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Juan M. Pulhin, Rose Jane J. Peras, Rex Victor O. Cruz, Rodel D. Lasco, Florencia B. Pulhin, and Maricel A. Tapia

University of the Philippines Los Baños

AIACC Working Paper No. 44
October 2006

Direct correspondence to:
Juan Pulhin, jpulhin@laguna.net

An electronic publication of the AIACC project available at www.aiaccproject.org

AIACC Working Papers

Distributed by:
The AIACC Project Office
International START Secretariat
2000 Florida Avenue, NW
Washington, DC 20009 USA
www.aiaccproject.org

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The AIACC project is funded by the Global Environment Facility, the Canadian International Development Agency, the U.S. Agency for International Development, and the U.S. Environmental Protection Agency. The project is co-executed on behalf of the United Nations Environment Programme by the global change SysTem for Analysis Research and Training (START) and The Academy of Sciences for the Developing World (TWAS).

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Vulnerability of Communities to Climate Variability and Extremes: Pantabangan–Carranglan Watershed in the Philippines[1]

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1. Introduction

Apart from intraseasonal and interannual variability in climate, extreme weather events such as cyclones, prolonged dry spells, and intense rainfall are known to cause adverse effects such as droughts and floods in tropical Asia. The 2001 report of the Intergovernmental Panel on Climate Change (IPCC, 2001) warned that a higher frequency of intense extreme events all across Asia is possible as a result of the projected global warming.

In the Philippines, watershed areas are believed to be among those to be adversely affected by climate change. Watersheds are critical to the economic development and environmental protection, and therefore, they are key to the pursuit of sustainable development. More than 70% of the country's total land area lies within watersheds. Much of the remaining natural forests that provide a host of environmental services are located in these areas. Also, it is estimated that no less than 1.5 million hectares of agricultural lands presently derive irrigation water from these watersheds. Moreover, around 20 to 24 million people—close to one-third of the country's total population—

[1] The research reported in this paper was supported by grant number AS21 from Assessments of Impacts and Adaptations to Climate Change (AIACC), a project that is funded by the Global Environment Facility, the Canadian International Development Agency, the U.S. Agency for International Development, and the U.S. Environmental Protection Agency and co-executed on behalf of the United Nations Environment Programme and by the Global Change SysTem for Analysis, Research and Training and The Academy of Sciences for the Developing World. Correspondence regarding this paper should be directed to Juan Pulhin, jpulhin@laguna.net.

inhabit the uplands of many watersheds majority of whom depend on its resources for survival.

Previous studies relevant to climate change in watershed areas have focused on the biophysical aspects (see, for instance, Jose et al., 1996). Completely lacking are studies that delve into the human dimension of climate change in these areas. In particular, there is hardly information on the impacts of climate change on local communities inhabiting these watersheds. Even more limited is the knowledge on the vulnerability of these communities to climate variability and extremes and their coping mechanism to minimize the adverse impacts of these phenomena. This paper hopes to fill this gap. It synthesizes the results of pioneering research on the vulnerability of local communities to climate variability and extremes within the Pantabangan–Carranglan Watershed located in northern Philippines. The focus is on the local scale, that is, on households and communities living within the watershed.

Specifically, the study sought to answer the following questions:

- What are the major natural occurrences experienced by the local communities in Pantabangan–Carranglan Watershed that reflect climate variability and extremes over the past few decades?
- Who are the vulnerable groups in the communities and where in the watershed are they located?
- What is the extent and nature of their vulnerability in relation to climate variability and extremes?
- What socioeconomic factors influence the vulnerability of the different groups?

- What conclusions could be drawn from the Philippine experience that could help advance the current state of knowledge and policies relevant to the vulnerability of local communities to climate variability and extremes?

The paper is divided into five major sections. Following this brief introduction, the next section outlines the key concepts and analytical frame that guide the assessment of the present vulnerability of watershed households and communities to climate variability and extremes. Section 3 presents a description of the study area, while section 4 discusses the research methodology used. Section 5 then presents the key findings of the study, highlighting the extent and nature of vulnerability of watershed households and communities and the factors that influence their vulnerability. The paper concludes by pointing out key research and policy measures that could help advance the body of knowledge and improve policy to reduce the vulnerability of communities in watershed areas, as well as the other vulnerable groups, to climate variability and extremes.

2. Analytical Framework

Vulnerability is one of the key terms in the climate change literature that has many different definitions and is subject to various interpretations and usage. A number of authors have reviewed the various definitions and approaches to vulnerability in relation to climate change (see, for instance, Cutter, 1996; Adger, 1999; UNEP, 2001; Brooks, 2003). Despite this, confusion appears to continue, and the term seems to defy consensus usage (Few, 2003).

This paper views vulnerability as the likelihood of households and communities in the Pantabangan–Carranglan Watershed to suffer harm and their ability to respond to stresses resulting from the impacts of climate variability and extremes. This conceptualization is consistent with Moss (1999) who views vulnerability to be a function of at least two major variables: sensitivity of the system to climate-related events and its coping capacity.

Climate variability refers to the variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2001). It may be due to natural internal processes within the climate system (internal variability) or to variation in natural or anthropogenic external forcing (external variability).

Meanwhile, a climate extreme is an event that is rare within its statistical reference distribution at a particular place (Gray, 2000). By definition, its characteristics vary from place to place. Gray (2000) further refers to it as an event that exceeds the average of a number of weather events over a certain period of time (e.g., rainfall over a season).

For the purpose of this study and in consideration of the climatic type in the study area, the occurrence of the following climate variability and extremes were assessed: El Niño, La Niña, early onset or delay of rainy season, prolonged rains, and occurrence of typhoons.

At the operational level, the nature and degree of people's vulnerability to the mentioned climate-related events were examined at two levels: community and household levels. At the community level, the degree of vulnerability of various socioeconomic groups was assessed by looking at the extent of impacts (positive or negative) of climate variability and extremes to four major areas of concern of local communities, namely, food availability, water supply, livelihoods, and health. In addition, the communities' adaptation strategies are also identified and their effectiveness determined, as a measure of their degree of vulnerability.

To better understand the nature of the household's vulnerability to climate variability and extremes, vulnerability indicators were identified and an index was developed, based on the above-mentioned four major areas of concern. This approach was patterned after the framework of Moss (1999) on a multiple indicators of vulnerability to climate variability and climate change from which a vulnerability index was developed on the basis of the system's sensitivity and coping capacity. Such an index was also necessary to determine the factors influencing the households' vulnerability to climate variability and extremes.

In the present study, a number of factors were hypothesized to influence their vulnerability. These are demographic (age, gender, ethnic affiliation, educational attainment, household size, migration), socioeconomic (income, household assets, expenditures, land ownership, farm size, farm practices, number of organizations, access to transportation, credit, and information), geographic (distance to market), and a number of coping mechanisms.

3. The Pantabangan–Carrangalan Watershed

3.1 Physical characteristics

The Pantabangan–Carrangalan Watershed lies between 15°44' and 16°88' north latitude and 120°36' and 122°00' east longitude (Figure 1). It is located in the municipalities of Pantabangan and Carrangalan in the province of Nueva Ecija, municipalities of Alfonso Castañeda and Dupax del Sur in the province of Nueva Vizcaya, and municipality of Maria Aurora in the province of Aurora. The watershed is ~176 km away from Manila (Saplaco et al., 2001).

On the basis of a 1999 land use map, the watershed has a total area of 97,318 ha, of which 4,023 ha comprise the water reservoir (Saplaco et al., 2001). It is considered as to be a critical watershed under the government's classification, as it supports a multipurpose dam for irrigation and hydroelectric generation. The watershed provides water for domestic and industrial uses and serves to tame the flood waters, which for years damaged the farm crops in Central Luzon. At present, it supplies the irrigation requirements of 24 municipalities in the provinces of Nueva Ecija, Bulacan, and Pampanga. It has a total service area of 102,532 ha, which is divided into four districts. A total of 369 irrigators' associations consisting of 62,039 farmers depend on the watershed for their farm irrigation needs (NIA-UPRIIS, 2004). It also generates 100,000 kilowatts of hydroelectric power, which supplies electricity within and in the adjacent region of Central Luzon (National Power Corporation (NPC), 1997).

The Pantabangan–Carranglan Watershed area largely falls under the Philippine Climatic Type I, with two pronounced seasons, namely, dry from December to April and wet the rest of the year. A small portion of the watershed, especially those at the boundary of the province of Aurora, falls under Climatic Type II, characterized by no dry season and very pronounced maximum rainfall from November to January. Its average annual rainfall based on measurements from 1960 to 1999 in four gauging stations within and adjacent to the watershed area range from around 1800 to 2,300 mm (Saplaco et al., 2001).

Minimum monthly temperature was recorded at 23°C and 34°C for the maximum monthly temperature, while the average annual relative humidity is 83% (NPC, 1995, 1997).

The topography of Pantabangan–Carranglan Watershed is characterized by complex land configuration and mountainous, rugged terrain. It ranges from nearly level, undulating and sloping, to steep hilly landscapes. Its soils originated mostly from weathered products of meta-volcanic activities and diorite. Surface soil textures are silty clay loam and clay loam to clay. There are four types of soils in the watershed, namely, Annam, Bunga, Guimbaloan, and Mahipon (Saplaco et al., 2001).

The major land use types found in the watershed are forestlands, open grasslands, and reforestation sites (Figure 2). Vegetation in the watershed is predominantly second growth. Since the logging boom of the 1960s, primary forest in the watershed has greatly declined, though remnants of dipterocarp forest can still be found (Saplaco et al., 2001). Nevertheless, of significant occurrence is the increase in the area of reforested sites, although these sites are now under intense pressure from increasing population. Residential and *barangay* (smallest unit of local government) sites, as well as cultivated areas, are included in the alienable and disposable areas.

