

ENVIRONMENT AND FOOD SECURITY INTERACTIONS AMID CLIMATE CHANGE

A MULTI-SCALE ANALYSIS IN A PHILIPPINE WATERSHED



EDITED BY

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University of the Philippines
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PREFACE

This book analyzes the food security and environment interactions, and the corresponding community adaptation, amid climate change in the rural communities located in the Sta. Cruz watershed, Laguna, Philippines. It aims to do three things: 1) to understand how changes in climate affect the environment and the food security in the watershed as a whole and in the communities and households; 2) to identify technological strategies that may be undertaken to minimize the adverse effects of these interactions; and 3) to recommend policies towards the food security of communities within the watershed.

The study first identifies the site's exposure to climate hazards and the sensitivities to these hazards then analyzes the impacts of these hazards on agriculture, the markets, communities and households. It then describes the adaptation strategies employed by the farmers and traders, communities and households; and lastly, it determines the impacts of these adaptation strategies on food security.

The use of watershed as a unit of analysis supports the contention that the upstream-downstream relationship is important in mitigating harsh climate change impacts in the watershed communities that may lead to the decline in food security status. The smallest unit of analysis in this book is the farm and non-farm household, which bears the major brunt in coping with climate change.

As popularly mentioned in the literature, climate change produces effects that vary dramatically based on location, and a localized analysis and assessment is needed to determine what those impacts may be and how best to deal with them. It is hoped that the methodology used in this book can be replicated in studies of watersheds and local communities elsewhere.

AGNES C. ROLA
Coordinating Project Leader and Professor, UPLB

FOREWORD

The research papers, undertaken by the faculty and researchers of the University of the Philippines at Los Baños (UPLB) and now put out by the University of the Philippines Center for Integrative and Development Studies (UP CIDS) as a compendium, is proudly an evidence-based documentation of the various socio-physical conditions of selected areas in the Laguna Province of the Philippines.

All the areas in the study have been put under pressure by the hazards of climatic changes and events. This book identifies the human-environmental interactions that take place in the sites and presents insightful observations and suggestions on possible adaptation strategies that can help the population achieve survival and overcome the challenges of food security. The research identifies the typology of farming practices and habitation in the lowland, mid-land and upland areas, which exhibit diverse agricultural practices and vulnerabilities to climatic events and food insecurity. The study bears implications for the individual, household, and community behaviors, as well as for policies relative to agricultural and environmental practices. For example, the research has noted that climate change impacts can create household vulnerabilities to food insecurity; to mitigate this, policy makers can consider, among others, investing in the education on coping strategies to manage disaster impacts, and promoting sustainable agriculture practices such as the raising of indigenous food crops and the managing of pests with the proper use of pesticides. Coping strategies also have implications to national and local policies; the study has found a need for devising an integrative local and national plan that can address the issues related to sustainable watershed management; this could include creating a public distribution system that offers a variety of cheaper and more available food substitutes, such as secondary crops, enhancing existing food assistance programs, and installing an early warning device for extreme climate events at the local government level.

The scientific assessment of human-environmental interfaces is crucial to educated policy formulation and delivery. This compendium is offered as a modest contribution of such in the aim of promoting informed policy decisions.

I urge our policy players to take cognizance of Environment and Food Security Interactions amid Climate Change: A Multi-Scale Analysis in a Philippine Watershed.

EDNA E. A. CO, DPA
Professor and CIDS Executive Director

CHAPTER 1

FOOD SECURITY AND ENVIRONMENT INTERACTIONS UNDER CLIMATE CHANGE: FRAMING THE ISSUES

AGNES C. ROLA, ZENaida M. SUMALDE, JOSE NESTOR M. GARCIA

Framing the problem on food security environment interaction under climate change necessarily focuses on adaptation by the agriculture sector to climate change. This chapter discusses the elements of the vulnerability framework used in the study highlighting impacts on agriculture and markets, communities and households. The framework likewise suggests that to achieve food security, adaptation strategies of the various sectors-farmers and traders, communities and households should be strengthened. The chapter also presents the data used and the methods of analysis as well as the local context of why food security and environmental interactions amid climate change has to be studied in a watershed scale.

Keywords: food security, climate change, environment, community, agriculture, Sta. Cruz watershed, Laguna, Philippines

INTRODUCTION

Climate change is a major constraint to increasing agricultural productivity through its effects on the environmental resources used in the production process. With long-term changes in temperature and precipitation, and increased frequency of extreme events, there is growing concern over its impact on future global food production and food security (Kurukulasuriya and Rosenthal 2003). The extreme and unpredictable weather conditions cause inconsistent crop yields that result in an unstable food supply on the local level; this, in turn, disrupts the overall food supply and affects the four dimensions of food security: food availability, food accessibility, food utilization and food systems stability.

There is clear evidence that changes in the weather pattern affect the agricultural resource base; water, agro-biodiversity, and soils—all of which are important production inputs—are susceptible to the negative effects of these changes and factor in the risks to productivity. Climate change will also continue to be a stressor to water resources—as evidenced by floods, water scarcity and water quality problems, which all impact on aquatic ecosystems. Communities in the coastal areas are at an increasing risk from sea level rises and storm surges. This may lead to water and food insecurity. In terms of soil productivity, exposure to heat and floods may also affect soil quality and, ultimately, agricultural productivity. Rincon and Virtucio (2008) further observed that in forest and watersheds, increase in temperatures results in the changing of growing seasons, heat stress among plants, incidence of pests and diseases, and changes in the hydrologic cycle.

