

Assessing Vulnerability to Climate Change Impacts in Cambodia, the Philippines and Vietnam: An Analysis at the Commune and Household Level

Maria Emilinda T. Mendoza¹, Bui Dung The², Heng Naret³, Vicente G. Ballaran, Jr.⁴ and Jamie Kim B. Arias⁵

ABSTRACT

The study takes on the framework that vulnerability to climate change depends on the interrelationship of key elements of exposure, sensitivity, and adaptive capacity (Adger, 2006). The general objective of the study is to arrive at an understanding of the community and household vulnerability in three study areas: Kampong Speu in Cambodia, Laguna province in the Philippines, and Thua Thien Hue in Vietnam. Specifically, it aims 1) to measure communes'/ barangays' relative vulnerability in the selected study sites; 2) to analyze social vulnerability of local communities in terms of underlying problems; and, 3) to measure and explain the vulnerability of households in relation to their economic and demographic features. Community level and household level surveys were conducted to gather data for the vulnerability analysis, in combination with qualitative data gathering tools such as key informant and in-depth interviews and focused group discussions.

About two thirds of communes/barangays in the studies sites were identified as highly vulnerable. These are mostly communities in lowland and coastal areas; especially communes/barangays with relatively high incidence of poverty, with large areas devoted for agricultural activities and with poor infrastructure facilities. On the other hand, household characteristics found to be related to vulnerability to climate-related risks and hazards include household income, types of livelihood, family size, education of the household head, and the level of exposure to identified hazards. Households living on natural resource-based livelihood are likely to be more vulnerable as these livelihoods are more exposed to and more sensitive to climate hazards. Most poor households are found to be vulnerable. Low adaptive capacity was found to be a key determinant of household vulnerability to climate change across countries.

Women were found to be more vulnerable to climatic hazard than men due to limitation in skills and opportunities but they were given more responsibilities in taking care of family member during risk hazard response and rehabilitation periods. An over representation of women during response and rehabilitation periods was found across the study sites.

Key words: Climate change, vulnerability, exposure, sensitivity, adaptive capacity

INTRODUCTION

Southeast Asia, in particular, has been reported as one of the world's most vulnerable regions to climate change. The study of Yusuf and Francisco (2010) in fact reported that all regions in the Philippines and Cambodia, and many parts of Vietnam are very vulnerable to the impacts of climate change.

The region's vulnerability stems from the fact that many countries of the region are located along coastlines, which have a high concentration of population and economic activities in coastal areas, and are heavily dependent on agriculture, natural resources and forestry for providing livelihoods -- income sources that are susceptible to the impacts of climate change (ADB 2009). In addition, the vulnerability of the region comes from high exposure to climate

hazards as manifested in increasing frequency and intensity of storms, increased flooding, seawater intrusion, coastal erosion, and episodes of intense droughts. The Philippines and Vietnam have long coastlines where many of the local populations rely on fisheries for their livelihood (Capili et al. 2005; Boateng 2009). Philippines, Cambodia and Vietnam are identified as most vulnerable to climate change in the region (Yusuf and Francisco 2010).

Cambodia, one of the least developed countries in the region has an economy highly dependent on agriculture. Hampered by low income, high mortality rates, and limited capacities to adapt, it is reported to be highly vulnerable to impacts of climate change such as droughts and floods (UNDP

¹ Component Leader for Social Vulnerability and Country Project Leader – Philippines, College of Human Ecology, University of the Philippines Los Baños. E-mail: makilinggazer@gmail.com (corresponding author)

² Project Coordinator and Country Project Leader – Vietnam, College of Economics, Hue University

³ Country Project Leader – Cambodia, Faculty of Social Science and Humanities, Royal University of Phnom Penh

⁴ Component Leader for Community Vulnerability Mapping, College of Engineering and Agro-industrial Technology, University of the Philippines Los Baños

⁵ Component Leader for Economic analysis of CCA Options, College of Economics, University of the Philippines Los Baños

2007). Every year Cambodia experiences flood, drought, windstorm, insect outbreak, underground water salinization and seawater intrusion, compounding the country's vulnerability to the impacts of climate change (RGC-MoE 2005). The difficulty of Cambodia to achieve the first among the Millennium Development Goals (MDGs), to wit, eradication of extreme poverty and hunger, is highly attributed to natural calamities. As of 2006, the Cambodian government produced its National Adaptation Programme of Action to Climate Change (NAPA), which serves as a guideline for development in the context of climate change. Cambodia has given emphasis on adaptation of the agriculture and water resource sectors. Irrigation scheme, flood prevention dike in the agriculture are stated as the highest priority in a short and long-term strategies for Cambodia (RGC-MoE 2006).

However, the expertise on economic analysis of adaptation is found wanting and vulnerability assessments are hardly done and thus considered as inadequate except for the studies for the national communication to the United Nations Framework Convention on Climate Change (UNFCCC) (MoE 2005; O'Brien et al. 2002). While there are a few studies on hazard and risk mapping in Cambodia, the vulnerability mapping study by the Economy and Environment Programme for Southeast Asia (EEPSEA) is the first that showed relative vulnerability of provinces in the country. For action planning and priority setting, vulnerability analysis and mapping need to be done for lower levels of local governance (Yusuf and Francisco 2009). The government of Cambodia has been generally slow at making progress in climate change-related initiatives especially in the area of community based development and vulnerability reduction because of serious capacity and resource deficiency.

In the case of the Philippines, the study of Yusuf and Francisco (2009) reported that it is among the top-3 countries in Southeast Asia that are most likely to be affected by climate hazards including floods, droughts, cyclones, and landslides. Being an archipelago, the country is especially vulnerable to climate change impacts such as sea level rise. The country's vulnerability is compounded by the dependence of the Philippine economy on climate-sensitive sectors such as agriculture, fisheries, and forestry. The country is also highly exposed to tropical depressions, storms and typhoons that form from the Pacific Ocean with an average of 20 typhoons entering the Philippine area of responsibility (PAR).