3.2 Demographic characteristics

There are a total of 36 barangays found in the Pantabangan–Carranglan Watershed, of which 17 are found in Carrangalan, 14 in Pantabangan, 3 in Alfonso Castañeda, and 2 in Ma. Aurora. As of 2000, about 61,000 people resided in the watershed, which comprises around 12,400 households (National Statistics Office, 2000).

Three ethnic groups inhabited the watershed long before the Spanish occupation. These are the Aetas, Irol-les, and the Italengs. They were soon joined by several groups of migrants; among them were Pangasinensis, Ibaloi, Ifugao, Waray, Bicolano, Pampango, Kalinga, Kankanai, Ibanag, Cebuano, and Ilongot. However, the construction of the Pantabangan Dam in 1971 has led to relocation of the residents of the town and caused waves of outmigration from the period of 1970s to 1980s. Today, residents in the Pantabangan–Carranglan Watershed are predominantly Tagalog and Ilocano. Other groups present in the area are Pangasinensis, Pampango, Waray, Bicol, Ifugao, and Ibaloi (Saplaco et al., 2001).

3.3 Socioeconomic characteristics

The largest portion of the watershed is located in the municipalities of Pantabangan and Carrangalan in the province of Nueva Ecija. The major source of livelihood of these municipalities comes from agricultural activities. In Pantabangan, 12% of the total land area, which accounts for about 5,400 ha are devoted to agriculture. Meanwhile, a total of about 19,700 ha or 28% is allotted for farming in Carrangalan. Among the major crops that they produce are rice, corn, onion, and vegetables. However, even if the Pantabangan reservoir is located in these areas, they only act as a host for irrigation water to the Central Luzon area. Their farmlands are unirrigated because of topography; hence, farmers are dependent on rain (Master Plan of the Municipality of

Pantabangan, 1998–2000; Development Master Plan of the Municipality of Carrangalan, 2003–2007).

Fishing is the second largest industry in these areas, much of which is located in Pantabangan. This is because the area houses the dam reservoir, which is one of the biggest fishing reservoirs in Asia. The municipality of Carrangalan, on the other hand, depends on large fishponds for their fish production. Other sources of income of the residents are cottage and business activities, which include wood and rattan craft, animal dispersal, and small stores (Master Plan of the Municipality of Pantabangan, 1998–2000; Development Master Plan of the Municipality of Carrangalan, 2003–2007).

More than half of the productive population of Pantabangan and Carrangalan are in the labor force. However, unemployment is still a problem due to limited employment opportunities in these areas (Master Plan of the Municipality of Pantabangan, 1998–2000; Development Master Plan of the Municipality of Carrangalan, 2003–2007). Hence, many residents depend on the goods and services provided by the watershed for their livelihood. Commonly practiced in these areas are slash-and-burn farming (*kaingin*) and charcoal-making.

3.4 History of development intervention in the area

The human-made lake that forms part of the Pantabangan Dam reservoir has submerged the old Pantabangan town and seven outlying *barangays* (Saplaco et al., 2001). All of the residents of the old town were resettled in the upper portion of Pantabangan. This resettlement process, which was a joint responsibility of the National

Irrigation Administration (NIA) (2004) and the Department of Agrarian Reform (DAR), started in May 1973 and completed in August 1974 (Toquero, 2003).

Because the construction of the dam, the area has continually received support from various agencies and institutions in the form of projects or programs (Toquero, 2003). Raising the economic conditions of the relocated settlers was a prime concern of the government, and DAR was the leading agency that took care of this mission.

One of the most prominent projects implemented in the watershed was the RP-Japan Reforestation Project, which was launched in partnership with the Department of Environment and Natural Resources (DENR). This JICA-funded project commenced in 1976 and ended in 1992. It aimed to reforest the open and denuded areas of the watershed and provide technical support through the establishment of the Afforestation Technical Cooperation Center and the Training Center for Forest Conservation. The project has not only rehabilitated the denuded parts of the watershed but also created jobs for the local residents. Moreover, more than 600 Filipino forestry personnel were trained through this project, who are now actively working in environment departments (Yoshida, 2000).

Aside from the joint project with the Japan government, the DENR launched several reforestation programs, particularly in the municipality of Pantabangan. These are the Regular Reforestation Program covering a total area of 823 ha and the Integrated Social Forestry Program, which reforested about 856 ha. The department has also engaged in Contract Reforestation Program with NIA from 1989 to 1990. In this program, the DENR contracted NIA to reforest a total of 900 ha in the Pantabangan–Carranglan Watershed (Master Plan of the Municipality of Pantabangan, 1998–2000).

NPC and NIA also have their share of projects implemented in the watershed area. Aside from training and extension services, NPC conducts yearly reforestation and extension projects in the three sectors under its jurisdiction. The reforestation projects cover an average of 30–40 ha a year.

Meanwhile, the biggest project implemented by NIA at Pantabangan–Carranglan Watershed is the Watershed Management and Erosion Control Project, which lasted from 1980 to 1988. This project was funded by the World Bank and aimed to control soil erosion and minimize sedimentation and siltation in the reservoir. It has four components, namely, reforestation, feasibility study of an integrated development, waste management, and smallholder agroforestry pilot project, and integrated forest protection pilot program. Aside from opening employment opportunities to 3,800 residents in Pantabangan in 1982, the project also provided revenue and profit sharing to the communities in the watershed in the form of facilities, such as domestic water supply, school building, and road improvements

The Casecnan Multipurpose and Irrigation Project, which began its operation in 2001, was designed to collect a portion of the waters of the Casecnan and Taan Rivers in Nueva Vizcaya and transport it to the Pantabangan reservoir. It was designed to irrigate 35,000 new hectares of agricultural lands and stabilize the water supply of the current areas serviced by the Pantabangan–Carranglan Watershed. Moreover, it will generate approximately 150 MW of hydroelectric capacity to the important Luzon grid (Calenergy Company, 2004).

As already mentioned, the above projects have significantly helped the residents in the watershed through the provision of jobs, livelihood programs, and various forms of assistance. But despite the three-decade development effort of the government (amounting to PhP 1.5 billion or U.S.$30 M), there is still widespread poverty in the resettlement, as shown by a high percentage of families with income below the poverty threshold of Php 7,377. The residents also perceived the services provided by the government organizations to be unsatisfactory. This implies the failure of the government in providing an economically viable resettlement area for the residents. A point of contention, which could have contributed to this failure, was the lack of participation of the residents in the planning and monitoring of the development projects or programs. Some residents were unaccustomed with the livelihood activities that were introduced; hence they were forced to open *kaingin* or slash-and-burn in the critical watershed (Toquero, 2003).

Moreover, these development projects and programs may have also resulted in the dependency of some people on these forms of assistance and even to the goods and services provided by the watershed for their source of living. With the recent completion of these development projects and programs, the local settlers resort to charcoal-making, which destroys the areas that they reforested. What aggravates the situation is that this type of livelihood is practiced by more than 50% of the residents in the watershed (F. D. Toquero, personal communication, 2005).

3.5 Institutions involved in watershed management

Spearheading the management of the Pantabangan–Carranglan Watershed are three national government agencies, namely, the DENR, the NIA (2003), and the NPC. Each institution has specific areas within the watershed that is under its jurisdiction. This institutional arrangement comes from the need to sustainably manage the watershed so that there will be sufficient water in the reservoir for irrigation and hydroelectric power generation (Cruz, 2003). Supporting these institutions in the performance of their functions are the local government units present in the area, which through the process of devolution instituted under the 1991 Local Government Code were given the mandate to conserve, manage, and protect the natural resources.

4. Research Methodology

4.1 Data collection

The study employed a combination of data collection methods: secondary data gathering, household survey, use of participatory rural appraisal techniques, and direct field observation and GPS readings of identified vulnerable areas. These are discussed briefly below.

4.1.1 Secondary data gathering

Available secondary information on the biophysical and socioeconomic aspects of the watershed was gathered from relevant agencies to understand the local and regional context of the local communities. Sources of information include municipal and provincial development plans, socio-demographic statistics from the National Statistics Office, atlas and other maps from various sources, project documents, and other pertinent information from different institutional stakeholders of the watershed as briefly discussed below.

Meanwhile, climatic data, like rainfall, temperature, El Niño and La Niña episodes, and other natural calamities that occurred in the area were obtained from the Philippine Atmospheric, Geophysical and Astronomical Services Administration

(PAGASA) and the weather station near the watershed. These data were gathered on a historical basis.

4.1.2 Household survey

A household survey was conducted to determine the vulnerability of households to climate variability and extremes and the socioeconomic factors influencing their vulnerability. It made use of a pretested interview schedule that contained the following information: *1*) socioeconomic profile of the respondent; *2*) household's use and benefits from the Pantabangan–Carranglan Watershed; *3*) climate variability and extremes experienced in the last few decades and their impacts; *4*) household's vulnerability in terms of food availability, water supply, livelihood, and heath; and *5*) adaptation strategies.

The survey covered the four municipalities of the three different provinces encompassing the watershed. These are Pantabangan and Carrangalan in Nueva Ecija, Alfonso–Castañeda in Nueva Vizcaya, and Ma. Aurora in Aurora. Twenty-six (26) of the 36 *barangays* within the watershed area were covered. Ten (10) of 36 *barangays* were excluded since a very small portion of their respective areas is within the watershed boundary and hence very few people live in these areas. A total of 375 respondents were randomly selected using the *barangay* records. This sampling technique employed was adopted from Chua (1999), which allows a 0.05 permissible error and 95% confidence interval level.