Approaching the problem on food security and environment interaction under climate change will necessarily focus on looking into how the agriculture sector adapts to climate change. One such adaptive procedure that can mitigate the impact of climate change on agriculture is to cultivate better management practices in soil and water conservation (Tongson 2011) and better practices in pest management. However, it is also important to understand the interactions across particular watersheds sharing water due to water allocation issues, effects of soil erosion downstream as a consequence of land use patterns upstream, and the characterization of the pest dynamics across space with the extreme events.

How will the tensions between climate change, environment and agriculture affect the food security status of households and communities? Rural households in many developing countries depend to a significant extent on agriculture for their livelihoods, where the poorer the household, the more dependent it is on the agriculture sector. For the poorest of these households, two-thirds or more of income is earned, on average, through agriculture—a total that includes income from the sale of crop and livestock goods in the marketplace, as well as the value of such goods produced by the household for home consumption. Such an agricultural dependence suggests that the income effects of a decline in agricultural productivity (all else being equal) could be significant. On the other hand, many rural households seek additional income in non-agriculture wage labor or self-employment (Lobell and Burke 2010). Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risks of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock (FAO 2008).

To mitigate hunger triggered by climate change, studies should be done to define adaptation strategies and policies that make the agriculture sector, households, and communities more resilient. This book contains results of the project investigating the food security and environment interactions under an extreme event scenario along multiple

levels: watershed, community, farm and households. Analyses also compare current adaptation measures in the upstream, midstream and downstream areas of the study watershed. From the results, technological and policy recommendations are formulated as adaptation strategies that can be used by households and communities in response to the various environmental hazards to which they are exposed.

CLIMATE CHANGE, ENVIRONMENT, AGRICULTURE AND FOOD SECURITY

Climate hazards are of two types: a) floods; and b) drought. For agriculture, excess or lack of water is not the only problem; the hazards also include strong typhoons, which bring powerful winds that can destroy even perennial crops and infrastructure.

Environmental hazards on agriculture that are caused by climate change include windy conditions, intense solar radiation, and temperature changes. For households, extreme weather events take the form of typhoons and floods.

People who are exposed to climate hazards have varying degrees of sensitivities. Some are more resilient than others. Small farmers who depend mainly on the marginal lands and the rain-fed production systems are the most vulnerable to climatic changes (Ludi 2009). In turn, this sensitivity to climate hazards will have an impact on agriculture and the markets, the rural communities as a whole, and the households (see figure 1.1). About half of the 88 million people in the Philippines live in rural areas where poverty is prevalent (IFAD 2009). Agriculture, as one of the major sources of living in most rural areas, will be under pressure in meeting the rising population demand, especially in a water-scarce scenario that is predicted to be further stressed by climate change. The reduction of this impact will be determined by the adaptation strategies available to the farmers, traders, communities, and households, which in turn determine their resilience to attain food security.

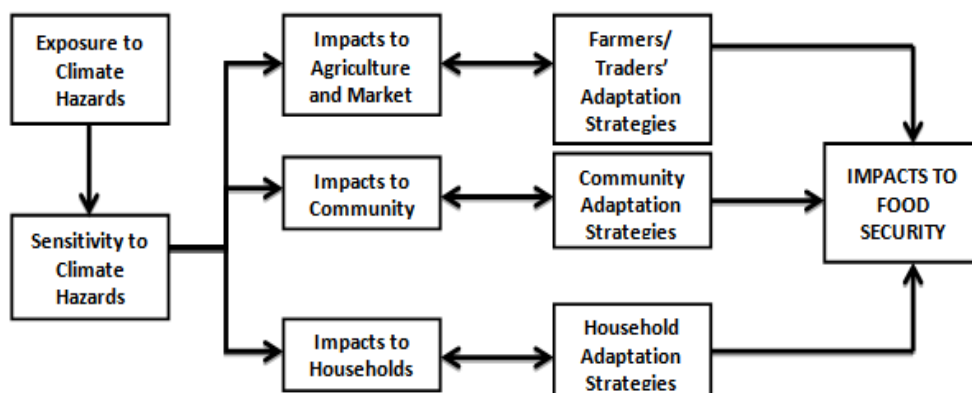


Figure 1.1. Food security and environment interactions under climate change

Adapting to the impact of climate change, however, poses a different and, in some ways, more difficult challenge for governments. Climate change produces effects that vary dramatically based on location, and a localized analysis and assessment is needed to determine what those impacts may be and how best to deal with them. It may be hard

to implement an action plan when the timeframes of major impacts are long term or if some adaptation actions are expensive. Adaptation and mitigation are both influenced by different indicators and economic and human activities in a particular location. These challenges persist even as recent experiences lend a greater sense of urgency to the need for adaptation planning (Perkins, Ojima, and Corell 2007).

Adaptation is distinctly regional and local, and the challenges faced by climate change impacts can vary dramatically even across small regions. The variations can be due to differences in the actual climatic changes, infrastructure constraints, existing environmental conditions, and community reliance on ecosystem services such as the protective functions of forest and mangrove ecosystems. Adaptation is a highly localized endeavor, and the findings of broad regional climate change impact studies are often “downscaled” or tailored to determine local impacts. Factors, such as adaptive capacity, are important for determining overall vulnerability and thus for making adaptation decisions. Government officials need to conceptualize and address these factors in a more than purely qualitative way. Additionally, many resources suggest a “path back to science,” that is, referring to scientific experts’ assistance in incorporating climate science into adaptation decisions (Heinz Center 2007).