The Government of the Philippines (GOP) has embarked on mainstreaming climate change and disaster risk reduction in the local development plans to lessen the impact of natural disasters such as typhoon and flooding. Republic Act 9729 or the Climate Change Act of the Philippines served as the national response to the global community's concern on the impacts of climate change as embodied by

the UNFCCC and has provided for the establishment of the Philippine Climate Change Commission which currently provides policy directions for the country's response to climate change. It also provided the impetus for the adoption of the National Framework Strategy on Climate Change (NFSCC) in 2010, which was eventually translated into the National Climate Change Action Plan (NCCAP) (RA 9729; CCC 2011). The NCCAP prioritizes food security, water sufficiency, ecosystem and environmental stability, human security, climate-smart industries and services, sustainable energy, and capacity development as the strategic direction for the Philippines over the period of 2011 to 2028. This document also generally assesses the current situation of the country with regard to climate change risk. On the other hand, the passage of Republic Act 10121, otherwise known as the Philippine Disaster Risk Reduction and Management Act of 2010 has provided for the local government units (LGUs) to take the lead role in disaster risk reduction through their respective local disaster coordinating councils. However, there is still a dire need for vulnerability assessments as rational bases for local climate change adaptations, as well as the need to strengthen the barangay's capability in disaster risk reduction and management.

Vietnam on the other hand, is also considered as one of the most vulnerable countries to the impacts of climate change and associated phenomenon such as sea level rise, increased frequency of natural disasters like typhoons, floods and droughts. The country suffers directly from six to ten storms and tropical depressions annually, causing heavy rains and flooding that impact on agricultural productivity. In the last ten years, more than 15 million people have been severely affected by climate-induced disasters. In 2006, natural disasters caused an estimated damage and losses totaled nearly 1.2 B US\$. Although the extent of sea level rise is unknown in Vietnam, projection of a 1 m sea level rise would flood 5,000 km² of the Red River Delta and 15,000 to 20,000 km² of the Mekong River Delta (Cruz et al. 2007), leading to extreme salinity intrusion and crop damage.

In order to introduce new policies related to disaster risk reduction, the Government of Vietnam approved the National Strategy on Disaster Prevention, Response and Mitigation in 2007, providing for policy and development directions until 2020 (<http://www.isgmard.org.vn/VHDocs/NationalPrograms/NationalStrategyfordisasterprevention2020>). This broader agenda on disaster management address multiple hazards and emphasize disaster risk reduction (DRR) over response mechanism. The government also approved the National Target Program (NTP) for the agriculture and rural development sector to cope with climate change under the Action Plan Framework for Adaptation and Mitigation of climate change for the agriculture and rural development sector (2008–2020). However, the capacity for planning and

action on climate change adaptation by local governments was lacking in Vietnam. Moreover, the historical weakness of farmers' extension services has slowed down progress of field-based capacity building projects among farmers. At the local level, some of the more urgent capacity building needs clearly identified is vulnerability assessment and economic analysis of adaptation measures.

Overall, response to reducing negative impacts of climate induced events such as flood and typhoon is not only the responsibility of the community, but is also largely the responsibility of the government to carry out its mandate to be at the forefront of disaster and climate risk management. The government must have adequate capacity to carry out its task for climate change adaptation. However in many cases, there is a seeming lack of capacity for planning and action on climate change adaptation of local governments in some Southeast Asian countries. In the case of Vietnam, Cambodia, and the Philippines, these deficits have delayed the progress in the initiatives of universities to link their research and training activities to the needs of provinces and districts. At the local level, some of the more urgent capacity building needs that have been clearly identified are planned climate change adaptations anchored on adequate vulnerability assessment and economic analysis of adaptation measures. This necessitates demonstration of an assessment of communities and household vulnerabilities that can be adopted by LGUs for their planning and implementation of adaptations to climate change-related events. This study was designed to meet such need. It intended to contribute to the growing literature on vulnerability assessment by demonstrating the utility of an index approach in assessing the relative vulnerability at the barangay/ commune and at the household levels.

Looking at the cases of three provinces in Cambodia, the Philippines and Vietnam, the study has the following objectives: to measure the relative vulnerability of communes/barangays in the study sites; to explain selected dimensions of the social vulnerability of local communities; and to measure and explain the vulnerability of households in relation to their economic and demographic features.

Conceptual Framework

The concept of vulnerability has seen a variety of definitions linked with the different stages that assessment of vulnerability to climate change had taken (*Fussel and Klein, 2006*). *Liverman (1990)* noted that vulnerability "has been related or equated to concepts such as resilience, marginality, susceptibility, adaptability, fragility, and risk." *Fussel (2007)* suggest that there is no single conceptualization of vulnerability that would fit all assessment contexts and that its definition is primarily a consequence of its use in a variety of policy contexts for different systems exposed to different

hazards. Following the IPCC definition (*Adger et al. 2007; Fussel and Klein 2006*) of vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change," the study adopted the concept of both the commune/barangay and the household as different levels of coupled human-environment systems, with attributes threatened by their exposure to specific hazard(s), within a time period of 10 years. The character and magnitude of external risk hazards confronting the communes/barangays and the households were factored in within the exposure dimension (degree to which they come in contact with particular climate change-related stressor) of their vulnerability, while several attributes of both systems were considered in looking at their sensitivity (degree to which they will respond to the given stressor) and adaptive capacity (as indicated by attributes assumed to enable them to cope better with existing or anticipated stresses). The interaction of environmental and social forces determines sensitivities, and various social, cultural, political and economic forces shape adaptive capacity.

METHODOLOGY

The study was conducted in three provinces in three Southeast Asian countries: Kampong Speu in Cambodia, Laguna in the Philippines and Thua Thien Hue in Vietnam. Across participating countries, the study had two major components: vulnerability assessment at the commune/ barangay level, and analysis of household level vulnerability. For all three countries, the province is the primary political and administrative division with geographic jurisdiction over a number of municipalities (in the case of the Philippines) or districts (in the case of Cambodia and Vietnam). In turn, each municipality/ district consists of a number of barangays or communes. The *barangay* (village)/commune is the smallest administrative and local government planning unit in all the study sites.

The study went through three major phases as shown in **Figure 1**. First was the clarification and identification of the determinants of vulnerability and corresponding indicators which were used to assess vulnerability of the study sites in Cambodia, the Philippines and Vietnam.

This was followed by data gathering through: the conduct of two surveys: the survey of communes/ barangays and the household survey; and the collection of information using focus group discussions (FGDs) and key informant interviews (KIIs) to enable the study to generate more in-depth and qualitative information as to the character of social vulnerability. The last phase consists of data processing and coding, commune/ barangay vulnerability mapping, and analysis. The participatory approach was applied across the phases through consultative meetings, discussions with stakeholders from the academe and research institutions,



Figure 1. Research Framework for Vulnerability Analysis.

provincial level concerned government agencies and LGUs, and constant engagement in the research process by LGU personnel, especially those from the planning, and disaster risk reduction and management (DRRM) offices.