4.1.3 Use of participatory rural appraisal techniques

Focus group discussions were conducted in 21 *barangays* to complement the household survey and determine the vulnerability of various socioeconomic groups at the community level. Of the 26 *barangays* included in the household survey, invited representatives from four (4) *barangays* did not show up during the scheduled focus group discussions; hence, they were excluded by default. A minimum age of 40, equal distribution of males and females, and presence of representatives from the different socioeconomic groups in the area were considered in the selection of participants..

The focus group discussions employed a combination of participatory techniques such as time line analysis, stakeholder analysis, participatory vulnerability assessment, and community mapping of vulnerable areas. The choice of these techniques was guided by the different research questions, the explicit objective of the study being to engage the local stakeholders in the process of assessing their current vulnerability, as well as the literacy level of the local communities (see Pulhin, 2002 for discussions on these techniques). Time line analysis was used to determine the major natural occurrences experienced by the local communities in the watershed that reflect climate variability and extremes from 1960s to the present. On the other hand, a combination of stakeholder analysis, participatory vulnerability assessment, and community mapping techniques were used to answer the second and third research questions as to which socioeconomic groups in the communities are more vulnerable, their location in the watershed, and the extent and nature of their vulnerability.

Aside from the assessment of the past and current vulnerability to climate variability and extremes, a scenario-building activity was conducted to determine the impacts of more extreme climate conditions as predicted by various global change models. The vulnerability of the different socioeconomic groups in the watershed to the feasible harsher conditions in the future was also explored through focus group discussions.

Consistent with the participatory approach of the research, focus group discussions were also employed to determine the communities' perspectives in determining the weights of the different variables to develop a vulnerability index. Further discussion on this is provided in Section 4.2.2.

4.1.4 Field observations and GPS readings

Direct field observation was also conducted to validate information gathered through household survey and focus group discussions. Vulnerable areas identified by the participants during the community mapping were verified on the ground and documented through photographs. In addition, GPS readings of vulnerable areas were also conducted for purposes of mapping these areas.

4.2 Data analysis

The study employed a combination of qualitative and quantitative approaches to analyze the information gathered through the above-mentioned methods. Qualitatively, the degree of present vulnerability of the different socioeconomic groups was assessed by aggregating and analyzing the results of focus group discussions. At the household level, a more quantitative technique using correlation and regression analyses was used to determine the factors influencing the household's vulnerability based on the vulnerability index developed. In addition, vulnerable areas were identified using Geographic

Information Systems (GIS) to complement the participatory vulnerability mapping conducted by the local communities.

4.2.1 Qualitative analysis

Results from focus group discussions conducted in 21 *barangays* were combined and synthesized to identify the climate variability and extremes experienced by the local communities in the last few decades; determine the more vulnerable groups and their location in the watershed; and assess the nature and extent of their vulnerability, including the effectiveness of adaptation strategies in terms of reducing vulnerability. This qualitative analysis centered on the vulnerability of major socioeconomic groups in the watershed as identified by the community members themselves during the focus group discussions. The emphasis on socioeconomic groups provides a broader perspective of the community vulnerability and complements the more detailed and quantitative analysis done at the household level.

4.2.2 Development of vulnerability index

Results from the household survey were used to develop a vulnerability index. The index consisted of four major component indicators: food, water, livelihoods, and health. The indicators were further divided into subcategories, which were given corresponding weights. Drawing from the framework of Moss (1999), the subcategories comprised relevant variables that involved certain characteristics of the component indicators in relation to climate variability and extremes (representing the household's sensitivity in relation to these components) and the presence or absence of adaptation strategies (representing the household's coping capacity).

Two types of weights were considered in the development of the index, that of the researchers' representing the experts' view, and that of the communities' representing the local stakeholders' view. The first iteration for the vulnerability index computation was based on the researchers' judgment that made use of composite weighing, in which all of the four major components (food, water, livelihood, and health) were given equal weights (25 points each) with a grand total of 100 points. The subcategories under each major component were also given corresponding weights with each level of the subcategories given equal points (Table 1). For instance, under the food category, the researchers assumed that the "availability of seeds" and "crop yield" are two major factors that influence the household's vulnerability to food supply. These variables were therefore considered as the subcategories under the food component and were given a weight of 12.5 points each. The subcategory "seed availability" was further divided into three subcategories, which were given corresponding weights of 4.17 each, depending on their characteristics in relation to vulnerability. Thus, where household finds it hard to avail itself of seeds, it is considered more vulnerable and hence given the weight 4.17 points, which is 1/3 of the 12.5 points given to the subcategory "seed availability". On the other hand, a weight of zero (0) is given if seeds are available year-round. Similarly, if seed availability is believed to be affected by climate variability and extremes, it is assumed to contribute to the household's vulnerability hence a weight of 4.17 points is given. Moreover, the presence of adaptation strategies is assumed to reduce the household's vulnerability; hence, households without adaptation strategies are given a weight of 4.17 points. On the other hand, a weight of zero (0) is given to those that practice adaptation strategies, since they are considered less vulnerable compared to those who did not.

Similar logic is followed by the researchers in giving weights to the other subcategories under the other three component indicators of vulnerability, namely, water, livelihood and health.

Other than the researchers' judgment, the local communities' perspective was also taken into account in the development of the index. Using the same set of indicators developed by the researchers, we conducted two separate focus group discussions in two clusters of *barangays* in the municipalities of Pantabagan and Carranglan, where participants were asked to provide their own weights for the index. The objective of the exercise was to determine whether there will be significant variation in the weights provided by the two groups and to determine the likely implications of this in the use of multilevel indicators of vulnerability. Consensus was sought from the participants during the focus group discussions on specific weights that they should assign for each component indicators at various levels.

Table 1 presents the vulnerability index developed using the researchers' judgment and that of the local communities'. Discussion on the index is reserved under the Section 5: Results and Discussion.

4.2.3 Correlation and regression analysis

The computed final vulnerability index, which is the summation of the food index, water index, livelihood index, and health index were correlated with the factors hypothesized to influence vulnerability using Spearman Correlation. These included a combination of demographic, socioeconomic, and geographic factors, including the number of coping mechanisms practiced by each household. Moreover, to determine the combined effects of the different hypothesized factors on households' vulnerability, regression analysis was done using SPSS for Windows, version 10. Both the correlation and regression analysis used a 0.01 to 0.05 level of significance.

4.2.4 Mapping of vulnerable areas

The assessment of vulnerable areas within the watershed was done using five key parameters, namely, slope, elevation, distance from the road, distance from the river, and distance from the community center. With the aid of GIS, the degree of vulnerability by land use type (i.e., grassland/brushland, agriculture/cultivation, and forest) was determined for the entire watershed using the category of low, medium, and high vulnerability (Table 2). A single vulnerability map was developed by overlaying all of the individual maps produced for each of the five parameters.

The vulnerability of grass and brushlands in the watershed was assessed in terms of its susceptibility to human-induced fire which is common in the watershed and which has been observed to increase during a prolonged dry season. On the basis of distance from the road, distance from the river and distance from community center, the vulnerability to fire was assessed in relation to its proximity to human activities that can start fire. The closer an area is to the road, river, or community, the greater is the chance that the area may suffer from human-induced fire. On the other hand, on the basis of slope and elevation, the vulnerability was evaluated to be low when the slope gradient and elevation of the area is low, as it is easier to control fire in favorable terrain. On the contrary, fire prevention and control is more difficult in adverse terrain; hence, vulnerability is high for areas with steeper slopes and higher elevation.

For an agricultural area, the vulnerability was assessed in terms of its susceptibility to soil erosion damages, resulting from large rain events, a commonly observed source of problem associated with climate change and variability and extremes in the watershed. In addition, the vulnerability of agricultural areas was also evaluated on the basis of its accessibility to farmers. A farm that is far from the road, river, or community center is more difficult to manage than a farm that is more accessible.

As for forests, the vulnerability level was assessed in terms of ease of management and protection associated with terrain conditions. Areas with favorable gradient and elevation are rated with low vulnerability since management and protection are less challenging here than in areas with adverse terrain. Further, forests that are more accessible (i.e., closer to roads, rivers, and community centers) are rated as highly vulnerable than forests that are hardly accessible due to greater chances of being encroached upon or cleared and converted to cultivated areas to compensate for the loss in productivity in existing farming areas due to increased erosion of the soil.

On the other hand, GPS readings were made for all the vulnerable places identified by the local communities themselves during the focus group discussions conducted in the different *barangays* using the participatory vulnerability mapping technique. Unlike the GIS-generated vulnerability map, which categorized the physical vulnerability of the watershed into low, medium, and high levels, the identified vulnerable places by the communities do not have these categories. Instead, the participants of focus group discussions were just asked to identify the location of vulnerable areas in the *barangay* map, which they themselves have drawn and were asked to explain the reasons why they think these areas are vulnerable based on their previous experience with climate variability and extremes. The GPS readings of the vulnerable places were plotted in the vulnerability map of the watershed developed through GIS.

The idea was to determine whether there will be a congruence between vulnerable areas identified using biophysical parameters though GIS with what the stakeholders see as vulnerable places.