THE CASE OF LAGUNA, PHILIPPINES

In the Philippines, one of the most vulnerable areas to climate change is the Laguna Lake watershed, home to over 12 million Filipinos. The number represents 13 percent of the country’s population. The Lake itself supports a range of environmental goods and services to the surrounding communities, which also extends to other stakeholders within and outside the basin. The proximity of the Lake and its watershed to Metro Manila and the continuing industrial development in the provinces of Laguna, Cavite, Batangas, and Quezon have and will exacerbate the pressure on this delicate ecosystem. As a result, the effects of climate change will accelerate the declining environmental condition in the Laguna de Bay watershed, a degradation due to increasing environmental stress from excessive discharge of pollutants, solid waste management, public health and sanitation problems, siltation and sedimentation, flooding problems and loss of biodiversity (Nepomuceno 2010).

Based on the experiences from Ondoy’s onslaught in Laguna de Bay, climate change projections indicate that the flooding would be more frequent, more intense and more damaging. The number of people at risk from flood damages would reach higher levels. Flood risks are more difficult to handle with weak governance, poor infrastructure planning, disregard for natural waterways and inundation areas such as wetlands, and over-reliance on ad hoc, short term and piecemeal measures without consideration to overall impacts of measures. Given its limited capabilities in addressing climate change, more so in designing and implementing effective adaptation strategies, the Laguna Lake Development Authority (LLDA) needs to revisit its role as a river basin office (RBO) in the context of climate change adaptation and disaster risk reduction management (DRRM). Taking the cue from the Second Thematic Workshop on Water-Related Disaster and Its Management in Asian Countries, “...for RBOs to effectively fulfill its role in water-related disaster and flood risk management and in the light of the fragmented nature of local flood risk planning, they need to assume a Flood Risk Management (FRM) focal point, thus providing a single framework that brings together information, guidance and key policies and providing a resource for all levels of government and external partners, in order to bring coherence and unity of action on flood risk management” (Nepomuceno 2010).

Table 1.1. Destructive typhoons that affected Laguna area, 2004-2006

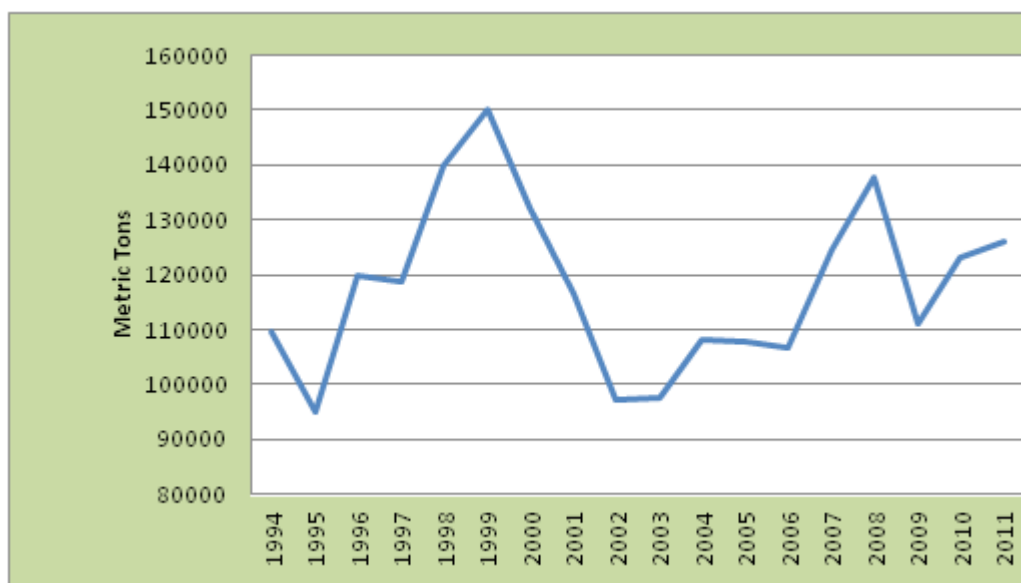
Name	Year	Population Affected		Properties Damaged (In Million Pesos)		Total Cost (In Million Pesos)
		Family	Persons	Agriculture	Infrastructure	
TY Yoyong	2004	1,665	6,748	-	-	-
ITCZ and LPA	2005	150	750	-	-	-
TY Caloy (Chanchu)	2006	517	2,589	111		111
TS Florita (Bilis)	2006			0.160		0.16
TY Milenyo (Xangsane)	2006	59,810	335,415	597	160	757
TY Reming (Durian)	2006	930	4,156	16	8	24

Source: Office of Civil Defense-Department of National Defense

Table 1.2. Damage to agriculture due to effects of El Niño Phenomenon in Laguna (as of 28 April 2010)

Crops	Production Loss (MT)	Actual Areas Affected (Hectares)	Production Loss (PHP Million)
Rice	7,554	6,890	69
Corn	-	73	1.8
HVCC	1,241	142	3.65

Source: NDCC

**Figure 1.2. Volume of palay production, Laguna, 1994 to 2011**

Source of basic data: Bureau of Agricultural Statistics

In Laguna, the effects of extreme weather—like typhoons and drought—on agriculture and rice production can be seen in tables 1.1 and 1.2 and figure 1.2. Between 2002 to 2006, palay production is in the downswing due to various typhoons that hit Laguna.

The goal of the Philippine government is to build the capacity of communities to adapt to climate change and increase the resilience of natural ecosystems to climate change. Adaptive capacity is defined as the ability of ecological, social and economic systems to: adjust to climate change; include climate variability and extremes; moderate or offset potential damages; and take advantage of associated opportunities (Climate Change Commission 2010).