Identification of Vulnerability Indicators

The study used the indicator approach to analyze vulnerability both at the commune/ barangay and household levels. A precursor study looked into for this approach was the country level study conducted by *Yusuf and Francisco (2010)*. The study commenced with the review of existing literature and discussions among the country core research teams towards identification and finalization of list of vulnerability determinants and their respective indicators to be used in the assessment. Gathering of possible indicators by all country research teams was done based on literature review and in consideration of experts' opinions and LGU partners inputs and suggestions. Key informant interviews with members of the scientific community and LGU technical personnel were conducted for this purpose. FGDs at the provincial level were also conducted per country. The list of possible indicators were presented for discussion by each country research team in a project workshop attended by all country research team members together with a few representatives from partner LGUs and government agencies. The workshop resulted to a final list of indicators agreed upon by all country research team members together with a few representative from partner LGUs and government agencies. A major consideration in the finalization of the list was the availability of data in each of the three countries, and the ease of accessing the information needed in case of unavailability. These determinants were categorized under dimensions of exposure, sensitivity and adaptive capacity. The indicators used for exposure, sensitivity and adaptive capacity for commune and household level analyses of vulnerability are found in **Tables 1** and **2**.

Data Collection

Commune/barangay survey. To gather data on the indicators

for commune/ barangay vulnerability, a combination of data gathering techniques were employed in the conduct of the survey. Primary data collection was done using FGDs, KIIs, and consultative meetings. Secondary data were obtained through the examination of existing documents including barangay/ commune level national data, municipal documents and commune/ barangay profiles. Physical measurements were done whenever necessary.

Household survey. A household survey was also conducted in each of the three study sites. A common structured interview schedule incorporating the indicators for household vulnerability was drawn for this purpose and translated to the local vernacular. A two stage stratified random sampling was applied in this study. The population of households was stratified by district/ municipality and then by whether the household is located in a rural or urban barangay. A stratified random sample of 600 households was then obtained using proportionate sampling.

In-depth case studies. In-depth studies of typical households, social groups and communities were undertaken. Focus group discussion (FGDs) coupled with participatory tools and techniques such as participatory mapping and tracing time-lines, and key informant interviews (KIIs) were also conducted in the study sites to generate information and insights among key and sectoral stakeholders in the area. On the average, nine FGDs, 22 in-depth household interviews and 25 KIIs were conducted in each of the study sites. Based on these, eight to 12 case studies were generated per study site to highlight social and gender considerations in vulnerability assessment

Analytical Procedure

Vulnerability assessment both at the barangay/ commune and the household level were done using the vulnerability indicators agreed upon. At the barangay/ commune level, mapping of relative vulnerability was done in addition to vulnerability measurement. Vulnerability was taken as a function of exposure, sensitivity and adaptive capacity with their relationship described as:

$$V_{it}^s = f(\bar{E}_{it}^s; \bar{S}_{it}^s; \bar{A}_{it}^s)$$

Where:

V_{it}^s = Vulnerability of system i to climate stimulus s in time t

\bar{E}_{it}^s = Normalized Exposure Index of system i to stimulus s in time t

\bar{S}_{it}^s = Normalized sensitivity Index of system i to deal with stimulus s in time t

\bar{A}_{it}^s = Normalized capacity Index of system i to deal with stimulus s in time t

Calculation of the average value of each exposure, sensitivity and adaptive capacity indicator for every commune/barangay was done and subjected to calculation of

Table 1. Indicators for *barangay*/ commune vulnerability.

Dimension	Type	Indicators
Exposure	Typhoon	1. Number of typhoons and tropical depressions in last 10 years
		2. Numbers of typhoon above 9 magnitude scale in last 10 years
		3. Number of sea level rises associated with typhoons in the last 10 years
	Flood	4. Number of flooding events above 2nd flood alert in last 10 years
		5. Average inundation level of the barangay/ commune
		6. Number of inundation days in barangay/ commune
	Drought	7. Number of droughts last over 4 weeks in last 10 years
Flash flood	8. Number of flashflood events in last 10 years	
Extreme cold	9. Number of extreme cold events last over 10 days in the last 10 years	
Sensitivity	Natural ecosystem sensitivity	1. % of Commune area with forest cover
		2. % of protection forest area to total commune area
		3. Percentage of Commune with steep slope (>30%)
		4. % of low-lying (inundated) area to total commune area
	Human sensitivity	5. Commune population density
		6. Percentage of Ethnic minorities living in commune
		7. Poverty rate of commune
		8. % of women-headed households
		9. % of solely elder headed households
		10. Commune malnutrition rate of under 5-year children
	Infrastructure sensitivity	11. % households accessing unhygienic water for daily use (water from river, lake, pond)
		12. % of households using water from wells for daily use
Livelihood sensitivity	13. % of commune laborers/households involving in agricultural sector (cultivation, husbandry, forestry, aquaculture)	
Adaptive Capacity	Infrastructure	1. % of irrigated land
		2. % of paved roads and concrete roads
		3. % of households accesses to tap water
		4. % of permanent houses
		5. % of two-storied houses
		6. No. of general doctors in commune health stations
	Economic	7. Average income per capita
		8. % of income from off-farm earnings
		9. Economic growth rate in last five years
	Technology	10. % of villages has loudspeaker
		11. % of households has Radios
		12. % of households has TV
		13. % of household has line phone & cell phone
		14. Number of Internet shops in a commune
	Social capital	15. % of Bachelor holders in commune staff
		16. Budget of development projects in the commune during last five years
		17. Number of projects undertaken by mass organization in the commune during last three years
	Human development	18. Number of training courses on climate change adaptation/year
		19. No. of doctors/1000 residents
		20. No. of hospital beds/ 1000 residents

Table 2. Indicators for household vulnerability.

