CI computed by Eq. 4.6:

$$CI = (\lambda_{max} - n)/(n - 1), \quad (\text{Eq. 4.6})$$

where λ_{max} is the maximum eigen value computed by averaging all individual eigen values λ , and n is the number of elements (or criteria) subjected to a priority judgment. Each individual λ was computed by dividing the nw_{ij} by their normalized values w_{ij}

$$\lambda = \frac{nw_{ij}}{\text{Normalized } w_{ij}}. \quad (\text{Eq. 4.7})$$

The computed CI was then compared with a random consistency index RI of the generated paired comparison matrix to determine the consistency ratio CR (Table 4.3). The CR established whether the decision maker's judgment scores or weights were accepted, where $CR \leq 0.10$ was deemed acceptable (Satty 1990; Satty et al. 1991), based on Eq. 4.8:

$$CR = \frac{CI}{RI}. \quad (\text{Eq. 4.8})$$

A top-down process was applied to select and evaluate the criteria and elements. In this process, all criteria were first evaluated, and once a criterion was found desirable for achieving a disaster-resilient coastal community, its attribute elements were selected and subjected to comparisons. New priority vector nw_{ij} values of the criteria and elements that fell within the acceptability range of $CR \leq 0.10$ were adopted as their respective weights, and were used as basis to determine their rank within their respective group.

Table 4.3. The order of the random index of consistency with a number of alternatives

N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

In each tier of the hierarchy, an exploratory approach to adopt $\geq 70\%$ representation of the criteria and elements that had been subjected to paired comparisons was considered. This means that the sum of the ratio of weights of the top criteria or elements to their respective overall weight was $\geq 70\%$, as shown in Eq. 4.9.

$$\sum \frac{\text{Individual } nw_{ij}}{\text{Overall } nw_{ij}} \geq 70\% \quad . \quad (\text{Eq. 4.9})$$

This percentage was thought to provide an optimal number of criteria and elements to represent each level. Hence, other criteria or elements were disregarded as being of low importance and having relatively small impact on the overall objective.

4.5. Selected criteria and elements

The comparison matrix at the criterion level was consistent with a value of 0.09 (Table 4.4). Based on the weights of alternatives at this level, Environment and Natural Resources Management (ENRM) and Physical Protection and Structural Technical Measures (PPST) were ranked as the highest and lowest criteria, respectively. The highest ranked criteria, i.e., Environment and Natural Resources Management (ENRM), Sustainable Livelihood (SL), Social Protection (SP), and Planning Regime (PR), were selected by the sum of their weights and accounted for 72% of the overall weights of the criteria being compared. Their attribute elements were then subjected to further comparison, and high-ranking elements were subsequently selected.

For Environment and Natural Resources Management (ENRM), the elements that characterized disaster-resilient communities were ENRMC1, ENRMC2, and ENRMC4, which accounted for 74% of the overall alternatives (Table 4.5), whereas the combination of ENRMC1, ENRMC2, and ENRMC3 accounted for 71% of the most important attributes that describe risk-reduction-enabling environment. The matrices of comparisons for these attribute elements fell within a *CR* value of 0.10 and 0.09, respectively.

Subsequent procedures for selecting and evaluating attribute elements were conducted for Sustainable Livelihood (SL), Social Protection (SP), and Planning Regime (PR). For Sustainable

Livelihood (SL), the elements SLC1, SLC3, SLC4, SLC5, and SLC7 were selected as elements that describe disaster-resilient communities, whereas SLE1, SLE2, SLE3, and SLE7 were selected as elements that describe risk-reduction-enabling environment (Table 5). These elements accounted for 78% and 75%, respectively, of each attribute group.

For Social Protection (SP), the elements SPC1, SPC2, and SPC3 (77%) and SPE1 and SPE3 (80%) were selected to represent elements that described disaster-resilient communities and that described risk-reduction-enabling environment, respectively. Finally, the elements PRC1 and PRC3 (80%) that described disaster-resilient communities, as well as PRE1, PRE2, and PRE4 (82%) that described risk-reduction-enabling environment were considered the most important elements for criterion Planning Regime (PR).

Table 4.4. Weights and ranks of various criteria of a disaster-resilient coastal community

Codes	Criteria	Weight	Rank
ENRM	Environmental and natural resource management (including natural capital and climate change adaptation)	1.90	1
HWB	Health and well-being (including human capital)	0.77	6
SL	Sustainable livelihoods	1.50	2
SP	Social protection (including social capital)	1.26	3
FI	Financial instruments (including financial capital)	0.81	5
PPST	Physical protection; structural and technical measures (including physical capital)	0.57	7
PR	Planning regimes	0.92	4
$\lambda_{max} = 7.69$; $CI = 0.11$; $CR = 0.09$			

4.5.1. Priority criteria and elements

Environmental and Natural Resources Management (ENRM) was the most important criterion for describing disaster-resilient communities because ecosystem benefits are crucial to communities. Orencio and Fujii (2013a) referred to coastal resources in Baler as an important resource, as most individuals depend on such resources for food and livelihood. This recognition of ENRM as an important criterion for resilience can be attributed to the decision maker's idea of sustainable ecosystem services that can be derived from a healthy resource (Grant et al. 2008).

Sustainable Livelihoods (SL) and Social Protection (SP) represented the desires of

communities to achieve systems that ensure livelihood and security, respectively, based on the recognition of environmental and social hazards that affect their lives. Communities understood that their level of susceptibility to hazards was caused by their fragile livelihood systems. For instance, most people in coastal villagers tended to seek employment in fishing industries, whereas upland people focused on farming and raising livestock (Mohanty 2005). Others became self-employed and ventured into small-scale businesses.