Adaptive capacity is enhanced when impact and vulnerability assessments are used as the bases of strategic and long-term planning for adaptation. Assessments would indicate areas where critical water shortages can be expected. Such supply deficit can lead to possible reduction of water available for domestic consumption, trimmed irrigation service delivery, and possibly, decreased energy generation by dams. Note that the adverse impacts would cascade, so that long-term pro-active planning for these possible impacts is imperative in order to be able to respond effectively and avoid mal-adaptations. A number of adaptation strategies should be considered. Among the wide array of these cost effective options are rational water management, planning so as to avoid a mismatch between water supply and demand, upgrading/rehabilitation of dams where these are cost-effective, changes in cropping patterns in agricultural areas, establishing rain water collection facilities where possible, and early warning (ADAPTAYO, MDGAF, and DOST-PAGASA 2011).

Local government institutions are mandated to be in the forefront of disaster risk management (DRM) and climate risk management (CRM). The response to climate-induced events largely depends on the LGU's capability, resources, and priorities. However, responding to climate events should not be the sole responsibility of the government but also of community organizations (COs) and individual households (Peñalba and Elazegui 2011). There must be concerted efforts in adaptation activities, particularly in dealing with water resources development and rehabilitation.

This book reports the results of the project that investigated the food security and environment interactions, and community adaptation, amid climate change, in the rural communities of the Sta. Cruz subwatershed in Laguna. The end goal of the researchers is to be able to formulate technological strategies and policy recommendations to minimize these adverse impacts on human well-being.

METHODOLOGY

The Study Site

The study was conducted in the Sta. Cruz Watershed (SCW) of Laguna (figure 1.3). The choice of site was based on the accessibility of the location, plus the presence of secondary information for the biophysical characterization and other climate-related variables. The watershed was studied using an interdisciplinary approach with the two following components: the socio-economic component; and the agricultural and environmental component.

The study sites were in three locations representing the high, medium and low elevation areas of the SCW. In each of the three locations, two barangays (towns) were selected to represent the areas that are either more vulnerable or less vulnerable to extreme climate events. The following were the study areas where primary data

were generated: (a) high elevation: San Francisco and Bukal, Nagcarlan; (b) medium elevation: Calumpang and Bungkol, Liliw; and (c) low elevation: San Pablo Sur and Patimbao, Sta. Cruz. A detailed description of these study sites is discussed below.



Figure 1.3. The Sta. Cruz subwatershed, Laguna

Source: Philippine GIS Clearinghouse (PhilGIS)

Climate Scenario in the Watershed

Existing Climate

According to the Modified Coronas Classification of PAGASA, which is based on the average monthly distribution of rainfall, Sta. Cruz Watershed has the Type III climate. This is characterized by no pronounced maximum rain period, with a dry season that lasts only from one to three months either during the period from December to February or from March to May. Simulated and calibrated data from the UP Los Baños Agrometrological Station reflected a monthly rainfall range of 15.15 mm to 271.88 mm for 1961 to 2010. The amount of rainfall starts to increase during the month of May, with the maximum rain period from July to November, then subsides during the month of December. This is consistent with the description of the Type III climate. Rainfall above the normal range has been observed to cause flooding in the Sta. Cruz Watershed particularly in the low lying areas.

Table 1.3. Climate related hazards and frequency of occurrence (every 10 years) in the study areas

Climate Hazard Observed	Low Elevation		Medium Elevation		High Elevation	
	San Pablo Sur	Patimbao	Bungkol	Calumpang	San Francisco	Bukal
Typhoon	30	20	20	20	20-30	20
Flood	10	1	-	1	-	-
Pests	10	10	1	-	1	-
Drought	-	-	-	-	-	2
Monsoon rain	-	-	-	-	-	10

Climate Hazards

The focus group discussions and the household survey conducted in the six study sites revealed that the common and most notable climate hazard experienced by respondents is a typhoon (table 1.3). They experience typhoons two to three times a year. Flooding, which is associated with the typhoon, is a problem in the low elevation areas, notably in Barangay San Pablo Sur. Lodging and submergence of rice and other annual crops, felling of trees, and damage to houses were commonly experienced by residents during typhoons. Flood is also experienced in the medium elevation areas particularly in Barangay Calumpang. Typhoon and flooding are related hazards, the occurrence of a typhoon usually results in the rise of the water level of the rivers and the lake, which inundates the nearby low lying areas. However, flooding may also be caused by continuous rain, which results in the rise of the water level in the lake.

Pest infestation maybe a normal occurrence in the low elevation areas, however, respondents from Barangay San Pablo Sur and Barangay Patimbao have claimed that pest infestation, particularly black bug and golden snail, has become more frequent than before. In the medium and high elevation areas, pest infestation has recently become a problem with the occurrence of coconut scale insects.

Other climate hazards like monsoon rain and drought were mentioned by some respondents, particularly in the high elevation areas.

In the timelines of climate hazards developed by the residents of the study sites, the typhoon is the one most remembered. The more damaging ones were Typhoons Rosing, Milenyo (2006), Santi and Ondoy.

Climate Projections

Rainfall Projections

Models indicate that, generally, precipitation will increase in tropical regions and over tropical Pacific. In the A1B Scenario (figure 1.4), numbers show an increasing rate of rainfall from June of the base period (188.73 mm) to the present period (227.97 mm) as opposed to the decreasing rate of rainfall from the present period (227.97 mm) to the 2080 period (189.12 mm). From January to May and November to December, the rate of precipitation is relatively increasing. In September and October, there is a significant increase of rate from the base period up to the 2080 period. The highest simulated rainfall count is the November 2020 period with 300.57 mm while the lowest is the February base period with 15.15 mm.