Dimension	Type	Indicators
Exposure	Typhoon	1. Number of typhoons and tropical depressions in the last 10 years
		2. Numbers of typhoons classified as Signal Number 3 and above in the last 10 years
	Flood	3. Number of flood events experienced in the last 10 years
		4. Highest flood height experienced in the 10 years (in feet)
		5. Longest flood duration experienced in the last 10 years (in days)
	Drought	6. Number of droughts experienced in the last 10 years
	Flash flood	7. Number of landslide events experienced in the last 10 years
Extreme cold	8. Number of flash floods experienced in the last 10 years	
Sensitivity	Human sensitivity	1. Dependence ratio: ratio of dependent person (unemployed family member) to family size
	Livelihood sensitivity	2. Percent of annual income generated from agriculture, fishery and forestry activities
	Infrastructure sensitivity	3. Ratio of family size to area of weak house
		4. Distance of dwelling unit to nearest body of water
Financial sensitivity	5. Percent of debt to total income of households	
Adaptive Capacity	Infrastructure	1. Average area of permanent dwelling per head
	Economic	2. Income per capita
		3. Amount of remittance per year
	Technology	4. Number of TVs, radios
		5. Number of line phones and cell phones/household
		6. Number of vehicles per household
	Social capital	7. Number of contacts the household can ask for financial help
	Human development	8. Number of working household members
		9. Level of education: schooling years that the household head finished

normalized values to make the indicator values comparable across communes/barangays. The following formula was used to normalize the value of indicators:

$$Z_{ij} = (X_{ij} - X_i^{\min}) / (X_i^{\max} - X_i^{\min})$$

Where:

Z^{ij} = the normalized value of indicator i of commune j (or household j in the case of the household vulnerability analysis);

X_{ij} = the original value of indicator i of commune j (or household j in the case of the household vulnerability analysis);

X_i^{\max} = the highest value among all communes (or among all households); and

X_i^{\min} = the lowest value among all communes (or among all households)

To arrive at a composite exposure index defined as the weighted average of all normalized values of exposure

indicators, weights were determined and assigned for each indicator using the Analytic Hierarchy Process (AHP), considering the level of importance of each indicator based on consultation with various stakeholders and experts. theFGDs were conducted in each of the district/municipality within the study sites as well as among identified experts from the academe for this purpose. The composite indices for sensitivity and for adaptive capacity were also arrived at following the same procedure. The overall index of climate change vulnerability of each barangay/commune was calculated as the simple average of the exposure and sensitivity indices and the inverse of adaptive capacity index. The barangays/communes were then ranked according to their respective indices to have a picture of the barangays' relative vulnerability. Unlike in the case of analysis of barangay/commune vulnerability, household vulnerability indicators were given equal weights.

To produce the barangay/commune vulnerability maps for this study, ArcView/Info software was used. Information generated through qualitative techniques were coded, subjected to core team discussions and organized for analysis.

RESULTS AND DISCUSSION

The Study Sites

The three countries namely, Cambodia, the Philippines and Vietnam are part of the Southeast Asian region (Figure 2).

Kampong Speu, Cambodia

Kampong Speu province, the study site in Cambodia, was identified by an EEPSEA vulnerability mapping study as



Figure 2. The country study sites.

Province of Laguna, Philippines

The province of Laguna is located 30 km south of the city of Manila. The province has a total land area of 1,759.7 km², 72 percent of which has been classified as alienable and disposable and the remaining 38 percent classified as forest lands. Laguna is politically divided into 674 barangays/communes within 25 municipalities and five cities. Eighteen of its 25 municipalities and five cities of Laguna belong to the coastal zone with relatively high exposure to and long term inundation from floodwaters. The total population of Laguna is around 2.5 million (NSO 2007), with majority engaged in agriculture that is highly affected by the vagaries of weather and climate. The EEPSEA study ranked Laguna as the 14th most vulnerable site out of 74 sub-national areas (Yusuf and Francisco 2009), with flooding, typhoons, landslides and occasional but increasingly intense droughts, as its dominant hazard exposures.

Due to the big number of barangays and the large population, the research in the Philippines took a watershed

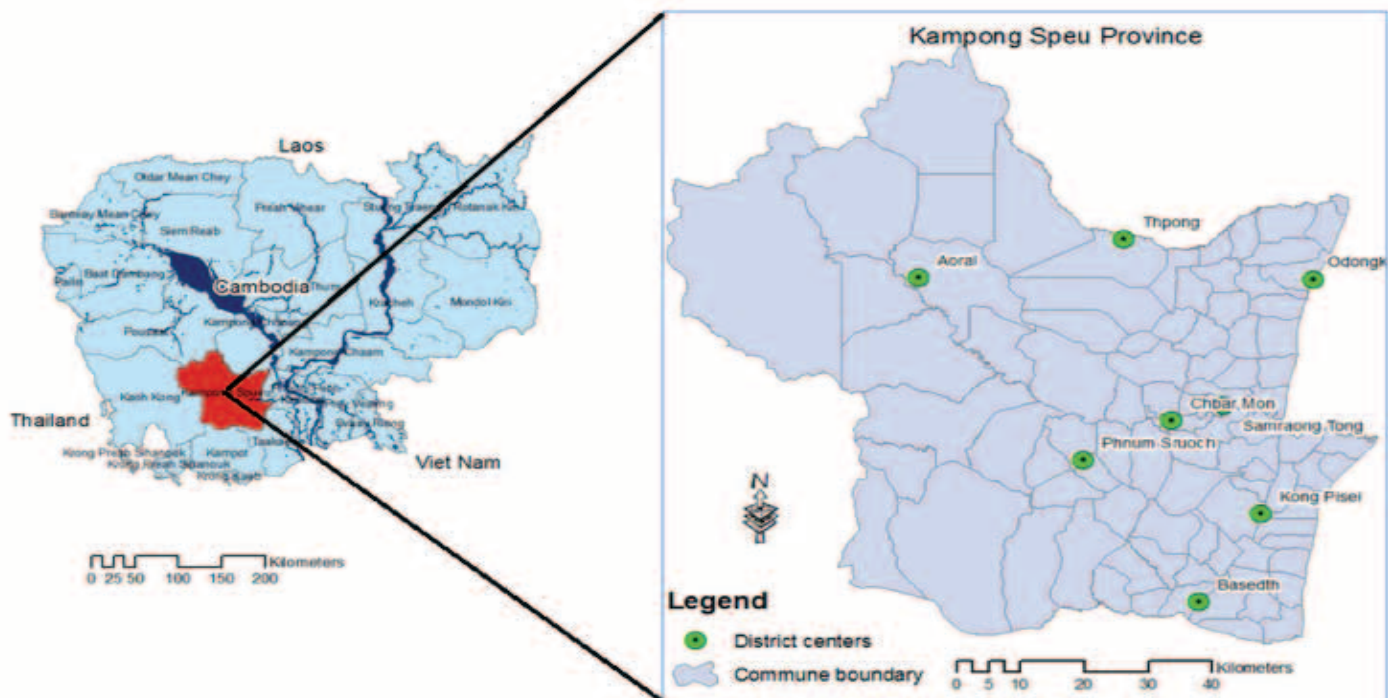


Figure 3. Location map of Kampong Speu, Cambodia.

approach and limited its study site to three adjacent watersheds of the Laguna Lake basin where agriculture was predominant. The Balanac, Sta. Cruz and Mabacan watersheds comprised of 12 municipalities with 270 barangays, 194 of which were covered by the barangay vulnerability assessment (Figure 4).