Typically, the open-access system and minimal capitalization of fisheries allows this to be a common safety net for individuals who cannot find permanent employment. Because of the very limited resources and lack of security and income stability, however, communities found it difficult to cope when struck by recurring hazards. Thus, communities believed that their ability to adapt and recover was related to sustainable livelihood, and this could be enhanced by the support of an institution that promotes equitable distribution of resources.

The Planning Regimes criterion (PR) describes community aspirations to achieve a process that facilitates implementation mechanisms based on participation by communities as a vital element of success. Most communities regard implementation as an offshoot of careful planning. Therefore, they recognized that many institutions lacked proper policy and management of important resources because communities were not adequately consulted during the planning process (Mohanty 2005). Hence, the interest of communities in participate in planning could be considered a prelude to informed decision making.

4.5.2. Delphi and AHP

To obtain a consensus on the scores in a paired comparison of alternatives in the AHP model, the Delphi technique was found to be effective in a multi-stakeholder decision-making process. However, the process required a strong facilitator who could harmonize the different perspectives of decision makers into a single objective. Despite similar experiences and exposures to risk and disasters, the social status (e.g., education) and level of engagement in disaster management systems varied among decision makers, resulting in a variety of opinions about each alternative.

Table 4.5. Weights and ranks of various elements that characterized the selected criteria to produce a disaster-resilient coastal community

Criteria	Elements of Disaster-resilient Communities		Weights	Rank	Elements of Risk-reduction-enabling Environment		Weights	Rank
ENRM	ENRMC1	Understanding of functioning environment and ecosystems	1.62	1	ENRME1	Supportive policy and institutional structure	1.31	2
	ENRMC2	Environmental practices that reduce hazard risk	1.58	2	ENRME2	Prevention of unsustainable land use	1.51	1
	ENRMC3	Preservation of biodiversity for equitable distribution system	0.76		ENRME3	Policy linking environmental management and risk reduction	1.03	3
	ENRMC4	Application of indigenous knowledge and technologies	0.85	3	ENRME4	DRR policies and strategies integrated with climate change	0.59	
	ENRMC5	Access to community-managed property resources	0.67		ENRME5	Availability of local experts and extension workers	0.97	
$\lambda_{max} = 5.47$; $CI = 0.12$; $CR = 0.10$					$\lambda_{max} = 5.41$; $CI = 0.10$; $CR = 0.09$			
SL	SLC1	High level of local economic and employment stability	1.28	2	SLE1	Equitable economic development	1.62	2
	SLC2	Equitable distribution of wealth and livelihood in community	0.74		SLE2	Diversification of national and sub-national economies	0.79	4
	SLC3	Livelihood diversification in rural areas	1.33	1	SLE3	Poverty-reduction targets vulnerable groups	2.19	1
	SLC4	Fewer people engaged in unsafe livelihood	1.18	4	SLE4	DRR reflected as integral part of policy for economic development	0.77	
	SLC5	Adoption of hazard-resistant agriculture	1.23	3	SLE5	Adequate and fair wages guaranteed by law	0.77	
	SLC6	Small enterprises with protection and business continuity/ recovery plans	0.98		SLE6	Supportive policy on equitable use and access to common resources	0.42	

Criteria	Elements of Disaster-resilient Communities				Elements of Risk-reduction-enabling Environment			
			Weights	Rank			Weights	Rank
	SLC7	Local market and trade links protected from hazards	1.07	5	SLE7	Incentives to reduce vulnerable livelihood	1.16	3
	$\lambda_{max} = 7.83 ; CI = 0.14 ; CR = 0.10$				$\lambda_{max} = 7.76 ; CI = 0.13 ; CR = 0.10$			
SP	SPC1	Social support and network systems on DRR activities	1.87	1	SPE1	Social protection and safety nets for vulnerable groups	1.25	1
	SPC2	Cooperation with local community for DRR activities	1.63	2	SPE2	Coherent policy and networks for social protection and safety nets	0.61	
	SPC3	Community access to basic social services	0.72	3	SPE3	Comprehensive partnership with external agencies on DRR	1.16	2
	SPC4	Established social information and communication channels	0.62					
	SPC5	Collective knowledge and experience of management of previous events	0.67					
	$\lambda_{max} = 5.42 ; CI = 0.11 ; CR = 0.09$				$\lambda_{max} = 3.03 ; CI = 0.02 ; CR = 0.03$			
PR	PRC1	Community decision making takes on land use and hazards	1.27	1	PRE1	Compliance with standard international planning	0.91	3
	PRC2	Local disaster plans feed into local development and land use planning	0.61		PRE2	Land use planning takes hazard risks into account	1.47	1
	PRC3	Local community participates in all stages of DRR planning	1.15	2	PRE3	Effective inspection and enforcement regimes	0.75	
					PRE4	Land use plan schemes based on risks assessments	1.02	2
$\lambda_{max} = 3.04 ; CI = 0.02 ; CR = 0.03$				$\lambda_{max} = 4.16 ; CI = 0.05 ; CR = 0.06$				

The Delphi was particularly important during the comparison of the alternatives at the level of attribute elements. Decision makers tended to regard alternatives as having similar objectives, which made comparison difficult. The role of the facilitator was to expound on the differences among alternatives and to organize the opinions of stakeholders. In this case, the group was able to establish a common view on each alternative prior to the paired comparison.

The use of the basic scale (Table 4.2) in scoring each paired comparison was difficult for decision makers because some had not used a quantitative measure to assess importance and to compare two alternatives. Comparisons were far more difficult and time consuming when there were seven alternatives because this could require 21 comparisons. Decision makers resolved a matrix that involved only three alternatives, as shown by their high consistency rates (Table 4.5). Less consistent rates were obtained in two rounds when there were more than three alternatives.