In the A2 Scenario (figure 1.4), the rate of rainfall increases from January to May and again from November to December. In the 2020 period, June reflects 183.23 mm but this

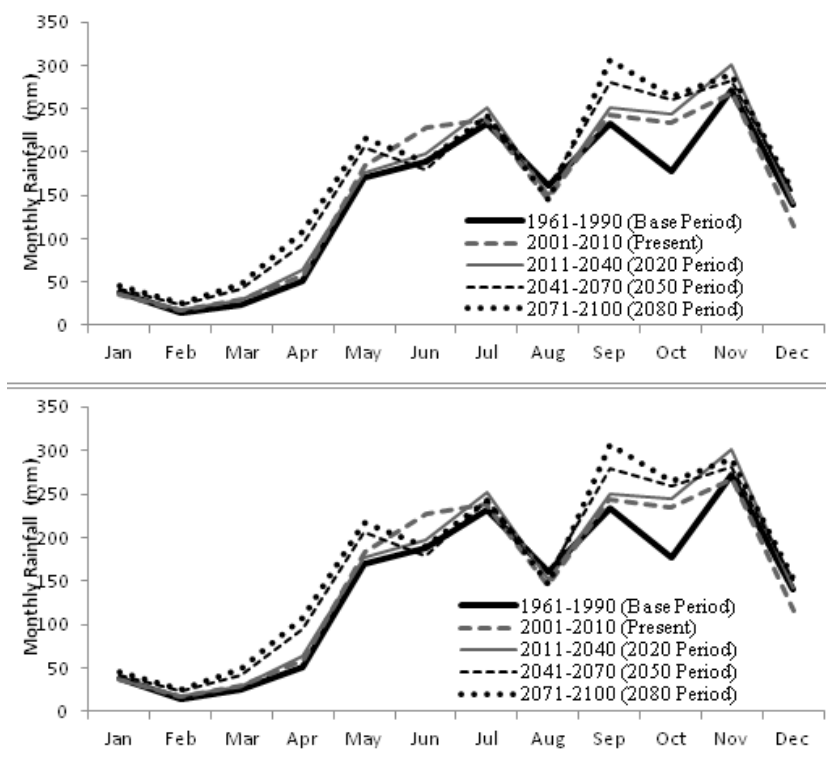


Figure 1.4.
Monthly
rainfall
projections
under A1B
(above) and
A2 (below)
scenarios,
Sta. Cruz
Watershed

Source:
Combalicer et al.
(2014)

number declines to 139.00 mm in the 2080 period. Simultaneously, September reflects a high rate of change from the base period to the 2080 period, where rainfall increases from 233.49 mm to 277.40 mm. In October, the rate of rainfall also increases from 177.16 in the base period to 340.81 in the 2080 period. The highest rainfall count simulated is the October 2080 period with 340.81 mm while the lowest is the February base period with 15.15 mm.

Temperature Projections

Air temperature is projected to increase. A further increase of about 0.1°C per decade is foreseen even if the concentrations of greenhouse gases are held constant during the projected periods. In the A1B scenario (figure 1.5), the highest temperature reflected in the simulation is at 31.4 °C, occurring in the May 2080 period, while the lowest temperature is at 25.9 °C occurring in January of the present period.

In every projection period, there is an increase in temperature that ranges from 0.1 to 0.9 °C monthly. A 0.1 °C increase in temperature is foreseen in the month of May and 0.9 °C in November. Under A2 scenario, it is projected that the global air temperature will increase every month at 32.7 °C; this is 1.3 °C higher compared to A1B scenario. On the other hand, the lowest temperature comes at 25.9 °C in January of the present period, which is the same as the A1B scenario. There is an increase of 1.3 °C in November from the 2050 to the 2080 period; in April, there is a 0.2 °C increase from the present to the 2020 period. In this scenario the range of increase in temperature through time is 0.2 to 1.3 °C, which is higher compared to A1B scenario.

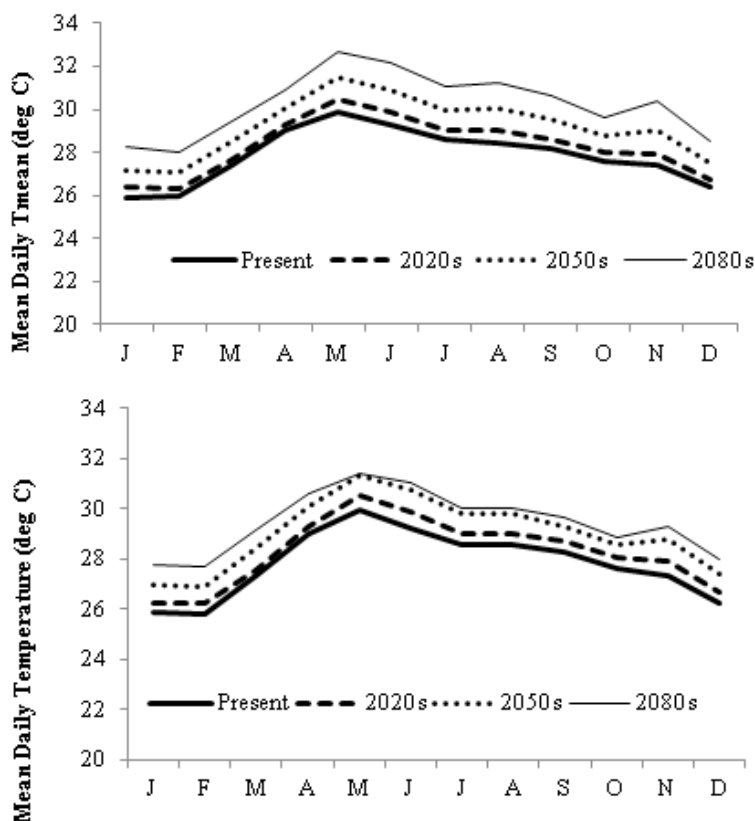


Figure 1.5.
Mean daily
temperature
projections
under A1B
(above) and
A2 (below)
scenarios, Sta.
Cruz Watershed
Source: Combalicer
et al. (2014)

Biophysical Characteristics of the Study Sites

Low Elevation Area

The low elevation area is a lowland plain dominated by wetland rice and coconut trees that occupy areas going towards the next elevation. The area receives water from the higher territories and drains to the Laguna Lake.