5. Results and Discussion

5.1 Major climate variability and extremes in Pantabangan–Carranglan Watershed

The major climate variability and extremes experienced in the area as identified by the respondents are listed in Table 3. The respondents were able to recall two strong typhoons that occurred in 1970s, with local names *Kading* and *Didang*. Even the names of the typhoons left an indelible mark in the minds of the respondents because of the large destruction that it brought to the communities within the watershed. The occurrences of strong typhoons in the area can be attributed to the climatic area where the watershed is located and its position is near the Pacific Ocean where typhoons form.

The respondents also noted several El Niño episodes, particularly its occurrences in 1979–1980, 1982–1983, and 1997–1999. These observations corresponded with El Niño events recorded by PAGASA, as shown in Figure 3. Prolonged rains were also observed by the respondents in 1984, which also marked the occurrence of a weak La Niña event (Figure 3).

Variability in the onset of the rainy season has become a common event since the year 2000. This indicates the unpredictability in the onset of rains, which may be early or delayed. On the other hand, forest fires are frequent in the area and have occurred yearly since the 1980s. Between 1980 and 1988, the DENR recorded an average of 43 forest fires annually in the Pantabangan–Carranglan Watershed, damaging an average of 600 ha of forests a year or a total of 25,783 ha for the 9 years. Although the high frequency of forest fires coincided with the almost cyclic occurrences of climate variability and extremes, such as El Niño, and delays in the onset of rainy season, its prevalence cannot be highly attributed to the latter. According to the respondents, most forest fires were intentional since people are practicing *kaingin* (slash and burn) and charcoal-making. These practices have become a source of livelihood for them after the termination of the RP-Japan Reforestation Project, which provided jobs for the residents.

5.2 Vulnerable people and places

Considering the watershed's geographic location, it can be said that all the communities living there are generally vulnerable to climate variability and extremes, as well as to other natural calamities like earthquakes. Data available from PAGASA indicate that from 1980 to 1995, a total of 58 strong typhoons—an average of about four typhoons per year—inflicted major damages in the area. In addition, three major drought episodes occurred during the same period with an average interval of only about four years per episode. These drought episodes occurred in 1983, 1987, and 1991 during which the lowest total annual rainfall and water inflow were registered in the period 1980–2001. This is not to mention the major 1990 earthquake that claimed thousands of lives in Northern Luzon and almost turned Baguio into a ghost city, which also wreaked havoc on the watershed.

Although the exact value of damages inflicted by past climate-related events in the watershed is not available, anecdotal evidence gathered during the survey and focus group discussions affirmed that significant losses were incurred. These losses included human lives, destruction of properties, infrastructures, and sources of livelihood, especially farmlands and fishing areas. Decrease in crop yield was also pronounced in specific years. For instance, records from NIA indicate that in 1990, rice yield fell below average by more than two cavans (1 cavan = 50 kg) per hectare in both wet and dry season cropping as a result of drought and typhoons during this year. Local people, however, claimed during the interviews and focus group discussions that crop loss could be as much as 100%, as a result of droughts and floods. Indeed, some community members are so vulnerable that even before they could fully recover from adverse impacts of previous events, another calamity will strike again and force them back to the original desperate condition.

Climate-related events were observed to have triggered several health problems such as diarrhea, amoebiasis, dehydration, dysentery, dengue, malaria, and typhoid. Among the leading causes of morbidity in the watershed were respiratory ailments like pneumonia, bronchitis, acute respiratory infection, and tuberculosis. Although not yet proven, these diseases may have also been caused by severe climatic conditions. Skin disorders are also prevalent in the area, which can be attributed to the use of unsafe water and unsanitary practices.

Assessment of vulnerability of the watershed by land use types using the five parameters discussed earlier (slope, elevation, distance from the road, distance from the river, and distance from the community center) with the aid of GIS revealed that more than 65% of the entire watershed is moderately vulnerable, while more than 25% is highly vulnerable (Figure 4). Most of the areas that are highly vulnerable are forests, grasslands, and brushlands mainly by virtue of their location in steep and highly elevated areas and proximity to roads. Areas that are moderately vulnerable are largely grasslands, brushlands, and forests.

On the other hand, among the vulnerable places identified by the local communities themselves during focus group discussions include low-lying flood-prone settlement areas, agricultural areas prone to floods, and droughts, intermittent streams/rivers, farmlands at the tail end of irrigation canals, highly erodible areas on steep slopes along riverbanks, unstable areas with steep slopes that support infrastructure, and grasslands and forested areas/plantations near roads and settlements that are susceptible to fire.

Plotting the GPS readings of vulnerable places identified by the local communities during focus group discussions in the vulnerability map generated through GIS, provides an interesting result. As shown in Table 4, there is high congruence between the GIS-generated levels of vulnerability with the vulnerable places identified by the local communities. Sixty-four of the 86 GPS readings or about 74% fell within the moderate vulnerable areas, while 15% and 11% fell in the high- and low-level categories, respectively.

Although the vulnerable places identified by the local communities during focus group discussions, where GPS readings were taken, do not have detailed categories of vulnerability levels unlike that of the GIS-generated vulnerability map, they are more specific in their location and hence are more relevant to the concerns of local communities in terms of minimizing area-specific risks associated with climate variability and extremes (i.e., flood, soil erosion, waters shortage, forest fire, etc.) and in enhancing local adaptation. On the other hand, the GIS-generated vulnerability map may be more useful for macro-level planning to reduce vulnerability in the entire watershed. This implies that the approach of combining the two methods of identifying vulnerable areas could be a useful tool to provide a more comprehensive assessment of vulnerable areas and potentially more useful to better address the vulnerability in these places.

5.3 Extent and nature of people's vulnerability to climate variability and extremes

On the basis of the vulnerability index developed from the results of the household survey, farmers, in general, are more vulnerable to climate variability and extremes compared to nonfarmers (Table 5). This finding is true regardless of the source of weights used in the index, that is, whether determined by the researchers or the local communities themselves. However, the index developed using the researchers' weights produced both the highest (66.53) and lowest value (4.37) compared to the weights provided by the local communities (59.12 for maximum and 11.8 for minimum value).

Indeed, the values of the index are relative since they are sensitive to the perceptions or experiences of whoever is giving the weights. This is more evident in the case of the weights given by local communities in Patabangan under seeds availability where households with an adaptation strategy gets a weight of 2, but those with no strategy get a weight of 1. This suggests that those with an adaptation strategy are more vulnerable, which appears counter-intuitive. However, when participants during the focus group discussion from Pantabangan were asked whether this was a mistake, they maintained that the weight they gave was logical. They cited that some households that used adaptation strategies in response to the lack of planting materials like shifting to other crops or buying high-breed varieties of seeds had to face higher risk because of the high costs involved, thereby making them more vulnerable. As experience by some farmers, doing nothing but to wait until seeds become available (no adaptation) can at times be a better option. The same explanation holds in the case of livelihood adaptation strategies also in Pantabangan, where higher weight was given by focus group discussion participants under the “without adaptation” (2 points) as against the “with adaptation” (1 point) option. A further inquiry into the matter revealed that a common adaptation strategy of farmers in the area was borrowing money from local usurers that charge high interest rates, which based on their experience, can increase their vulnerability. On the basis of these examples, there is certainly the need to involve the different stakeholders in coming up with a vulnerability index, particularly those directly affected by climate variability and extremes like the local communities to ensure the appropriateness of the index.

On the other hand, local communities are themselves very heterogeneous. During the focus group discussions, the local community members identified at least three categories of farmers, as well as other socioeconomic groupings in Pantabangan–Carranglan Watershed that have varying degrees of vulnerability to climate variability and extremes. These are “small,” “average,” and “rich” farmers, fishermen, employees, and small-business entrepreneurs. The group that showed evidences of being the most vulnerable, based on the focus group discussions, are the small farmers. They were characterized by the participants as having very low educational attainment, not owning a parcel of land, having a very meager income and lacking capital, and lacking access to other productive resources. Some may even live in vulnerable places and have ineffective adaptation strategies to variable and extreme climate conditions. This group is considered the most vulnerable, because even if the overall climate-related losses may not be that devastating at the community level, the damage it creates to the household could have lasting impacts and could lead to a chain reaction of negative effects.

The group considered to be moderately vulnerable comprises fishermen, farmers with small land and little capital, owners of small enterprises, *sawali* (local name for a walling material made from bamboo) makers, and employees of various agencies. They are better educated compared to the small farmers and may have access to productive resources such as land, capital, and technology, although they don't have control over them. Despite this, however, few of them may have income below the annual per capita poverty threshold recorded at 13,843 pesos for the Central Luzon Region. Some of them may also live in vulnerable areas such as in low-lying flood-prone places and those where sources of water are limited in case of drought. Compared to the most vulnerable group, they are relatively less sensitive to climate-related losses because of their access to limited resources, and they have relatively better adaptation strategies.

The least vulnerable group consists of rich farmers and the households with family members working overseas. Affluent farmers in general are the most educated among the three groups. They usually own large tract of land/farm, possess investment capital, own farming machineries and tools, and have control over other factors of production, including technology. They also live in favorable areas that are less susceptible to flooding and have effective adaptation strategies. On the other hand, overseas workers are also better educated, like the more affluent farmers. Overseas workers have some access to financial resources and have linkages with other institutions outside the community. Their families are considered among the least vulnerable group because the financial support they provide is fixed and stable and not affected at all by variable and extreme climate events in the local area. Similar to the well-off farmers, their families also live in safer places and have better adaptation strategies.

Table 6 presents a detailed description of the different socioeconomic groups in Pantabangan–Carranglan Watershed relevant to their degree of vulnerability to climate variability and extremes. It should be highlighted that among the three groups, the small farmers in general may, in fact, have the greatest number of adaptation strategies. Some of these strategies, however, like availing themselves of high-interest loans, are ineffective, thereby increasing their degree of vulnerability.