To simplify scoring paired comparisons, the two alternatives located diagonally across from each other in the matrix (Eq. 4.2) were scored following a rule of thumb. In this rule, when a judgment favored the alternative on the left-hand side of the matrix, an actual judgment value (e.g., 1, 2,...9) was used for scoring, and the reciprocal value (e.g., $\frac{1}{2}, \frac{1}{3}, \dots, \frac{1}{9}$) was used when the judgment favored the alternatives placed on the right-hand side of the matrix (Teknomo 2006).

4.6. Framework index and metrics to evaluate disaster-resilient communities

With reference to important criteria and attribute elements selected using the hierarchical structure in the AHP model, the top four criteria were considered when designing the disaster-resilience outcome framework (Figure 4.2). This framework was used as a basis for developing the outcome indicators for the composite index, which will serve as a tool to evaluate a disaster-resilient coastal community at the local level.

To view disaster resilience only with its outcome, however, creates a limitation in placing emphasis on the human role in disaster-risk management (Manyena 2006). While, outcome components are important for the real achievements in terms of community empowerment and capacity building, process components should also be considered to provide for an understanding of a community and for the sustainability of a disaster-resilience program (Kafle 2010). Hence, the measure of coastal community disaster-resilience was developed with consideration on both outcome and process components that the community had achieved and implemented.

Table 4.6. Weights of criteria and element indicators that describe a disaster-resilient coastal community

Criteria	Normalized Weights	Elements of Disaster-resilient Communities		Normalized Weights	Elements of Risk-reduction-enabling Environment		Normalized Weights
ENRM	0.40	ENRMC1	Understanding of functioning environment and ecosystems	0.47	ENRME1	Supportive policy and institutional structure	0.35
		ENRMC2	Environmental practices that reduce hazard risk	0.44	ENRME2	Prevention of unsustainable land use	0.44
		ENRMC4	Application of indigenous knowledge and technologies	0.09	ENRME3	Policy linking environmental management and risk reduction	0.21
SL	0.28	SLC1	High level of local economic and employment stability	0.23	SLE1	Equitable economic development	0.29
		SLC3	Livelihood diversification in rural areas	0.25	SLE2	Diversification of national and sub-national economies	0.09
		SLC4	Fewer people engaged in unsafe livelihood	0.18	SLE3	Poverty-reduction targets vulnerable groups	0.43
		SLC5	Adoption of hazard-resistant agriculture	0.21	SLE7	Incentives to reduce vulnerable livelihood	0.18
		SLC7	Local market and trade links protected from hazards	0.14			
SP	0.21	SPC1	Social support and network systems on DRR activities	0.53	SPE1	Social protection and safety nets for vulnerable groups	0.54
		SPC2	Cooperation with local community for DRR activities	0.43	SPE3	Comprehensive partnership with external agencies on DRR	0.46
		SPC3	Community access to basic social services	0.04			
PR	0.11	PRC1	Community decision making takes on land use and hazards	0.55	PRE1	Compliance with standard international planning	0.14
		PRC3	Local community participates in all stages of DRR planning	0.45	PRE2	Land use planning takes hazard risks into account	0.63
					PRE4	Land use plan schemes based on risks assessments	0.23

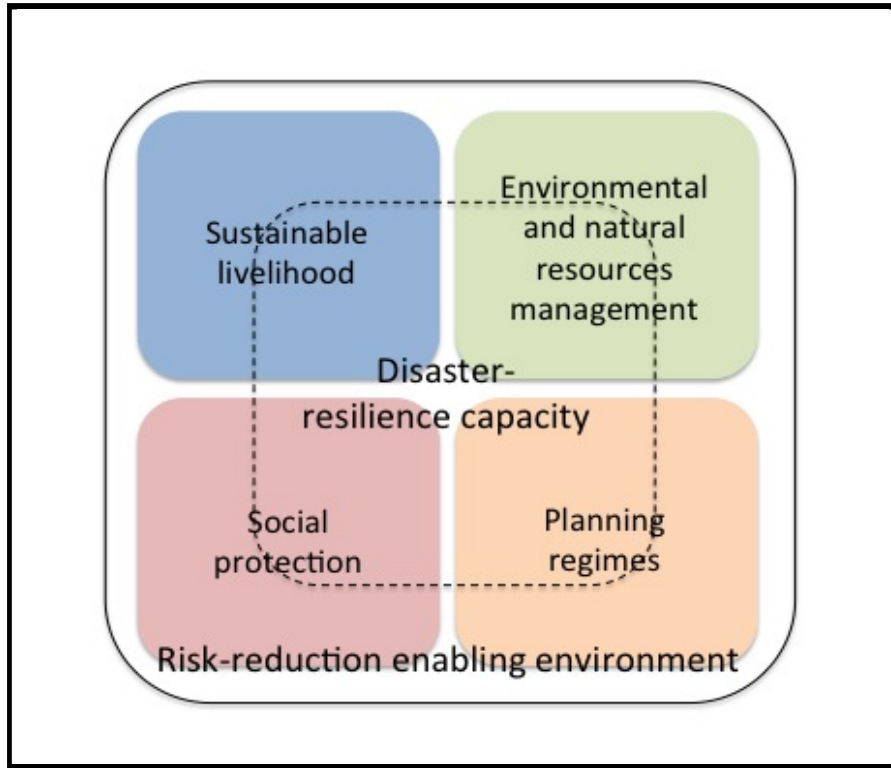


Figure 4.2. The AHP-designed coastal community disaster-resilience outcome framework for Baler, Aurora in the Philippines

Meanwhile, since only criteria and elements as outcome components were provided by the AHP (Figure 4.3), process components were developed with respect to the Integrated Community-based Risk Reduction (ICBRR) model of the Canadian Red Cross (CRC) and the Indonesian Red Cross Society (PMI) (Figure 4.4). This framework has 10 specific activities for establishing disaster-resilient communities, which include implementation of risk-reduction measures (Kafle 2010). As a result, a composite index for a disaster-resilient coastal community (Figure 4.5) was developed based on an aggregate measure of an overall outcome indicator computed based on four important AHP criteria and their elements, and an overall process indicator that was quantified from 10 specific activities of the ICBRR.