Barangay San Pablo Sur, Sta. Cruz

Barangay San Pablo Sur, one of the urban-typed barangays of Santa Cruz, Laguna, lies half a kilometer away from the municipal proper and is situated east of Laguna Lake.

The dominant land covers are built-ups and annual crops. While most of the agricultural lands have been converted to built-ups and residential areas, a large proportion of the barangay's income comes from the farming industry with rice, vegetables, poultry and livestock as their main products.

The Mines and Geoscience Bureau (MGB) identified the barangay as an area moderately susceptible to flooding. Typhoon Ondoy caused massive destruction to properties, infrastructure and residents' livelihood.

Barangay Patimbao, Sta. Cruz

Barangay Patimbao, one of the rural-typed barangays of Santa Cruz, Laguna, is located two kilometers away from the municipal proper. It is classified as a lowland, with an elevation ranging from 10-20 meters above sea level (masl). The barangay has a total area of 236.85 ha.

One third of the barangay's total land area (78.16 ha) is devoted to the production of rice. Rice is continuously planted twice a year, making rice one of the top products of the area. Coconut and sampaguita (an ornamental plant) are also widely grown in the barangay. Based on the Barangay Disaster Risk Reduction Management Plan (BDRRM), flooding is identified as one of the major hazards in the area. However, the Mines and Geoscience Bureau (MGB) has classified the barangay's susceptibility to flooding as low.

Medium Elevation Area

The medium elevation area has a dominantly undulating terrain; it is located in the convergence of several Sta. Cruz River tributaries and starts from the gradually ascending slopes of the lowland. Crops in the area are a combination of the crops from the low and high lands.

Barangay Calumpang, Liliw

Barangay Calumpang is a rural-typed barangay of Liliw, Laguna and is located 11 km away from the municipal proper. The barangay has a total area of 159.85 ha with six sitios. Agriculture plays a major role in the economic activity of the barangay; it has 333 ha of land devoted to agriculture. Its main products are coconut and rice.

The barangay is vulnerable to typhoons. Information from the residents of the barangay revealed that typhoons have destroyed crops, properties, livelihood and infrastructures. Flooding, on the other hand, is less of a threat to the barangay due to its elevation. MGB has likewise identified the barangay as an area moderately susceptible to flooding. The barangay, however, has had to deal with the coconut scale insect; this is considered as one of the biggest problems encountered by the residents since coconut is one of their main crops.

Barangay Bungkol, Liliw

Barangay Bungkol is a rural-typed barangay of Liliw, lying southeast of Barangay Calumpang. It has a total area of 81,248.5 ha with four sitios. From the total area of the barangay, 87 percent is devoted to agriculture. Forty percent of the residents are dependent on farming as a means of livelihood and most of them are vegetable growers.

High Elevation Area

The high elevation area is the upper part of the watershed characterized by steep slopes. The head waters of the Sta. Cruz River are located in this area. Forested landscapes occupy the upper portion of Mt. Banahaw. Crops planted are mostly vegetables but coconut can be found in the lower portion.

Barangay San Francisco, Nagcarlan

Barangay San Francisco is a rural-typed barangay of Nagcarlan, Laguna located south of the town proper, along the foot slopes of Mt. Banahaw and below Barangay Bukal. The barangay has a total area of 428 ha. Slopes are rolling to steep, incised with intermittent streams. Erosion is one of the major problems of the barangay. The MGB hazard map identifies the barangay as an area with a low susceptibility to landslides.

Major crops produced include coconut, lanzones, banana, chayote, green beans, cabbage, calamansi, sweet potato, taro, squash, tomato and rice.

Barangay Bukal, Nagcarlan

Barangay Bukal is a rural-typed barangay of Nagcarlan, Laguna located seven kilometers away from the municipal proper; it lies at the foot of Mount Banahaw. The barangay has a total area of 49.66 ha and is surrounded by nine mountains, namely Banahaw, Mabuna, Tanasyo, Sumansal, Siapo, Ganit, Gudya, Kabagan and Bunsuran. Slopes are steep to mountainous.

The barangay's soil is black to dark brown and is high in organic matter, which is favorable for growing of crops. The barangay produces crops like banana, coconut, lanzones, tobacco and vegetables including bitter melon, cabbage, chayote, cucumber, green beans, pechay, radish, sweet potato and tomato. The residents also engage in backyard raising of the native chicken, broiler chicken and swine.

In the Barangay Disaster Risk Reduction Management (BDRRM) Plan, erosion has been identified as one of the problems the barangay has to deal with, particularly during typhoons. Erosions are mostly seen on the hilly and elevated regions of the barangay. The MGB hazard map places the barangay as an area highly susceptible to landslides.

Socio-economic Characteristics of the Study Areas

As indicated above, the study considers the elevation of the study areas. Classification of elevation is based on the standard metric measurement of elevation, meters above sea level (masl). High elevation has an meters above sea level above 148 m; medium elevations are areas located at 20-147 masl, while the low elevation areas measure less than 20 masl. The high elevation area is represented by the municipality of Nagcarlan, the medium elevation by the municipality of Liliw and the low elevation by Sta. Cruz. Two barangays were sampled for each municipality.