Thua Thien Hue, Vietnam

Thua Thien Hue is located in central Vietnam, bordered on the east by the South China Sea and on the west by Laos (Figure 5). The province has an area of 5,053 km², in which 49,107 ha is agricultural land and 180,412 ha is forest.

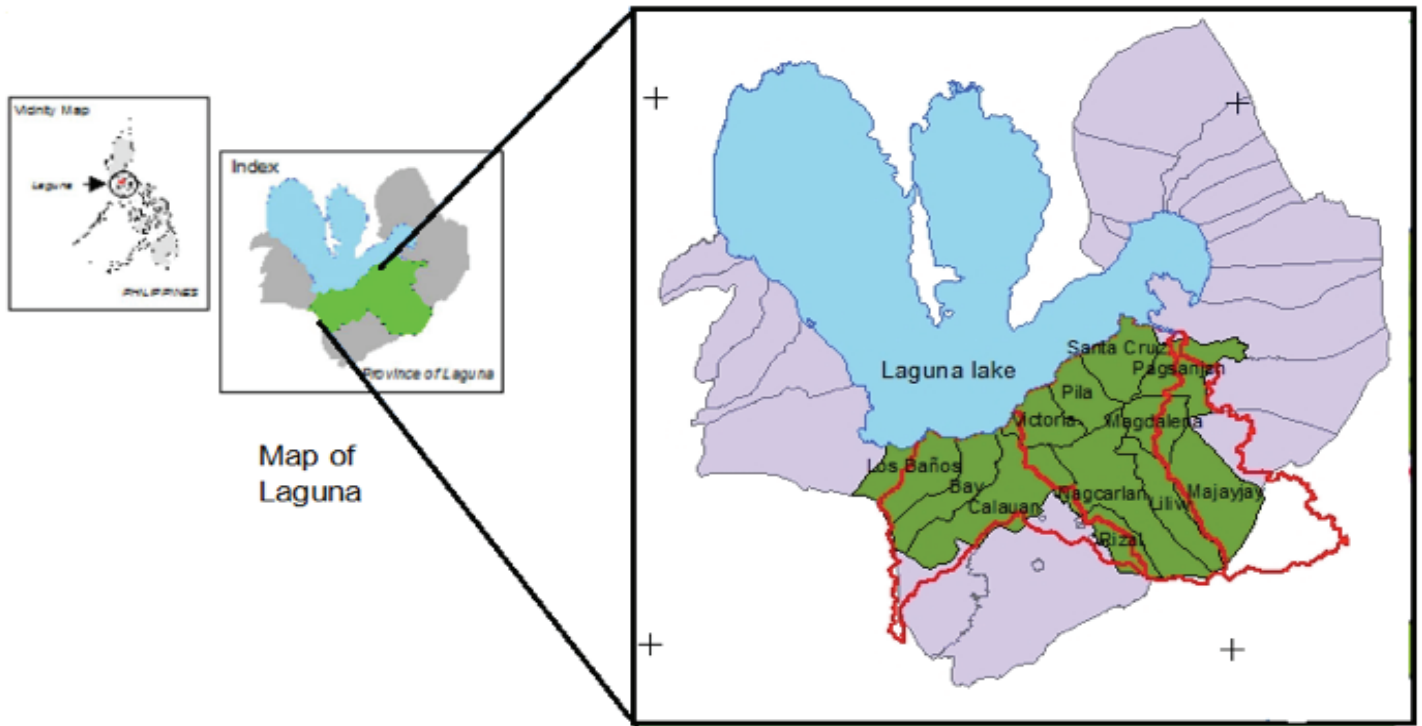


Figure 4. Location map of the Philippine study site.



Figure 5. Location map of Thua Thien Hue, Vietnam.

Thua Thien Hue province is divided into eight administrative districts and Hue city. Except Nam Dong and Aluoi districts that are located in the mountainous area, the other districts are in the plain and strongly affected by inundation.

Thua Thien Hue is considered amongst the most disaster prone areas of Vietnam. During the rainy seasons, crops, infrastructure, natural environment, and the inhabitants of these river basins suffer huge losses due to disastrous floods and storms. Including minority groups, the population of the province was 1,148,324 in 2008, 401,628 people reside in urban areas. Agriculture is the largest employer (57% of the total labor force) and will continue to play a significant role in employment creation and poverty reduction. The agriculture activities are highly exposed to recurring natural hazards including storms, extreme cold, floods and droughts.

Vulnerability analysis and measurement at barangay/commune level

Vulnerability analysis was conducted in the three provinces in three countries covering a total of 428 barangays/communes (Table 3). Climate-related hazards that communities and households in the study sites have experienced within the last ten years differed in terms of type, intensity, and frequency (Table 4). The province of Thua Thien Hue faced more types of hazards such as flood, typhoon, storm, extreme cold, drought, land slide and storm surge. The most dominant hazards were typhoons and floods. Flood happens frequently in lowland areas, 2-4 floods every year. Typhoon is less frequent but more damaging and affects every part of the province. Traditional adaptations to typhoons are less effective due to the increasing intensity and unpredictability.

Similarly, Laguna province was exposed to typhoon, flooding, landslides/erosion, and droughts. Typhoon and flooding are identified as having the most serious damages. This was corroborated by about 98% of the surveyed households indicating the experience of three to four typhoons on the average per year, and 89% of the same respondents reporting to have witnessed the perils that went with these typhoons at a signal number 3 intensity. Fifty-six percent experienced being inundated with an average water depth of about a foot that lingers for about seven days.

As for Kampong Speu province, Cambodia, the main

hazards were drought, storm surges and flashfloods. Drought occurred almost every year in both lowland and mountainous areas of the province. Flashfloods are more damaging but occurring less frequently than droughts and affecting only some areas nearby river. With a range of 0 to 1, with 1 indicating highest vulnerability index (VI) value, the level of exposure is highest for Thua Thien Hue, followed by Laguna province and then Kampong Speu. The exposure maps of the three study site in Figure 6 attest to this with Laguna barangays having lighter shades compared to Kampong Speu and Thua Thien Hue.