The fundamental metrics for the index followed a weighted linear combination (WLC) of indicators for outcome and process components. For the WLC, outcome indicators were assigned weights based on a weighting system to provide a basis for intensifying the indicator scores. These were taken from the nw_{ij} values that determined the ranks in the AHP model and were computed with the minimum–maximum method following Eq. 4.10:

$$W_n = (W_{act} - W_{min}) / (W_{max} - W_{min}), \quad (\text{Eq. 4.10})$$

where W_n is the normalized weight of a criterion or element, and W_{act} is the actual weighted values of a criterion or element within the compared set of alternatives, whereas W_{max} and W_{min} are the maximum and minimum weights, respectively, of criteria or elements within that set. The normalized weights of the selected criteria and elements were shown in Table 4.6.

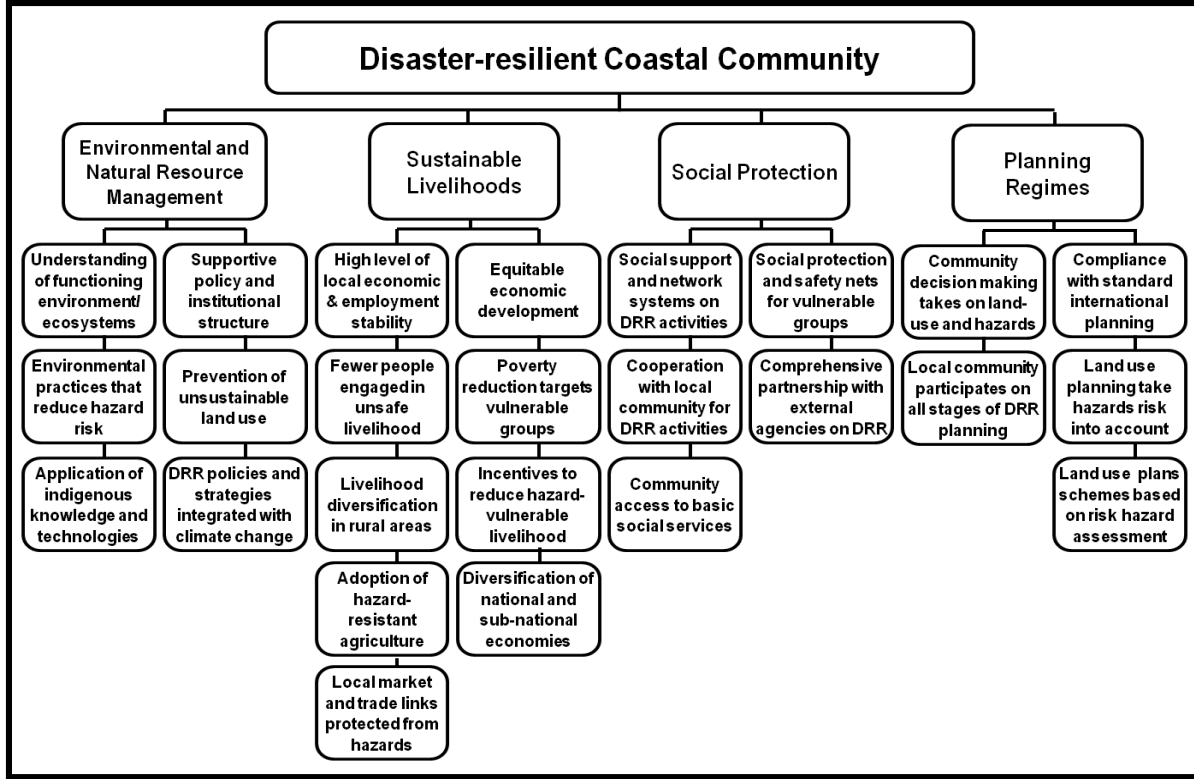


Figure 4.3. The criteria and elements for outcome components of a disaster-resilient coastal community from the AHP model

During the design of the metric computations for the attribute elements for ENRM, SL, SP, and PR, only two elements characterizing disaster-resilient communities for the criterion PR and the external enabling environment for the criterion SP were selected. These criteria only had three elements that are used for comparison, and inclusion of the lowest ranking alternative resulted in a normalized weight of zero. Because weights were used to intensify the scores in the proposed assessment, those elements with weights of zero were excluded from the selection.

Initially, to compute for the outcome indicator, each criterion was measured based on attribute element scores ES . The ES were based on a level of attainment or success in designating a distinct step in disaster risk reduction (DRR) (Twigg 2007).