5.4 Vulnerability of people to future climate variability and extreme events

Model simulations of climate change have projected decreases in precipitation ranging from roughly 5% to 80% and increases in average temperatures ranging from 1.7% to 8.4% during the dry season in the Pantabangan–Carrangalan Watershed by the end of this century (Cruz et al., 2002). This is expected to further cause negative effects in the food availability, crop production, livelihood, health, and water supply of the residents in the watershed.

Further increase in temperature and decrease in precipitation present a gloomy scenario for the small farmers in Pantabangan–Carranglan Watershed. Results of the scenario-building activity revealed that not only a decline in crop production, but hunger is likely, leading to malnutrition and other kinds of diseases (Table 7). Many of them will be engaging in other jobs since the farms that they used to tend will be confiscated because of unpaid debts. Access to high-interest loans may no longer be an available adaptation option since they do not have collateral to guarantee their loans. Moreover, lenders will also be selective of their clients and provide loans only to individuals who have capacity to pay. The poor farmers also have no choice but to stay in their area because they do not have money to transfer to other locations. Hence, in times of extreme weather conditions like typhoons, they need to evacuate to safer places like schools.

Meanwhile, average farmers and fishermen and employees or small entrepreneurs will still have moderate vulnerability to probable increased temperature and decreased precipitation in the future. Though their food, livelihood, health, and water supply may be affected by future climate variability and extreme events, a few adjustments on their expenditures and other activities will enable them to cope with negative impacts. Should the need arise, they also have the capacity to transfer to less vulnerable places in times of extreme weather conditions.

Finally, the rich farmers, although slightly affected by the probable changes in climate, appear to benefit more from the situation. Rich farmers will gain farmlands and other possessions from the collateral of poor farmers who are not be able to repay their debts.

5.5 Factors influencing vulnerability

As implied in the previous sections, while the Pantabangan–Carranglan Watershed communities are generally vulnerable to climate variability and extremes by virtue of their geographic location, their degree of vulnerability varies based on a combination of other factors. These factors include the farmer's or household's socioeconomic circumstances, as well as the broader sociopolitical and institutional contexts.

5.5.1 Socioeconomic factors

Table 8 presents the significant factors associated with vulnerability based on Spearman correlation analysis considering the weights provided by the researchers and the local communities. Using the researchers' weights, we found that three factors have significant correlation with vulnerability: farm income, monthly food expenditures, and farm distance to market. In the case of the first factor, considering that most of the respondents are farmers, those with high farm income have the tendency to be more vulnerable compared to those with low farm income. This implies that the more dependent people are in their income from the farm, the more vulnerable they are to climate-related disorders. On the other hand, the variable on monthly food expenditures is negatively correlated with vulnerability. This means that people who spend less on food—presumably because they have limited financial resources—are likely to be more vulnerable to adverse climate conditions. Finally, farm distance to market is also positively correlated with vulnerability, although the degree of associated is quite weak (at 0.05 confidence interval). As learned during the field work, households from far-flung areas are cut off from the market during rainy season and flooding that make them more vulnerable.

Similarly, three factors were also found to have a significant relationship with compliance, using the weights provided by the local communities themselves: number of organizations joined, farm size, and monthly food expenditures. A positive relationship existed between the number of organizations joined by the farmers and their vulnerability. This implies that what really matters in terms of reducing vulnerability is not the number of organizations joined by the farmers but the quality of services provided by these organizations. Similarly, farm size was positively correlated with vulnerability, meaning the larger the farm size owned by the household the greater the vulnerability. This can be explained by the fact that most farmers in Pantabangan–Carranglan Watershed usually devote their farms into single commodity, rice—making them more vulnerable to variable and extreme climate conditions.

To identify and evaluate the combination of factors that significantly affect the households' vulnerability, the vulnerability index was regressed with the different predictor variables. Out of the 17 postulated predictor variables, five variables were found to be significantly related with households' vulnerability using the weights provided by the researchers (Table 9). These were sex and ethnic affiliation for demographic factors, number of organizations joined and land ownership for socioeconomic factors, and farm distance to market for geographic factor.

In terms of demographic factors, households headed by women were found to be more vulnerable compared to men, whereas migrants were more vulnerable than native inhabitants. The vulnerability of women heads of households to climate variability and extreme events may be attributed not only to their limited physical capacity but also to their overwhelming family burdens. Family issues such as caring for sick children or extreme events like crop failure may impel them to borrow money to make ends meet. They must cope with these events, in addition to already burdensome daily household chores. On the other hand, the migrants' vulnerability may be related to their difficulty in having access to new land to cultivate since the watershed area is mostly classified as government land and therefore legally prohibited from further encroachment and cultivation by new settlers. Migrants are also unfamiliar with the area; hence, they are unable to better prepare or develop appropriate adaptation strategies to cushion the adverse impacts of variable and extreme climate conditions.

For the predicted socioeconomic variables, the increase in the number of organizations joined by the farmers does not necessarily accrue a reduction of their vulnerability but may, in fact, exacerbate it. More organizational involvement has the potential to take up farmers' time that could otherwise be devoted to other productive purposes. Meanwhile, households that don't own land are likely to be more vulnerable, as land is a very important asset for agricultural livelihoods, which are the major source of occupation for the majority of households.

In terms of geographic consideration, farm distance to market was positively and significantly related to vulnerability. This affirms the significant relationship between these two variables using the correlation analysis.

Using the weights provided by the communities, we found four variables to be significantly related with households' vulnerability: ethnic affiliation, household size, monthly food consumption, and farm distance to market. Two of these variables, namely, ethnic affiliation and farm distance to market, were also found to be significantly related with the household's vulnerability, using the weights provided by the researchers. On the other hand, larger households are likely to be more vulnerable compared to smaller households, probably because the former have more mouths to feed compared to the latter. Moreover, monthly food consumption was found to be negatively and significantly related with vulnerability. This affirms the output of the correlation analysis that households who are unable to spend much for food potentially because they have limited financial resources are inclined to be more vulnerable than those who can spend more.

On the basis of the computed coefficient of determination, about 46% and 44% of the total variation in vulnerability using the weights provided by the researchers and the local communities, respectively, are explained by the above mentioned significant variables (Table 9). This means that an average of around 55% of the vulnerability variance based on the weights provided by the two groups are still unaccounted for on an aggregate level. There is thus the need to look for other factors that may help explain household vulnerability aside from those identified in the regression model.

5.5.2 Contextual factors

In addition to the above-mentioned significant factors, the broader sociopolitical context by which the communities participate influence their level of vulnerability. As mentioned earlier, the chain of development projects implemented in the area from 1971 to the present has in some ways created a sense of dependency in the part of the local communities for external assistance. This is because these projects, especially the resettlement scheme, were more of a "dole-out" in their orientation with very little attempt toward building local capacities. Consequently, the culture of self-reliance was not fully developed, contributing to the vulnerability of some members of the local community, especially with the termination of these projects.

Instead of perpetuating external dependency through ill-conceived projects, one could create more positive impacts by implementing enabling national policies and crafting a more responsive institutional support system. Such national policies and an institutional support system could help reduce the local communities' vulnerability and enhance their adaptive capacity to minimize the adverse impacts of climate variability and extremes. For instance, the national government forest policy prohibits timber harvesting in all watershed areas that support big infrastructure projects, such as the Pantabangan–Carranglan Watershed, even if the communities themselves are involved in plantation establishment. This has discouraged their active participation in reforestation and forest protection activities and has led in many cases to deliberate burning of established plantations. In the absence of direct benefits from established plantations and because of limited sources of livelihood opportunities in the area, community members are compelled to engage in illegal cutting and charcoal-making to augment their meager income that has led to the degradation of some parts of the watershed contributing to its biophysical vulnerability. Similarly, despite the presence of the different institutions in the area, such as NIA, NPC, and DENR, their main focus is to protect their investments. The interest of the local communities, while these are seen as important is only of secondary priority. Previous institutional efforts have not given attention to the provision of more sustainable sources of livelihood. Moreover, institutional support to anticipate and adequately plan for the occurrence of variable and extreme climate conditions has yet to be developed. Similarly, there are yet no initiatives directed to enhance current adaptation strategies and build capacity at the local level.

Finally, the prevailing inequity that characterizes the Philippine social structure is evident in Pantabangan–Carranglan Watershed that further contributes to the vulnerability of the poor community members. The community's own typology of small, average and rich farmers is a concrete reflection of the inequitable social structure that prevails in the area. As already mentioned, the well-off sector of the community has better access and control over productive resources and has the option to live in safer places putting them at a less vulnerable situation. The same sector is also more inclined to capture most of the benefits from the different development projects due to their better association and linkage with the institutions that implement these projects.

6. Conclusions

Given the same climate stressors, vulnerability varies among different socioeconomic groups, depending on their access to production resources and other assets, options to live or have their assets in less vulnerable areas, and the effectiveness of coping mechanisms or adaptation strategies. In addition, broader societal, policy, and institutional contexts can exacerbate the adverse impacts of climate change that can compound the vulnerability of certain group.

Looking at the multiple stressors that contribute to people's vulnerability—which include a combination of climate and nonclimatic factors both at the micro and macro levels—is a useful way of understanding this complex concept. There is a need for bottom-up assessment and planning to address vulnerability and enhance adaptive livelihood at the local level. Participatory action and research that engages the different stakeholders, particularly the local communities, should be pursued to minimize vulnerability of the poor and enhance adaptive capacity at the local level.