In terms of sensitivity, findings on the study sites in the three countries are quite similar. Communes/barangays that are highly sensitive to climate hazards are found located in fragile location (erodible river bank and hill, and low-lying areas), natural resource -based (agriculture, forestry and aquaculture) and of high poverty rate. There is a strong linkage between topographical feature, types of livelihood and local vulnerability. In turn, livelihood characteristics are important factor determining a household's level exposure and sensitivity to hazards. Crop and aquaculture yield and fish catch are very much influenced by climate factors such as rainfall, humidity, temperature, etc. Mapping of the sensitivity indicators of vulnerability yielded a representation of the contribution of sensitivity to overall vulnerability, showing darker shades for all three study sites compared to exposure (Figure 7).

The poor are easily impacted upon by climate hazards as they do not have facilities to fend against the negative and their ability to bounce back also is limited. The majority of communes at the study sites have low adaptive capacity due mainly to low income and poor infrastructure and low awareness of climate change. Integration of climate change adaptation into local development planning remains to be a gap. Thien Hue communes, however, registered relatively higher adaptive capacity than the barangays/communes from the study sites in Cambodia and the Philippines. Among others, this was attributed to higher social capital index of Thua Thien Hue compared to those of the barangays/communes in Kampong Speu and Laguna.

Where, within a range of 0 to 1, a vulnerability estimate of 0.5 or higher indicates that a barangay or commune is vulnerable, the percentage of vulnerable barangays/communes per study site differ. For all study sites, however,

Table 3. Total number of districts and barangays/commune included in the vulnerability assessment.

Study site	Number of districts/ municipalities	Number of barangays/ communes
Kampong Speu, Cambodia	7	82
Laguna, Philippines (3 watersheds)	12	194
Thua Thien Hue, Vietnam	9	152
Total	28	428

Table 4. Average frequency of climate hazards in the last 10 years.

Disasters	Kampong Speu	Laguna	Thua Thien Hue
Typhoons	0.10	3.8	4.2
Floods	0.18	6.0	2.7
Droughts	3.75	2.0	1.3
Landslide	n.a.	0.0	0.7
Flashfloods	n.a.	1.0	1.0
Extreme colds	n.a.	n.a.	3.0

these are mostly communities in lowland and coastal areas; especially communes/barangays with relatively high incidence of poverty, with large areas devoted for agricultural activities, with poor infrastructure and social facilities including those related to provision of good education and medical services, etc. In the case of Laguna – Philippines what contributes more to the vulnerability of the communities, and perhaps to the whole province, is high sensitivity and low adaptive capacity such as their relative unpreparedness, their fragile location (slopes, by the coast or river banks, etc), lack of amenities (including economic, social and infrastructure) that help fend against the negative impact of typhoons and floods, and scarce knowledge and information about climate change and its impact. The informal settlers along the lakeshore and waterways were

found to be one of the most observable vulnerable sectors in this regard.

For Thua Thien Hue in Vietnam, the dominant factors contributory to vulnerability in most cases are high exposure to hazard and low adaptive capacity due to low income and lack of infrastructure. Another important factor is the lack of a long-term planning perspective. The local authorities in the province have been primarily focused on building response capacity such as having yearly evacuation plans, training people in disaster drills, and providing weather data to local authorities, etc. Still, Thua Thien Hue generally registered higher adaptive capacity compared to the capacity levels of the barangays/communes in Kampong Speu and Laguna as indicated by the lighter colors in the case of Thua Thien Hue in the adaptive capacity maps of the three study sites (Figure 8).

As for Kampong Speu province, the relation between topographical feature of communes and their level of vulnerability level is difficult to generalize as a more geographical fragmented pattern could be observed. In each district, there are communes with very low and high vulnerability levels. Nevertheless, it is clear that high sensitivity and low adaptive capacities tend to aggravate overall vulnerability even if exposure levels are relatively low.

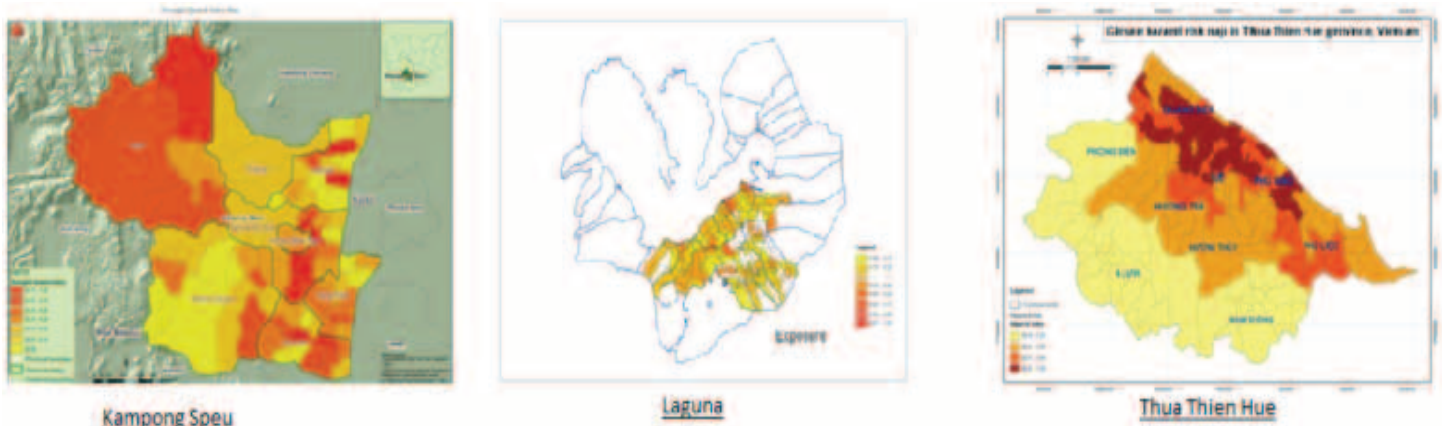


Figure 6. Exposure maps of three study sites.