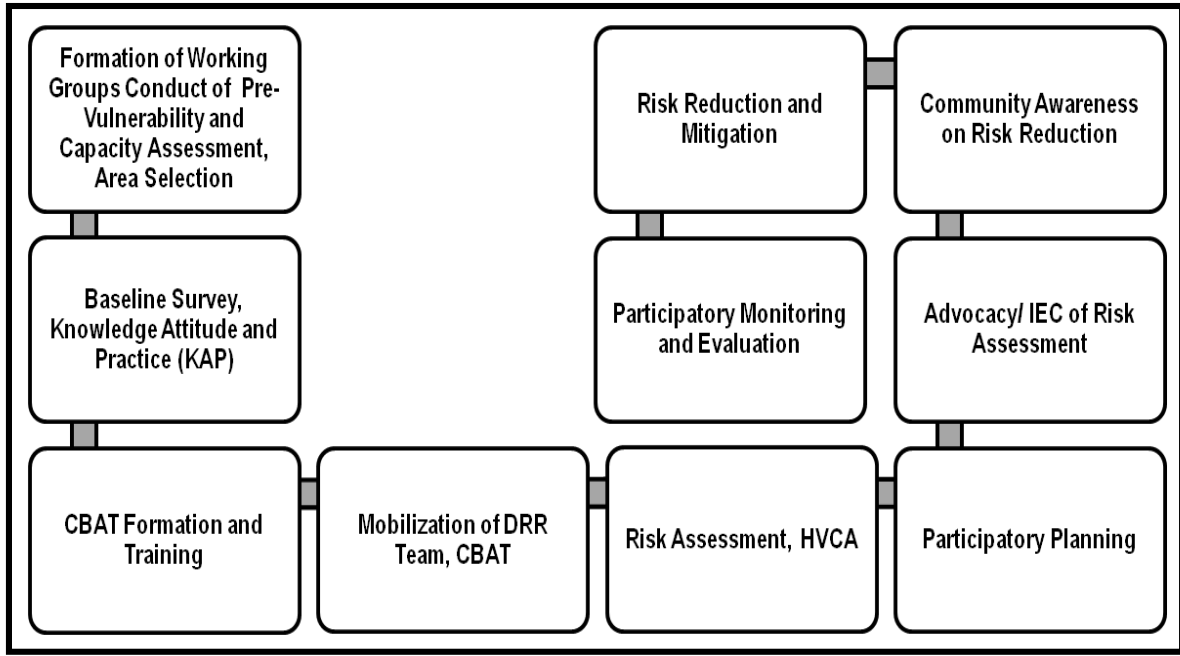


Figure 4.4. The ICBRR model used by the Canadian Red Cross and the Indonesian Red Cross Societies for building disaster-resilient organizations at the local level (Kafle 2010)

Using this scale, Level 5 was considered the highest, and Level 1 was the lowest in terms of degrees of implementation. However, I proposed the addition of another level to modify this to a six-point scale, where 0 was the lowest and referred to situation where DRR activities were non-existent and were not implemented (Table 4.7).

All *ES* corresponding to the criterion were summed to obtain the criteria scores using Eq. 4.11:

$$CS = \sum_{j=0}^{j=5} C(W_i ES_j) + \sum_{j=0}^{j=5} E(W_i ES_j), \quad (\text{Eq. 4.11})$$

where *CS* represents the overall criterion score, *C* represents the attribute elements for disaster-resilient communities, *E* represents the attribute elements for risk-reduction-enabling environment, *W_i* represents the weights of all attribute elements *i*, and *R_j* represents the rank or values of attribute elements *j*.

All *CS* values were combined to determine the overall outcome-indicator score, as shown in Eq. 4.12:

$$OS = \sum_{j=0}^{j=5} C(W_i CS_j), \quad (\text{Eq. 4.12})$$

where *OS* is the overall outcome-indicator score, *C* represents the criteria, *W_i* represents the

weights of criteria i , and CS_j represents the scores for each criterion j .

Table 4.7. Six-level scale for ranking indicators as modified from Twigg's (2007) five-level scale for ranking distinctive disaster risk-reduction interventions

Levels	Distinctive Disaster Risk-reduction Intervention
Level 0	Absence of a clear and coherent activity/ activities in an overall disaster risk reduction program.
Level 1	Little awareness of the issue(s) or motivation to address them. Actions limited to crisis response.
Level 2	Awareness of the issue(s) and willingness to address them. Capacity to act (knowledge and skills, human, material and other resources) remains limited. Interventions tend to be one-off, piecemeal and short-term.
Level 3	Development and implementation of solutions. Capacity to act is improved and substantial. Interventions are more numerous and long-term.
Level 4	Coherence and integration. Interventions are extensive, covering all main aspects of the problem, and they are linked within a coherent long-term strategy.
Level 5	A "culture of safety" exists among all stakeholders, where Disaster Risk Reduction (DRR) is embedded in all relevant policy, planning, practice, attitudes and behavior.

The overall process-indicator score, on the other hand, was determined by Eq. 4.13:

$$PS = \sum_{j=0}^{j=5} P(W_i R_j), \quad (\text{Eq. 4.13})$$

where PS represents the overall process-indicator score, P represents process indicators based on the 10 activities of the ICBRR model, W_i represents the weights of indicators i with equal values that sum to 1, and R_j represents the ranks or values of process indicator j . Similarly, the ranking or scoring of indicator values followed the modified six-level scale (Table 4.7), with 5 representing completely attained. It should be noted that because indicators have W_i , the sum of which equals 1, W_i for each corresponding process indicator was 0.10.

Finally, the overall index score was determined by combining the process- and outcome-indicator scores, as shown in Eq. 4.14:

$$IS = PSW_i + OSW_i, \quad (\text{Eq. 4.14})$$

where IS represents the overall index score, PS represents the overall process-indicator score, OS represents the overall outcome-indicator score, and W_i represents the weights of the process and outcome indicators i . Because the process and outcome indicators have equal W_i , the sum of which

equals 1, W_i for each indicator was 0.50.