To reduce vulnerability, policies and development programs should aim to empower the local communities to broaden their range of choices of appropriate adaptation strategies rather than making them dependent on external support. This should not preclude questioning the large-scale structural causes of vulnerability such as poverty, inequity, institutional, and economic barriers to development.

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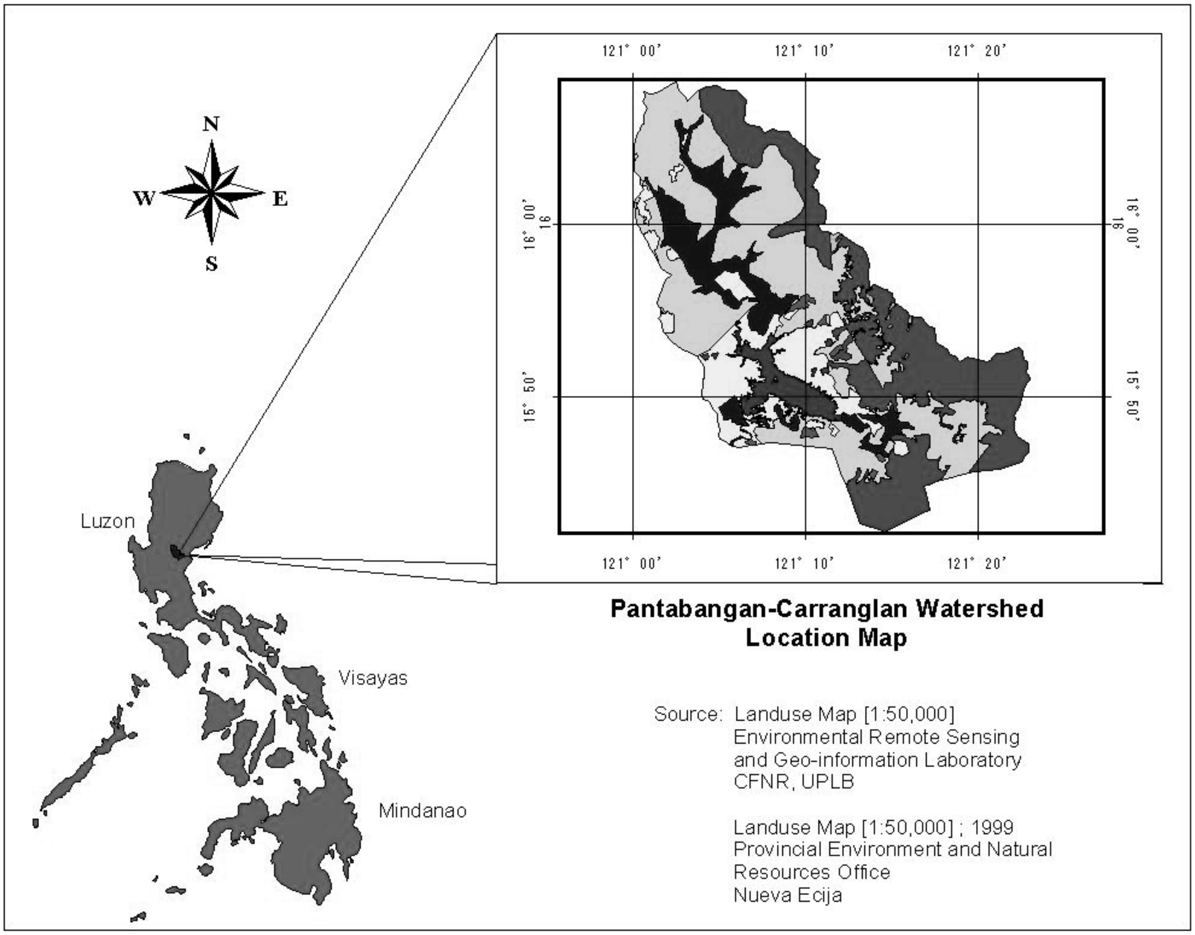


Figure 1. Location map of Pantabangan–Carrangalan Watershed.

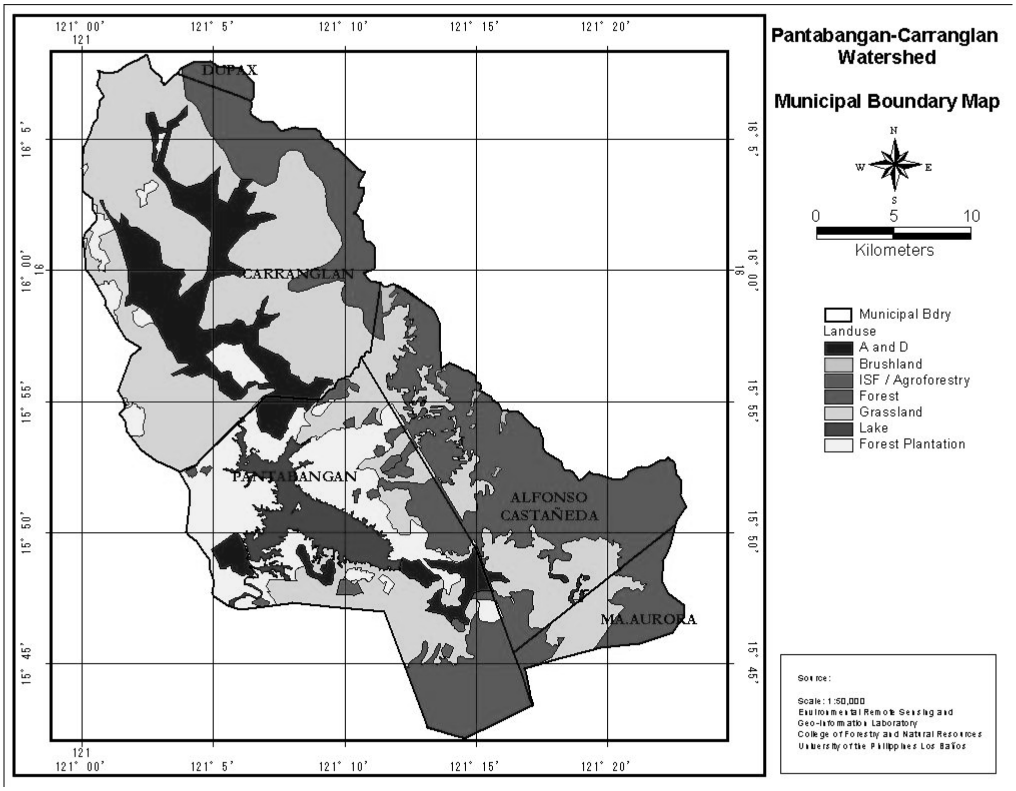
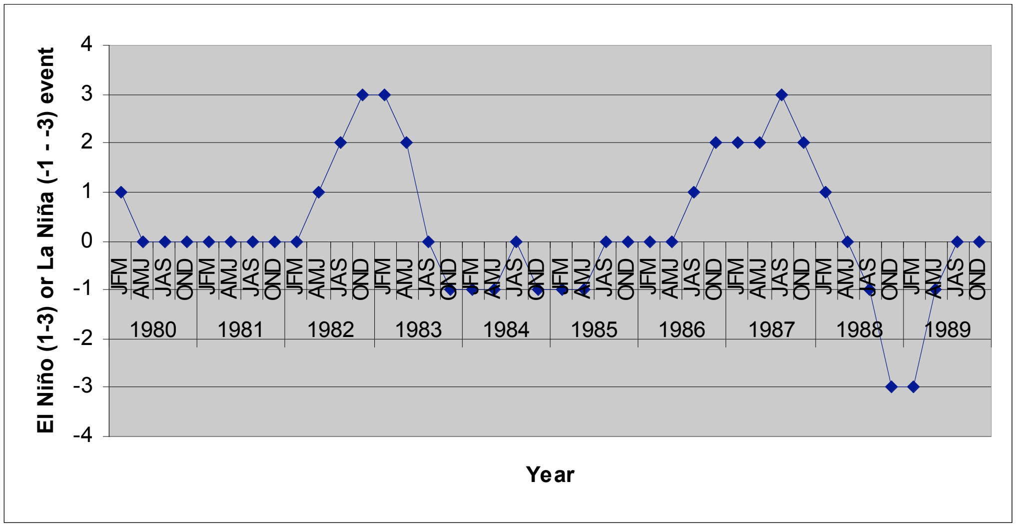
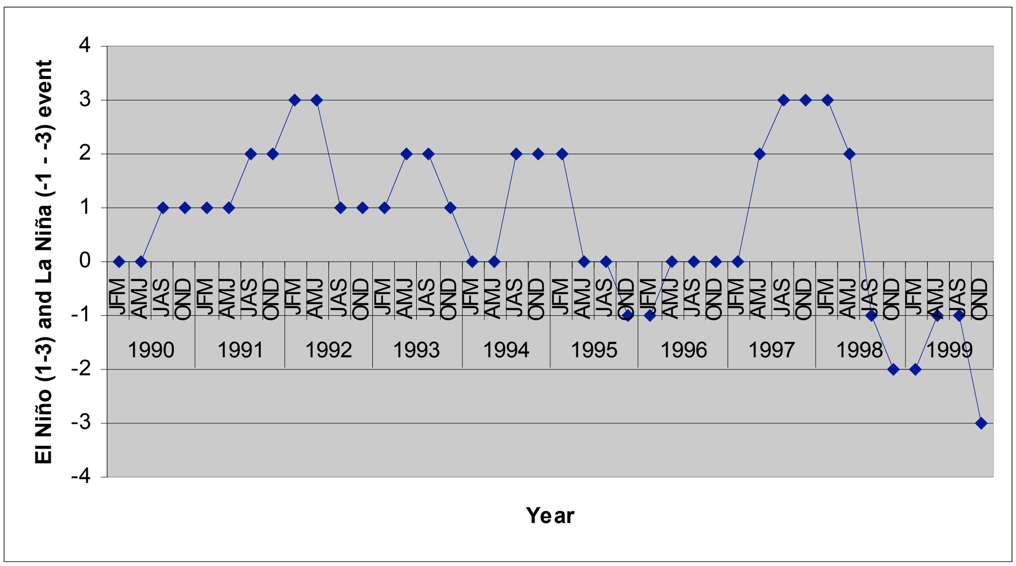


Figure 2. 1999 Land use map of Pantabangan–Carranglan Watershed with municipal boundary.