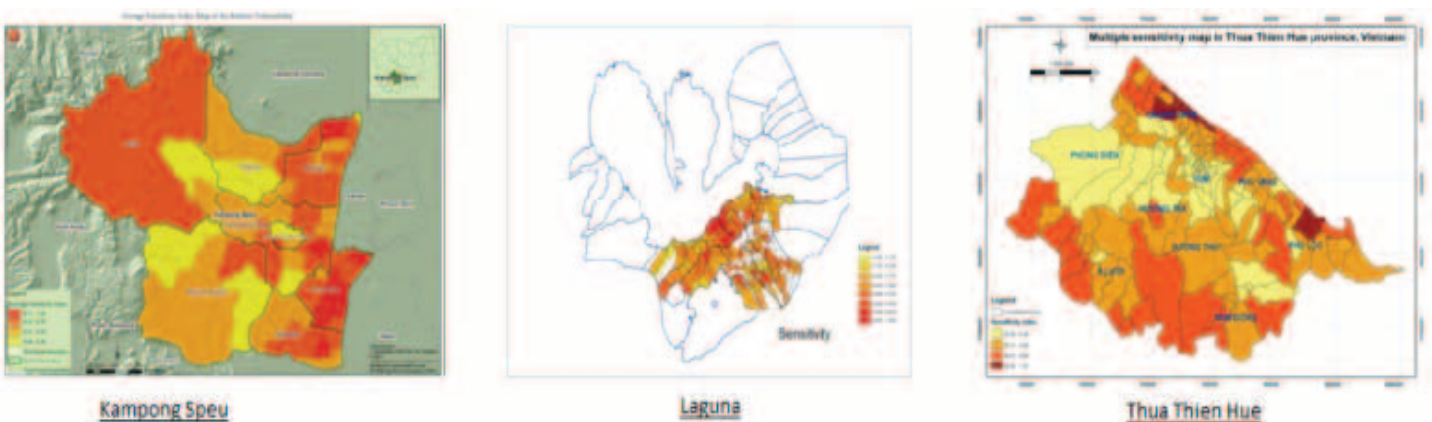


Figure 7. Sensitivity maps of three study sites.

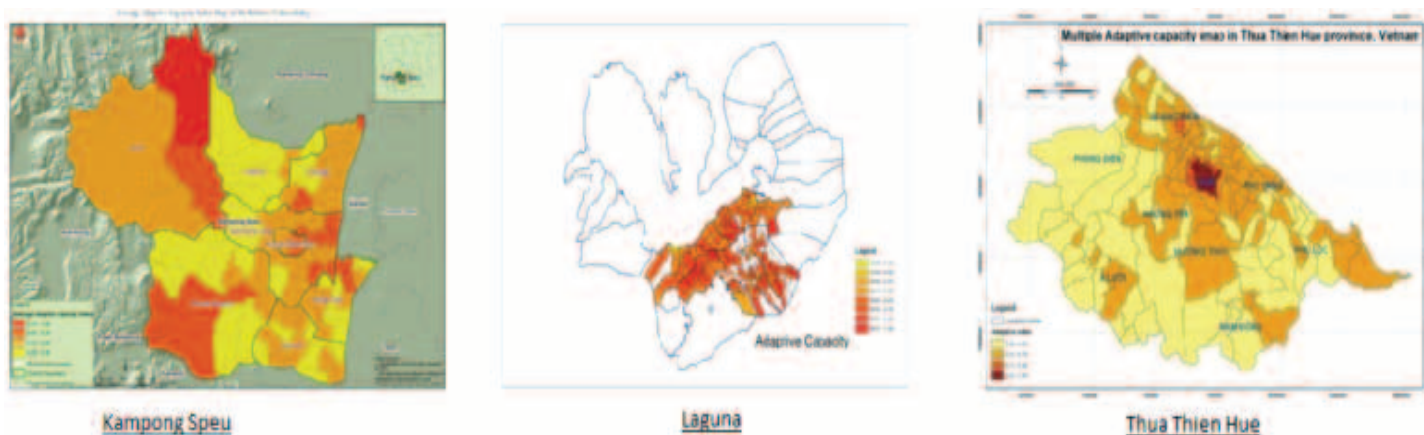


Figure 8. Adaptive capacity maps of three study sites.



Figure 9. Composite (overall) vulnerability of three study sites.

Vulnerability analysis at household level

The household vulnerability analysis at the three study sites was primarily based on the survey conducted among 600 households in each of the study sites. Results showed that household characteristics related to resource access and exposure play a dominant role in determining household vulnerability. These include household income (consumption), types of livelihood, health status, family size, education of the household head, and the level of exposure to hazard income.

The difference in geographical and climatic characteristics of the three study sites accounts for the exposure to different hazards as well. Kampong Speu households are more exposed to drought while Laguna and Thua Thien Hue households are confronted with higher exposure to typhoons and floods (Table 4). Kampong Speu experienced about four drought events in the last 10 years, while Laguna experienced 34 typhoons. Thua Thien Hue respondents reported experiencing an average of 4.2 typhoons over the same period. These corroborated with the findings on the exposure indices at the *barangay*/commune level.

Within a range of 0 to 1, a vulnerability estimate of 0.5 or higher means that a household is vulnerable to impacts of climate-related risk hazards. In Laguna the mean household vulnerability index is 0.43, while

in Thua Thien Hue it is 0.42. In Kampong Speu, the households has a mean index of 0.48. The vulnerability of households in Laguna is mainly attributed to high sensitivity and low adaptive capacity, while the vulnerability in Thua Thien Hue is determined mainly by high exposure to identified hazards. In Kampong Speu, household vulnerability is largely attributed to high sensitivity and low adaptive capacity (Table 5).

The distribution of households by level of vulnerability differed across study sites. The incidence of vulnerability, which is the percentage of households with a vulnerability index of 0.05 or higher, was observed to be highest in Kampong Speu at 67%. In the case of Laguna and Thua Thien Hue, about two-thirds of the surveyed households had a VI of 0.05 or higher.

Table 5. Household exposure, sensitivity, adaptive capacity and composite vulnerability.