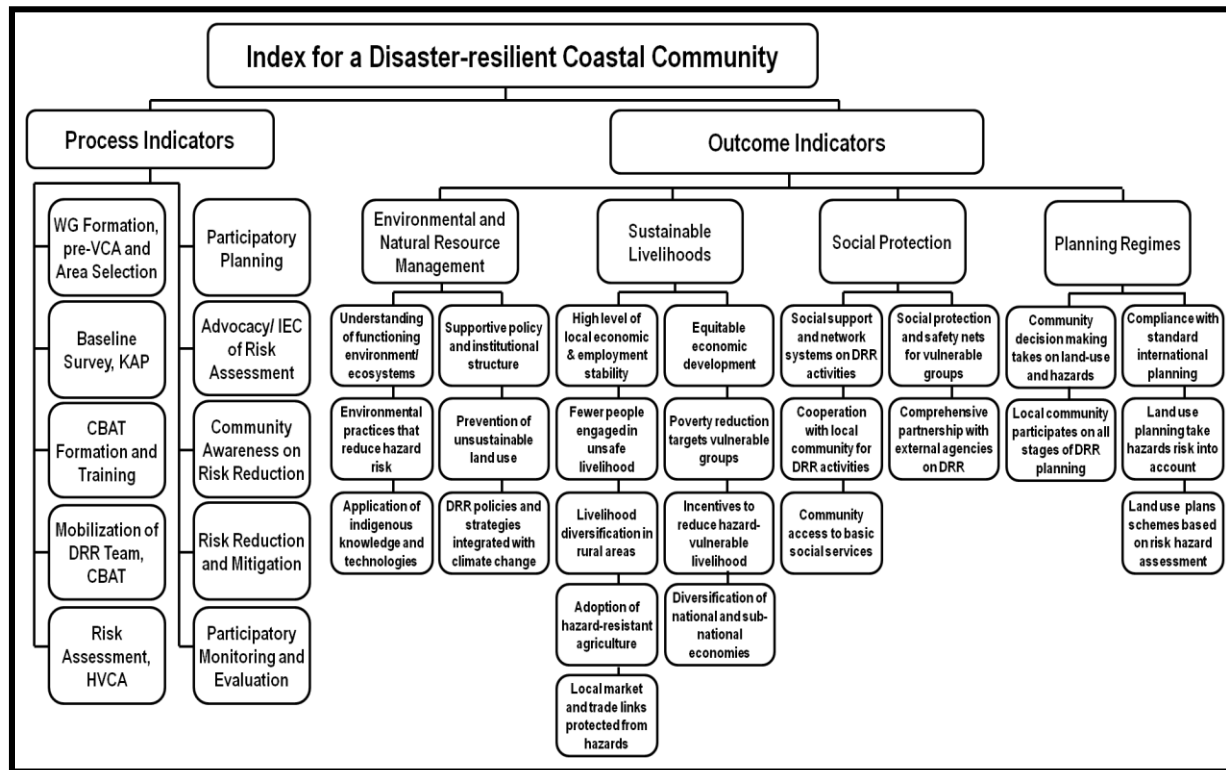


Figure 4.5. The process and outcome components of the composite index for a disaster-resilient coastal community

4.7. Limitations of the proposed index

In this study, I developed an index for a disaster-resilient coastal community with the ability to objectively assess the degree of attainment of each critical indicator for both process and outcome components. The outcome indicators were developed from the synthesis of disaster resilience components using the AHP. However, the process indicators developed based on the Integrated Community-based Risk Reduction (ICBRR) model to assess disaster-resilience of a coastal community still depend on some assumptions, as risk-reduction programs implemented at the community level in the Philippines followed the Citizen-Based and Development-Oriented Disaster Response (CBDODR) and the Community-Based Disaster Risk Management (CBDRM) approaches. Concepts may vary among approaches, but most activities were similar. Hence, the proposed process indicators could be assessed at the activity level to limit bias resilience measurements.

The proposed WLC measurement for the disaster-resilience index relied on the weights and scores assigned to each indicator. The weights for the outcome indicators varied since they were based on values derived from the AHP, but equal weights were assigned to process indicators. Since weights were used to intensify the scores in the assessment, this may pose some limitations in providing a quality measure for process indicators. This limitation can be resolved by undertaking a further AHP for the process indicators. Nevertheless, a score range of 0 to 5 to rank both process and outcome indicators could be used for more objective evaluation.

Further agreements on the use of the ICBRR approach to model disaster-resilient communities could be considered, as this may also serve as a framework to evaluate local DRR activities. Reports regarding the International Federation of the Red Cross' intentions to implement this approach in Southeast Asia and to develop communities into disaster response teams could provide a good opportunity to enhance the Philippines' local disaster-management and risk-reduction system.

4.8. Pilot assessment

The next important step in the process is a pilot assessment in a coastal community using the composite index. The community-based assessment will involve individuals in scoring and ranking both process and outcome indicators based on a fundamental rating scale that was developed to categorize the quality of community interventions in undertaking DRR. A sensitivity analysis will be applied to identify important flaws and subsequent development needs. This analysis will further refine the exploratory approach for criterion and element selection, such as the arbitrary decision to select overall criterion and element scores that summed to $\geq 70\%$. In this way, the relationship that existed between selected criteria and elements could be properly defined, and the underlying structure would likely provide a quality benchmark measure of disaster-resilient coastal communities.

CHAPTER FIVE

OVERALL BENEFITS OF ESTABLISHING LOCAL LEVEL INDICATORS OF VULNERABILITY AND RESILIENCE IN MANAGING RISK TO SOCIAL AND ENVIRONMENTAL CHANGES

Indicators have served as outpost for analysis in various studies involving society and environment. The purpose behind the development of indicators for vulnerability and resilience in this dissertation was to validate local communities' characteristics towards managing risk brought by the multi-dimensional components of social and environmental change in the coastal areas. In the absence of census data, viable methods for selection and categorization based on the indicator's scientific validity were explored to provide information at the local scale. Information developed from the analysis was also considered as vital inputs to local development as well as interventions such as policy and planning, system development and implementation. The interventions, when properly undertaken, could help reduce people's vulnerabilities and strengthen their capacities towards an improved management of risk from disaster-causing hazards.