Classification of the Communities

Both the high and medium barangays are classified as rural agricultural areas that are suited for crops production. On the other hand, the low elevation barangays are classified into two: Barangay San Pablo Sur, in Sta Cruz, is a pure urban area while Barangay Patimbao, also in Sta Cruz, is an urban-lowland community where rice is also grown. The major crops grown in these barangays are discussed in the previous section.

Population and Household

High Elevation Area

On the average, barangays in the high elevation area have the lowest population counts of 2,602 for Barangay San Francisco and 779 for Barangay Bukal, with an average family size of four persons and three persons, respectively. These resulted in population densities of 17 persons/ha in San Francisco and 12 persons/ha in Bukal.

Medium Elevation Area

Barangay Calumpang has a total of 3,754 people, with a population density of 24 persons/ha. There are 748 households with an average family size of five. Barangay Bunkol, meanwhile, is relatively less populated with only 759 people of 172 households and a family size of four. Because of its wide land area, majority of which is planted with crops, and small population, the barangay is the least densely populated with a population density of only nine persons/ha.

Low Elevation Area

As urban communities, the study areas in the low elevation barangays have high population counts of 2,573 persons in San Pablo Sur and 7,910 in Patimbao that comprised 600 and 2,500 households, respectively. Despite having the smallest family size among the three study sites, Patimbao has the highest population density of 34 persons/ha. In fact, the low elevation areas have the highest population density among the elevations, which indicate crowdedness in the urban barangays.

Educational Attainment

There is no marked difference in the number of years of schooling by elevation; on the average, residents reached nine years of schooling. Among respondents from the low elevation areas, 33 percent finished college while among the respondents in the high and medium elevation areas, 46 percent and 45 percent, respectively, are high school graduates.

Annual Income and Sources

In general, residents of the study areas rely on the internal revenue allocation (IRA) as the source of their income. However, annual household incomes vary depending on the type of occupation they have.

High Elevation Area

Farming is the major source of income in the high elevation area. Majority (61 percent) of the households are dependent on farming and farm-related activities with an average household income of PHP 159,548 per year.

Medium Elevation Area

The sources of income in the studied barangays in the medium elevation are quite varied. While farming is the dominant source of income, other households are engaged in off-farm labor and service-related jobs. The average annual household income in the area is PHP 191,110, which is the highest among the study areas.

Low Elevation Area

While there is a higher percentage of households who were able to reach and finish a college education, households are either engaged in service-related work and off-farm labor with 28 percent and 26 percent, respectively. Only a few are able to work in government offices. These indicate the limited job opportunities in the area. The average annual household income in this area is PHP 174,113.

Source of Water

All the barangays in the study areas have access to a community water supply. In the communities with low elevation, a second to third level water supply is available to the households. Domestic water supply in the communities at the medium elevation is from water providers such as Liliw Water district and Liliw Waterworks association. In the communities at the high elevation, a large percentage of people already have access to the community water system although a portion of households in Barangay Bukal get their water supply from springs.

Data and Data Collection Methods

Both secondary data and primary data were generated. Secondary data was taken from the municipal agricultural offices, from the results of previous research done in the site, and from national agencies. Primary data were gathered from the study barangays through household surveys, focus group discussions (FGDs), and key informant interviews (KIIs). Sampling strategies are found in the various working papers produced by the project staff (Sumalde et al. 2014; Quillooy et al. 2014; Garcia et al. 2014; Abrigo et al. 2014; Chupungco et al. 2014; Tiburan et al. 2014).

Tables 1.4 and 1.5 summarize the indicators and identifying variables for the various information needed by the technical and socio-economic components, respectively. The sources of data are also indicated.

Table 1.4. Indicators and variables gathered by the socio-economic component

Areas of Concern	Indicator	Variable	Source of Data
Food Security	% Sufficiency in rice, vegetables, livestock - Food Consumption Pattern	% of food secured household # of meals/day - Kind and quantity of food eaten	- Household Survey - MAO - PAO - PNAO
Income	Annual Household Income	- Sources of Income and income earned - Per capita income	Household Survey
Social Capital	Organization and/or Associations in the area (GA, NGO, Cooperatives, Civic Org, etc.)	- Households' membership in organization - Households' participation in organization's activities - Assistance provided by the organizations and availed of by the households	- Household Survey - MAO
Adaptive Capacity	- Cognitive (knowledge and skills) - Affective (attitudes and feelings) - Behavioral (practices that are acquired and indigenous)	- Level of knowledge, skills and attitudes - Proportion of acquired practices vs. indigenous practices for each community under study - Inter-and intra- community comparisons for the above variables	- Community survey - Focus group - Secondary data from LGUs, NGOs and barangay records
Production and Marketing	Crops and Livestock production and disposal, marketed	- Kinds of crops and livestock grown - Volume/quantity of crops grown - Frequency of production - Product outlet - Prices received by the farmers - Quantity sold and % of produced sold - Terms and mode of sale - Problems about production and marketing	- Household Survey - Key informants - Focus group discussion
Value of Damage due to Extreme Weather Event	Types, Quantity and Value of Damage	- Quantity of crops damaged - Damage to Properties - Foregone Income	- Household Survey - Key informants - Focus group discussion
Coping Mechanisms or Adaptation Strategies	Types of Coping Mechanisms	- Types of coping mechanisms before, during and after the calamity - Value of the coping mechanisms	- Household Survey - Key informants - Focus group discussion

Table 1.5. Indicators and variables gathered by the agricultural and environmental sciences team