Vulnerability	Kampong Speu	Laguna	Thua Thien Hue
Mean Exposure	0.21	0.08	0.469
Mean Sensitivity	0.46	0.26	0.38
Mean Adaptive Capacity	0.36	0.17	0.45
Mean Vulnerability Index (VI)	0.48	0.43	0.42

Source: field survey in 2011 and calculation by the research teams

Laguna and Thua Thien Hue studies found a strong correlation between type of livelihoods and household vulnerability. In Laguna, the study shows households engaged in agriculture-related livelihoods registered higher VIs compared to non-agriculture based households. Similarly, the study in Thua Thien Hue also confirmed that households with agriculture, aquaculture and forestry as main livelihood have higher VI compared to other types of households. Among the natural-resource based households, those with aquaculture and rubber plantation as main source of income are most vulnerable. For Kampong Speu province, agriculture households (cropping and animal husbandry) have a significantly higher vulnerability index as compared to other households. Households living on natural resource based livelihood are likely more vulnerable as these livelihoods are more exposed to and more sensitive to climate hazards.

Poverty was consistently found to be a factor in vulnerability in the three study sites. Most poor households were found vulnerable. However, a poor household is not necessarily vulnerable as vulnerability is shaped by the combination of the three components of exposure, sensitivity and adaptive capacity. The wealth status of a household is found only as an important factor determining its adaptive capacity. In Kampong Speu, results showed that about 80% of surveyed households are vulnerable and most of them are poor households based on a poverty threshold of US\$1 a day.

For Laguna, low adaptive capacity is the key to households being very vulnerable to climate change. The most vulnerable are the community constituents who tend to have more difficulty during disasters and have low capacities to bounce back to normal, pre-hazard conditions. These sectors are: low-income households; households dependent on agriculture-based sources of income and those whose productive members are daily wage earners; informal settlers; and who are residents along the lakeshores of Laguna de Bay, or other waterways like rivers and irrigation canals. Aggravating the plight of the informal settlers is their limited access to social services, including formal sources of credit and disaster response services extended to legitimate members of the community.

For Thua Thien Hue and Kampong Speu, high exposure and low adaptive capacity contributed much to the vulnerability of households. Thua Thien Hue's exposure analysis shows that over about 70% of households living in coastal, delta and upland communes experienced moderate to high level of exposure to climate hazards, with a hazard index ranging from 0.5 to 1. The current adaptive capacity of households is low, due mainly to low income, poor infrastructure, and lack of technologies to fend against negative impact of climate hazard. The household most vulnerable are poor households, households in coastal and low-lying area with aquaculture/fishing (especially sampan household) as main livelihood, rubber growing households in the uplands and households located in fragile locations.

Social vulnerability

The analysis of the social aspect of vulnerability to climate change in the three sites shed support to vulnerability as gender, socially and spatially differentiated across populations and scales of decision making. Different sectors of the society experienced different level of vulnerability to climate hazards. FGDs conducted among various sectors and key stakeholders in the three study sites identified vulnerable groups and sectors as found in **Table 6**. Among these are women and women-headed households, including widows, those engaged in agriculture, agroforestry and aquaculture, children, the elderly and large households. Informal settlers in the case of Laguna were also identified, many of whom are living below poverty thresholds and have difficulty accessing social services. Ethnic groups such as the Sampan in the upland communes of Thua Thien Hue were also identified as highly vulnerable to the impacts of climate change due to low adaptive capacities.

Lastly, It was established in all three study sites that climate-related hazards pose differential impacts on gender. The study in Laguna found an over-representation of women during and in the aftermath of climate-related disasters. While demand for effort and participation in the productive sphere goes up for both men and women during response and rehabilitation periods, there is no increase in demand for men to participate in the domestic front except for the

Table 6. Vulnerable sectors in the study sites.

Kampong Speu, Cambodia	Laguna, Philippines	Thua Thien Hue, Vietnam
Elderly	Elderly; elderly-headed HHs	Elderly; solitary elderly
Handicapped	Children	Handicapped
Children	Women-headed HHs	Children
Orphans	Residents on / near lakeshore and rivers	Farmers (rice, rubber and acacia plantation)
Rice farmers	Agriculture sector	Aquaculturists
Widows	Households with high incidence of poverty	Sampan
Poor family with more than five children	Large families/ HHs	Ethnic minorities
Family with violence	Informal settlers	Poor
	Poor	Women-headed HHs

rebuilding of physical structures. Older women members of the household, on the other hand, tend to have more burden in terms of caring for the sick, children and the elderly during and after disasters. Gleaned during the data generation was also the tendency for men to focus more on the effects on and rehabilitation of infrastructures and physical amenities, while women are more focused on difficulties in the conduct of usual domestic activities and ensuring health services at the community level. Women were more vulnerable to climatic hazard than men due to the fact that women are not physically strong as men, having limited skills and opportunity but more responsibilities in taking care of family member.

CONCLUSION AND RECOMMENDATIONS

Vulnerability to climate change impacts as a phenomenon is regional, with Southeast Asian countries equally confronted with climate-related risks and hazards and their consequent impacts. The breadth and depth of such exposures, however, importantly differ across local contexts and sectors. Vulnerability is obviously a function of exposure of varying human ecosystems to identified hazards. However, it is significant to note that human, social and economic sensitivity to these hazards and the adaptive capacities of communities has major contributions to overall vulnerability. Aggravating the exposure factor are other indicators of vulnerability such as poor infrastructure, lack of alternative livelihoods and inadequate attention to climate change issues that constraints the improvements of communities' current and future resilience. Relative vulnerability as a local phenomenon must be taken into account by national governments in planning and providing support for local governance and mainstreaming of climate change adaptation into local government plans.

Vulnerability assessment for purposes of providing adequate bases for planning and implementation of decisions for increasing the capacities of communities and households will benefit from further refinements of measurements of vulnerability. This includes the identification and setting of appropriate indicators, and the implication of this on policies toward improving the availability and access to corresponding data and data gathering / information generation techniques. Vulnerability assessment anchored on a participatory epistemology is highly recommended in this regard. Richer information and insights on the character of local vulnerabilities is generated with the inclusion of community stakeholders in the process of assessing vulnerability. In recognition of vulnerability assessment as a rational bases for climate change adaptation, assessment methodologies appropriate for different level of governance should be developed and refined.

The study have but scratched the surface of a number of growing dimensions of climate change vulnerability that

need further research. Among these are the issues confronting gender in relation to climate change impacts, the case of informal settlements which may well be related to migration in the light of climate change, the continuing need to delve into the risks confronting the agricultural sector, and the relevance of social capital within the climate change discourse. It is recommended that national governments look into these dimensions and provide support for researches that will provide knowledge- and science-based anchor for policies and on-ground interventions toward climate change adaptation. Given the many facets of vulnerability, the study also recommends for further refinement of the index approach by looking at other indicators for relative vulnerability.

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