5.1. Indicators in public information and policy-making

Indicators have influenced decision-making on management and policy-making at all scales in different aspects of studies involving environmental impact assessment (e.g., Niemeijer and de Groot 2008), business management (e.g., Sharma and Mahajan 1980) and human development (e.g., UNDP 1990). On the ecological side, Dale and Beyeler (2001) showed that indicators could easily measure a system's sensitivity and response to stress in a manner that is predictable, anticipatory and integrative. In this case, quantifiable indicators were needed to ensure that processed information can be compared easily and objectively (Schomaker 1997; Layke et al. 2012).

Data availability, credibility, and portability were among the criteria for selecting indicators that provide credible and reliable public information (Oudenhoven et al. 2012; Layke et al. 2012). For instance, portability refers to the question whether indicators are repeatable and reproducible in other studies, and across different regions (Riley 2000). Likewise, within this premise, indicators should be scalable such that they could be aggregated or disaggregated to different scale levels, without losing their sense or value (Hein et al. 2006).

In reality, however, the creation of an index is largely constrained by the availability of data (King 2001), especially at the local level. While independent secondary data sets are scarce, potential measures on indicators should be developed with techniques and protocols for construction and valuation. In this dissertation, participatory approaches were introduced to bridge the data gap in developing viable indicators, while maintaining the scientific basis for their selection. In the process, both empirical and exploratory works and with reference to the indicator's analytical utility within the total constellation of a selected set of indicators were considered. This resulted to lesser arbitrary decisions, which made the process more objective in providing a good analysis of the communities' characteristics. Because of this, the approach can also be applied in areas with similar geographical situations.

5.2. Use of participatory approaches

Within this dissertation, participatory approaches through social assessment methods were conducted to develop indicator frameworks for vulnerability and resilience. These indicators were found capable of characterizing coastal communities' inherent capacity to various disaster-causing hazards. The relative vulnerability and resilience patterns were determined via metrics that enable the analysis of complex structures and socio-environmental interactions. This is an important requirement for decision-making and information sharing in the field of risk reduction and adaptation and mitigation planning. Moreover, the method envisioned the application bottom-to-up process in implementing the indicator development, where more stakeholders from grassroots communities were involved.

The benefit of undertaking this methodology was three-fold. Firstly, the structured analysis of factors influencing vulnerability underlying inter-dependencies (e.g., which factors were the sources of vulnerability) helped to better understand the complex phenomenon of a coastal community (e.g., contribution of the sub-indicators to overall vulnerability). Secondly, resilience measurements was developed based on the context of outcomes and processes identified based on the inverse of highly vulnerable conditions. Thirdly, the results of the additive models can be used to compare different coastal communities with regard to their potential vulnerability and resilience. A robust set of metrics was found useful to quantify and this could guide decision-making of policies for DRR. Given the inclusion of local people in the process, the result of the analysis has provided details on the factors that affect vulnerability and resilience. This information could be

useful for local governmental decision-makers in developing place-based risk reduction strategies and approaches for building disaster-resilient coastal communities.

5.3. Important factors influencing vulnerability and resilience

The Coastal Community Vulnerability Index (CCVI) provided a way to reduce the complexity of vulnerability in the coastal communities by undertaking a simplified measurement of plausible conditions using the social survey. 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 factors as attributed to their highly rated indicator values (Orencio and Fujii 2013a).

Meanwhile, the Analytic Hierarchy Process (AHP), which involves paired comparisons of various alternatives, provided a potential method to synthesize disaster-resilience components from the national level and select the most important ones to be used in undertaking in the local level. AHP was found effective in selecting the criteria and elements that best described a disaster-resilient coastal community with the participation of local decision makers. Based on the results, four criteria, i.e., Environmental and Natural Resource Management (ENRM), Sustainable Livelihoods (SL), Social Protection (SP), and Planning Regime (PR), were considered the most important criteria to describe outcomes for a disaster-resilient coastal community (Orencio and Fujii 2013b).

The factors that contributed to differential characteristics and capacities of population (e.g., susceptibility to change or to anticipate, adjust to, and recover from damaging events) have been identified at local levels. This can be observed in Table 5.1.

Table 5.1. Important factors or criteria that influenced the level of vulnerability and resilience of coastal communities in Baler, Aurora, the Philippines

Vulnerability		Resilience	
•	Economic and livelihood	•	Environmental and natural resource management
•	Policy and institutional	•	Sustainable livelihood
•	Food security	•	Social protection
		•	Planning regime

Because of this identification, there is now a validated set of indicators and procedures for

measuring vulnerability and resilience at this scale of geography. Firstly, this has enhanced the understanding of the multidimensional nature of these conditions and has provided a framework for further research on metrics. Learning what sets of criteria and indicators contribute to differential levels of vulnerability or resilience among communities could facilitate a better understanding of the differential susceptibility or impacts that exist across the built environment. Secondly, the results could provide a means to highlight the strengths and identify weaknesses in the coastal communities that can be addressed by local government agencies, nongovernmental organizations, the private sector, stakeholders, and communities themselves.

5.4. Insights to index development

The construction of vulnerability and resilience indices, in this dissertation, has outlined ways to address several constraints in index development. Firstly, the vulnerability and resilience concepts should be conceived not as single dimension but rather complex interrelations that was better apt for experimental tests such that the use of exploratory rather than empirical evidence. Secondly, designing the criteria and set of indicators showed most components were nested in various human aspects and societal contingencies, which were bound to differ in levels or scales. Thirdly, in the absence of data, the concepts were found difficult to estimate due to methodological reasons. In solution, indirect numerical proxies or surrogates of qualitative phenomena should be constructed for each indicator, in order to achieve computation and comparability. Finally, selection of criteria and indicators should consider both the scientific validity and practicality for application to consequently paint a different picture for both vulnerability and resilience, respectively. A picture could present an explicit difference in temporal and spatial forms to determine trends that can be measured and mapped over time, for instance through mapping and GIS analyses (e.g., Orencio and Fujii in press). A spatiotemporal approach to analysis of information collected from the Center for Research on the Epidemiology of Disasters (CRED). This takes off point from constructing indicators out of existing sources and databases and valuing them by meta-analysis using statistical tools to establish datasets for analyzing at-risk-populations and regions.