Legend: 3 = strong El Niño event; 2 = moderate El Niño event; 1 = weak El Niño event
-3 = strong La Niña event; -2 = moderate La Niña event; -1 = weak El Niña event
0 = no El Niño or La Niña event

Figure 3. El Niño and La Niña events recorded by PAGASA from 1980-1999

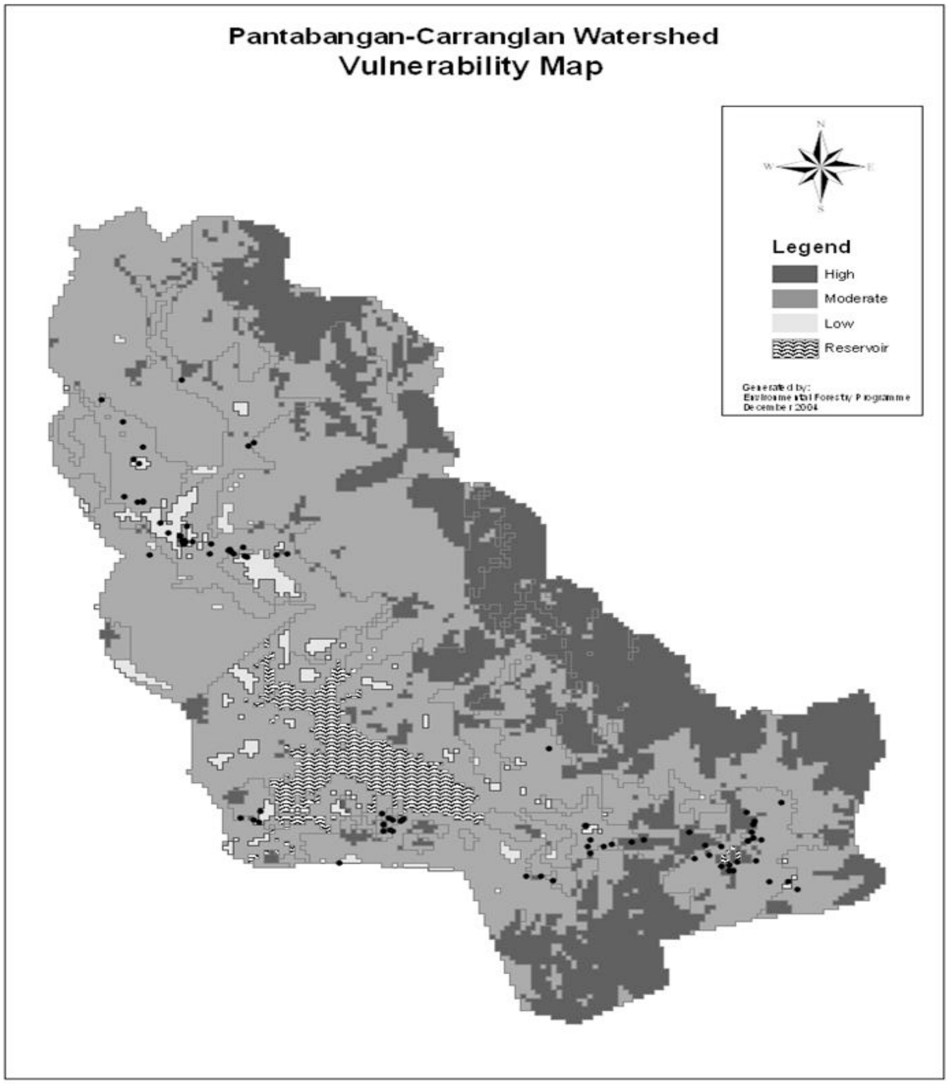


Figure 4. Level of vulnerability by land use types and location of vulnerable places as identified by local communities (GPS points)

Table 1. *Multilevel Indicator of Vulnerability of Pantabangan–Carranglan Watershed Households to Climate Variability and Extremes Using Varying Weights*

Vulnerability Index	Weights Provided by Researchers	Weights Provided by Local Communities		
		Pantabangan	Carranglan	P & C Combined
A. Food	25	25	40	32.5
a.1 Seeds availability	12.5	20	15	17.5
a.1.1 Availability of planting materials	4.17	8	7	7.5
i. Available any time of the year	0	3	2	2.5
ii. Seasonal or hard to find	4.17	5	5	5
a.1.2 Is it affected by CV and E?	4.17	9	5	7
i. Yes	4.17	9	4	6.5
ii. No	0	0	1	0.5
a.1.3 Adaptation strategies	4.17	3	3	3
i. With adaptation	0	2	1	1.5
ii. Without adaptation	4.17	1	2	1.5
a.2 Crop Yield	12.5	5	25	15
a.2.1 Percent (%) lost in rice production	4.17	1.5	10	5.75
a.2.2 Is it affected by CV & E?	4.17	2	10	6
i. Yes	4.17	2	7	4.5
ii. No	0	0	3	1.5
a.2.3 Adaptation strategies	4.17	1.5	5	3.25
i. With adaptation	0	0.5	2	1.25
ii. Without adaptation	4.17	1	3	2
B. Water	25	40	40	40
b.1. Domestic Water	12.5	33	15	24
b.1.1 Sources of domestic water	2.5	11	7	9
i. Natural sources	2.5	8	6	7
ii. Through agencies	1.25	3	1	2
b.2.1 Distance of house to sources of water	2.5	5	2	3.5
i. 0–250 m	0.62	0.4	0.2	0.3
ii. 251–500 m	1.25	1	0.3	0.65
iii. 501–1000 m	1.88	1.5	0.5	1
iv. > 1000 m	2.5	2.1	1	1.55
b.1.3 Observation for the supply of domestic water	2.5	7	2	4.5
i. Declining supply	2.5	3	1	2
ii. Increasing supply	0	2	0.5	1.25
iii. No change	1.25	1	0.5	0.75
b.1.4 Is domestic water supply affected by CV & E?	2.5	5	2	3.5
i. Yes	2.5	3	1.5	2.25
ii. No	0	2	0.5	1.25
b.1.5 Adaptation strategies	2.5	5	2	3.5
i. With adaptation	0	1	0.5	1.25
ii. Without adaptation	2.5	4	1.5	2.75
b.2 Irrigation water	12.5	7	25	16
b.2.1 Regularity/problem with supply?	4.17	3	10	6.5

i. Problem with supply	0	1	3	2
ii. No problem with supply	4.17	2	7	4.5
b.2.2 Effects of scarcity	4.17	2	10	6
i. Decrease in production/income	2.78	1	7	4
ii. No (zero) production/income	4.17	0.5	1	0.75
iii. Delayed harvest	1.39	0.5	2	1.25
b.2.3 Adaptation strategies	4.17	2	5	3.5
i. With adaptation	0	0.56	2	1.28
ii. Without adaptation	4.17	1.44	3	2.22
C. Livelihood	25	15	10	12.5
c.1 Seek sources of income in cases of CV& E?	8.33	6	2	4
i. Yes	0	4	0.5	2.25
ii. No	8.33	2	1.5	1.75
c.2 Is income from other sources sufficient?	8.33	6	6	6
i. Sufficient	0	2	2	2
ii. Not sufficient	8.33	4	4	4
c.3 Adaptation strategies	8.33	3	2	2.5
i. With adaptation	0	2	0.5	1.25
ii. Without adaptation	8.33	1	1.5	1.25
D. Health	25	20	10	15
d.1 Experienced health problems during CV & E?	6.25	6	2	4
i. Yes, experience health problems	6.25	4	1.5	2.75
ii. No	0	2	0.5	1.25
d.2 Kinds of health problems experienced during CV & E	6.25	7	4	5.5
i. Diarrhea, amoebiasis, dehydration, dysentery	4.17	3	2	2.5
ii. Dengue, typhoid, malaria	6.25	2	1	1.5
iii. Others: hepatitis, bronchitis, sore eyes, etc.	2.09	2	1	1.5
d.3 Access to medical services	6.25	3	2	2.5
i. Sufficient	0	1	0.5	0.75
ii. Not sufficient	6.25	2	1.5	1.75
d.4 Adaptation strategies	6.25	4	2	3
i. With adaptation	0	1.8	0.5	1.15
ii. Without adaptation	6.25	2.2	1.5	1.85

Table 2. *Criteria Used for the Assessment of Vulnerability of Pantabangan-Carranglan Watershed to Climate Change*

Land Use	**Slope**			**Elevation (m)**			**Dist from road (m)**			**Dist from river (m)**			**Dist from community (km)**		
	Low	**Mod**	**High**	**Low**	**Mod**	**High**	**Low**	**Mod**	**High**	**Low**	**Mod**	**High**	**Low**	**Mod**	**High**
Grass/Brush	0-50	-	>50	100-250	250-500	>500	>500	200-500	<200	>1000	500-1000	<500	>1000	500-1000	<500
Agriculture/Cultivation	<8	8-18	>18	100-250	250-500	>500	<500	500-1000	>1000	<500	500-1000	>1000	<500	500-1000	>1000
Forests	<18	18-50	>50	100-250	250-500	>500	>1000	500-1000	<500	>1000	500-1000	<500	>1000	500-1000	<500