5.5. Research contributions

In terms of research contributions, there were numerous benefits that can be gained from

this dissertation not only from academic purposes but for pragmatic planning in response to social and environmental change. Firstly, on the academic perspective, the method used in this dissertation presented viable frameworks for analyzing the multidimensional concepts of vulnerability and resilience. The first step in the transition from conceptual framework to assessment was the identification and development of indicators that are robust and representative of the phenomena being measured.

In an integral step towards the construction of a composite index for any given purpose, indicators are selected based on analytical soundness, measurability, coverage, and relevance (Freudenberg 2003; Saltelli 2007; Nardo et al. 2008). A composite index is, above all, the sum of its parts, and the strengths and weaknesses of composite indexes are derived largely from the quality of their underlying variables (Freudenberg 2003). However, the variable selection process for the construction of a composite index may be quite subjective, and there is the possibility of different indicators of varying quality being chosen to fulfill the same purpose. There is the potential for what some analysts refer to as indicator rich, but information poor environments (Nardo et al. 2008).

Secondly, on policy development, to address the problem of DRR at the local level by empowering the most vulnerable areas in the Philippines and enabling local governments to prepare disaster risk management plans. This dissertation presented a systematic approach to community based disaster risk management and an enhanced inputs for planning analyses by recognizing risks posed by both social and natural hazards and the related socio-economic vulnerability to the disasters they produced. Because of the focus and the kind of information that this could provide, it could prompt collaboration among stakeholders to jointly undertake risk assessments. In the future, the approach could employ an inter-local government cooperation scheme that accommodates other local governments within the river basin to participate in a comprehensive system for managing risk from disaster-causing hazards.

5.6. Final Conclusion

Managing risk from various sources is one of the many important components for achieving sustainable development. In this research, risk management can be facilitated by looking at the intrinsic characteristics of at-risk-communities determined through vulnerability and resilience analysis. It was observed that employing an approach for analyzing the concepts

through the use of participatory assessment could increase people involvement in the process of risk determination. Because of the increase in involvement and participation, the capacity of people and formal organizations at any scale, in turn, has developed and enhanced, specifically in crafting strategies for risk mitigation and adaptation measures, which are part and parcel of a viable risk-reduction system.

Within this research, characterizing at-risk communities has provided viable inputs for managing risk towards the development of disaster resilient communities. In the absence of high level methods for analysis, the use of indicators presented a pragmatic approach towards this objective. However, while indicators have provided inputs concerning the aspects of management and decision-making because of the kind of radical information they could readily provide, these were also not full-proof and this was the reason why they should be tested and applied to reduce its fallibility.

Hence, the most important consideration in undertaking an index approach for evaluating vulnerability and resilience was to establish the values for the indicators. Since the indicators were quantitatively valued using attitudes of people subjected in the analysis, these were rather subjective. In this case, the use of scoring system for evaluating perception and experience, coupled with a kind of weighting, such as the ones developed from AHP, and the metrics for aggregation, such as the application of weighted linear combination, were the determining factors for coming up with robust indicators and their composites.

On the other hand, applying an all participatory approach in generating the values of the indicators presented a limitation in terms of scale of application. Although this proved to cater for an improved decision-making process, it could only be undertaken within a well-defined area where social survey is possible. It should be noted that the greater the area, the higher the complexity so there would be more variables involved in the assessment. Nonetheless, with the increasing development of data repository systems, mixing qualitative and quantitative information in an indicator approach for assessing vulnerability and resilience at a higher scale should be possible.

ACKNOWLEDGEMENT

The author is very grateful for the following persons and organizations which contributed for successfully completing this dissertation:

To the Japanese Government for providing the MEXT scholarship, and Hokkaido University's Sustainable Low Carbon Society Project and Program for Risk Information on Climate Change of Ministry of Education, Culture, Sports, Science and Technology, Japan, for the funding and administrative support for this research;

To the five coastal communities of Baler and their local government staff and executives for the hospitality during the conduct of the community research activities;

To Mayor Arturo Angara of Baler, Ms. Liza Costa of the Municipal Environmental and Natural Resources Office of Baler, and to Dr. Eusebio Angara of the Aurora State College of Technology for supporting the conduct of the research, lending their rooms and equipment, assisting in the conduct of field activities, and providing pertinent secondary information;

To Associate Professor Masahiko Fujii, for sharing invaluable insights and for unequivocal kindness, patience and guidance during the thesis writing and practice presentations, and for providing equipment, books and travels needed to facilitate the research activities;

To Professor Noriyuki Tanaka, Professor Makoto Taniguchi, Professor Masahiro Nakaoka, Professor Shunitz Tanaka and Associate Professor Mamoru Ishikawa for providing equally significant contributions and suggestions for enhancing the dissertation as the direct referees;

To Professor Michio Kishi for the additional contributions to my master's research which has become the base study of this dissertation;

To the staffs and members of the Aurora Marine Research and Development Institute, especially to Dr. Marivic Pajaro, and with special appreciation to the three musketeers for their time and support from planning until the successful completion of all field research activities;

To my family, *Jelyn, Tala and Eli*, for being my source of joy, inspiration and confidante, and for always fueling my thoughts with ways to be a better person; to my *Dade* and *Mame (+)*, for the guidance and support throughout my strive for higher education; and to *Jojo, Tonton, Bogs* and *Renzo*, to who I share this passion with the hopes to inspire them strive for a better day;

And finally, for God Almighty for completing this research in His time and glory– the Maker of heaven and earth, the Source of truth, and the Provider of all great learning.

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