Table 3. *Major Climate Variability and Extremes Identified by Respondents From Key Informant Interviews and Focus Group Discussions*

Year	Climate Variability and Extremes
1974	Typhoon Didang
1978	Destructive typhoon Kading
1979–1980	Drought/El Niño
1982–1983	El Niño
1984	Prolonged rains
1989	Delay on the onset of rainy season
1997–1999	El Niño
2000	Delay on the onset of rainy season
2001	Early onset of rainy season
2002	Delay on the onset of rainy season
2003	Early onset of rainy season

Table 4. *Number of GPS Readings of Vulnerable Places Identified by the Local Communities per Municipality That Fell Within the Different Vulnerability Levels Generated Through GIS*

Province/Municipality	No. of GPS Readings Within the GIS-Generated Vulnerability Levels			
	Low	Moderate	High	Total
Nueva Ecija				
Carranglan	6	29	0	**35**
Pantabangan	2	21	2	**25**
Nueva Vizcaya				
Alfonso Castañeda	0	8	9	**17**
Aurora				
Maria Aurora	1	6	2	**9**
Total GPS Readings	9	64	13	86

Table 5. *Values of Vulnerability Index for Farmers and Nonfarmers Based on the Weights Provided by Researchers and Local Communities*

Source of Index's Weights	No. of Respondents	Vulnerability Index (Possible Value from 0 to 100)		
		Mean	Minimum	Maximum
Researchers				
Farmers	70	38.14	6.87	66.53
Nonfarmers	38	24.56	4.37	43.00
Combined	108	33.37	4.37	66.53
Local Communities				
Farmers	70	42.87	18.95	59.12
Nonfarmers	38	26.30	11.80	55.12
Combined	108	37.04	11.80	59.12

Table 6. *Vulnerability of Various Socioeconomic Groups to Current Climate Variability and Extremes as Perceived by Focus Group Discussion Participants Based on Certain Qualitative Indicators*

Description	**Socioeconomic Groups**			
	Small Farmers	**Average Farmers and Fishermen**	**Employees/ Small Entrepreneurs**	**Rich Farmers and Overseas Workers**
General socioeconomic characteristics	Mostly with low educational attainment, no farmland or capital, very low income, almost no access to other productive resources.	Finished elementary education or reached high school; some access to productive resources such as land, capital, and technology	College or high-school graduates, some access to productive resources, such as land, capital, and technology	College or high-school graduates; more access and control over productive resources, including appropriate linkages
Nature of impacts of climate variability and extremes	Decline in crop production, food, livelihood, health condition; more debt incurred	Decline in crop/fish harvest and income, food availability, livelihood sources; health condition may or may not be affected	Increase in prices of commodities; limited sales	Decline in production and income; no change in food availability, livelihood, and health
Degree of negative impacts	High	Moderate	Moderate	Low
Examples of adaptation strategies	More likely to take out high-interest loans or borrow from relatives; plant vegetables along rivers/plant other crops; work in nearby towns; engage in other jobs	Plant vegetables along rivers/plant other crops; engage in other sources of livelihood	May take out government loans; engage in backyard projects; store food supply and other farm inputs for sale	Store food and farm inputs
Effectiveness of adaptation strategies	Some effective, others not	Effective	Effective	Effective
Location of settlement/properties relevant to vulnerable areas	Some are located in vulnerable areas	Some are located in vulnerable areas	Some are located in vulnerable areas	Generally located in secured areas
Degree of vulnerability	High	Moderate	Moderate	Low

Table 7. *Vulnerability of Various Socioeconomic Groups to Future Climate Variability and Extreme Events Based on Certain Characteristics*

Description	Socioeconomic Groups			
	Small Farmers	**Average Farmers and Fishermen**	**Employees/Small Entrepreneurs**	**Rich Farmers**
Impacts:				
Food availability and crop production	Decline in crop production; starvation	Decline in crop production and other livelihood resources	Increase in prices of commodities, hence increase in expenditures	Supply of food is not affected because they have money to buy
Livelihood	Worsening poverty condition; more debts incurred and longer time to repay	The livelihood sources of some will decline, while others will improve, especially those who loan money to the poor farmers with collateral.	Decline in business activities of small entrepreneurs and limited money to spend because of increase in prices of commodities. However, they are not much affected because some have alternative sources of livelihood, like livestock raising.	They become richer because they obtain the farms and other possessions (collateral) of the poor who loaned money and was not able to repay. The poor farmers also approached them for farm inputs, which the they return with interest. The rich farmers are also the buyers of "palay"; hence, they have control over the prices of crops.
Health	Their health will be affected by intense climate condition and malnutrition. Because they don't have money to consult a doctor or buy medicine, they will just resort to medicinal herbs or consult an "albularyo".	Their health will not be much affected.	Their health will not be much affected.	Their health will not be much affected.
Water supply	Shortage in water	Some will	Their expenditures	Their water

	supply for farm and domestic uses. The assistance given by government in terms of water pump usually does not reach them.	experience water shortage, while others will not be much affected because they have money to buy water for domestic and drinking purposes, as well as water storage facilities.	for water will increase, but their water supply will not be much affected because they have money to buy water for domestic and drinking purposes, as well as water storage facilities.	supply will not be much affected because aside from the capacity to make/find alternative sources of water, they also have money to buy water for domestic and drinking purposes, as well as water storage facilities.
Degree of negative impacts	High	Moderate	Moderate	Low
Examples of adaptation strategies	They work in other farms, engage in other jobs, work in nearby towns, or even apply for jobs abroad. They also plant crops that can adapt to the dry season, like onions and tomatoes. Others make "sawali" from cogon grasses that can be harvested in the mountain.	They plant fast-growing crops and store food supplies. They also invest in other businesses or find other sources of income. They look for jobs in other places.	They decrease budget in some expenditures and store food supplies.	They will be selective of whom to lend money to. They plant crops in other areas where there is water. They store food supplies.
Effectiveness of adaptation strategies	Some effective, others not	Some effective, others not	Some effective, others not	Some effective, others not
Location of settlement/ properties relevant to vulnerable areas	They have no choice but to stay in their area because they don't have the capacity to transfer to safer locations. In times of extreme weather events like typhoons, they need to evacuate to safer areas like schools.	They have the capacity to select or transfer to safer locations. Also, most of them live in high and safe places and their homes are made of sturdy materials like concrete.	They have the capacity to select or transfer to safer locations. Also, many of them live in safer places, and their houses are made of sturdy materials like concrete.	They have the capacity to select or transfer to safer locations. Their houses are located in safer places and are made of concrete. There are some who have houses in other places.
Degree of	High	Moderate	Moderate	Low

vulnerability				
Present distribution of farmers	75–85%	5–15%	5–10%	2–5%
Probable distribution of farmers in the future	85–90%	5%	5–8%	2–5%

Table 8. *Correlation Coefficients Between the Postulated Factors and Vulnerability*

Postulated Factors	Weights by Researchers		Weights by Communities	
	Vulnerability Coefficients	Level of Significance	Vulnerability Coefficients	Level of Significance
1. Demographic				
age	–0.07935		–0.1208	
gender				
ethnic affiliation				
educational attainment	–0.06391		–0.0398	
household size	0.01438		0.0015	
2. Socioeconomic				
total income	0.03483		0.0266	
household asset	–0.1782		–0.0845	
number of organizations joined	0.18399		0.2205	0.05
farm size	–0.1199		0.3241	0.01
farm income	0.26165	0.01	0.4393	
number of transportation system	–0.07328		–0.0168	
monthly food expenditures	–0.29576	0.01	-0.295	0.01
no. of loan applied	0.06742		0.12755	
no. of information sources	0.01012		0.1116	
3. Geographic				
farm distance to market	0.24182	0.05	0.212	
4. Overall coping mechanisms				
number of coping mechanisms	–0.08644		0.0282	

Note: The yellow highlight implies that the degree of association is significant at 0.05 level of confidence interval and highly significant at 0.01 levels.

Table 9. *Coefficients of thePostulated Predictors of Household's Vulnerability by Stepwise Regression Analysis*

Postulated Predictors	Code	Weights by Researchers		Weights by Communities	
		Regression Coefficient	Level of Significance	Regression Coefficient	Level of significance
1. Demographic					
age	AGE				
gender	SEX	–9.66	0.01		
ethnic affiliation	NATIVE	–10.11	0.01	–0.2907	0.01
educational attainment	EDUC				
household size	HHMMDEPD			0.2781	0.05
2. Socioeconomic					
total income	TOTNCOM				
household asset	HHASSET				
number of organizations joined	NORGJ	9.74	0.01		
farm size	FARMSIZE				
farm income	FARMNCOM				
number of transportation system	NTRANSP				
monthly food consumption	FUDMON			–0.3929	0.01
number of loans applied for	NLOAN				
number of information sources	NFOSURZ				
land ownership	LANDOWN	–8.3	0.05		
3. Geographic					
farm distance to market	FRMDSTMK	0.0006	0.01	0.4010	0.01
4. Overall coping mechanisms					
number of coping mechanisms	NOCOPING				
Intercept		46.25		43.73	
Coefficient of determination		0.46		0.43	

Note: Variables without corresponding coefficient values does not meet the 0.05 level of significance for entry into the model.