Areas of Concern	Indicator	Variables	Source of Data
Crops	• Cropping intensity	• Crops planted and hectarage • Number of crops/year • Cropping patterns	• Municipal Agricultural Offices • Focus group discussion • Household survey
	• Productivity	• Yield/ha/crop	• Household survey
	• Profitability	• Gross income • Cost of production	• Household survey
	• Agrobiodiversity	• Number of crop species raised and varieties • Number of animal raised	• Municipal Agricultural Offices • Focus group discussion • Household survey
	• Stability of production	• Productivity over time	• Focus group discussion • Household survey
Pests and Diseases	• Pests and disease incidence	• Kind of pests and diseases present	• Key informants • Focus group discussion
	• Frequency of occurrence	• Number of occurrences per year	• Key informants • Focus group discussion
	• Trend in pests and disease occurrence	• Historical and current pests and diseases occurrences	• Key informants • Focus group discussion
	• Effectiveness of controlling pests and diseases	• Pests and disease control measures • Effectiveness of control measures	• Key informants • Focus group discussion • Household survey
	• Safety of control measures	• Presence and level of pesticide residues	• LLDA
Soil	• Land capability class	• Soil type • Topography • Land use	• UPLB ASC
	• Efficacy of soil fertility management	• Fertilizer material used • Fertilizer management • Productivity of fertilizer material	• Key informants • HH survey
	• Soil erosion	• Soil erosion potential for each land use	• UPLB ASC

ENVIRONMENT AND FOOD SECURITY INTERACTIONS AMID CLIMATE CHANGE

Water	Water resources availability & sustainability (variation with time)	- Sources & quantity of water supply - spring water - streamflow - groundwater - Spring discharge variation - Streamflow variation - Groundwater level variation - Nature of recharge areas	- LGU - NIA LLDA - Water districts - Key informants - Previous projects - Literatures
	Water resources abstraction methods / practices	- Storage dams / ponds - Stream/riverflow - Diversion Wells - Spring water abstraction	- LGU - NIA - LLDA - Water districts - Key informants - Previous projects - Literature
	Efficiency of water supply usage for agriculture	- Irrigation / cropping intensities of existing irrigation systems - Crop productivity levels of irrigated farms	- NIA - Provincial Agricultural Office - Municipal Agriculture Office - Irrigators Association or Cooperatives - Key informants - Literatures - HH survey
Forest	Status of forest cover	- Forest coverage - Forest species present - Trend in forest cover	- DENR - LLDA - Previous projects - Key informants
	Biodiversity	Species diversity (floral aspect)	- UPLB CFNR - LLDA - DENR
	Effectiveness of forest management	- Forest management - Impacts on forest cover	- LLDA - DENR
	Forest utilization	Historical and current forest utilization	- LLDA - DENR
Livestock	Livestock Raised and trend in commercialization	- Commercial vs. backyard raisers (cattle, goat, swine chicken, duck) - Impact of commercial piggery farms on water resources and pollution	- DA-BAS - DA-Province and Municipalities - Previous studies - HH survey
	Summer Heat Stress in relation to productivity	- Temperature - Humidity - Thermal Humidity Index - Productivity (egg, sow, daily gain, milk)	Previous Studies
	Feed: product assessment	- Feed utilization (commercial vs locally available resources) - Trend in feed cost - Trend in price of products - Presence of Organochlorine Pesticide (OCPs) - Presence of heavy metal Cadmium	- DA-BAS - PCARRD funded Swine project - U.P. S&T Grant/ DA-BAR/ DA-Biotech funded Duck Project - Published research articles - HH survey - Feed and Product Analyses for heavy metal Cd
	Native Animal Utilization	- Production systems and productivity - Feed resources utilization - Indigenous knowledge	- DA-Province and Municipalities - HH survey

Data Analyses

Data on the impacts of climate hazards and the corresponding adaptation strategies were generated. The following levels of analysis were considered: policy, watershed, community, farm and household level.

Policy Level

Policy analysis was done with respect to the problems of water and land use as affected by climate change and the constraints faced by the local governments within the watershed to adapt to these. Adaptation strategies include technologies in handling issues about water scarcity and its impact on agricultural productivity; and about land cover, land use and the implementation of land use plans in the study areas as they affect food security.

Watershed Level

The following analyses were done: (a) description of soil and water adaptation strategies for food security; (b) adaptation strategies by market actors or traders; and (c) evaluation of crop and livestock adaptation technologies to attain food security under climate change conditions.

Community Level

Evaluation of the adaptive capacity of the community to ensure food security under climate change was done.

Household Level

Description of the coping mechanisms of households to attain food security under extreme events were done by evaluating the profitability of the different crops and cropping patterns and their effects on household incomes and household food and nutrition security. Valuation of damage and coping strategies of households to an extreme event were also assessed.

ORGANIZATION OF THE BOOK

The subsequent chapters are organized according to the multiscale levels within a watershed context. Chapters 2 and 3 discuss land and water use and the adaptation policies needed at the watershed level. Chapters 4, 5, and 6 discuss the farm adaptation strategies and agricultural technologies at the watershed scale. Chapter 4 suggests cropping patterns as adaptation measures; Chapter 5 explores the pest and diseases management options of farmers amid climate change; while Chapter 6 discusses the livestock food security nexus amid climate change.

Chapter 7 discusses the role of markets in maintaining food security during extreme events while Chapter 8 focuses the discussion on the adaptation strategies at the community level, again during extreme events. Chapter 9 analyzes the household coping strategies for achieving food security during extreme events; while Chapter 10 translates damages due to climate hazards into monetary values. Chapter 11 presents the summary, conclusions, and policy and technology recommendations.

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CHAPTER 2

LAND USE AND LAND COVER CHANGE ANALYSIS AND ITS IMPLICATIONS TO FOOD SECURITY UNDER A CHANGING CLIMATE

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Land use and land cover change studies are very significant in understanding the nature, extent and dynamics of land conversion in a particular area. In this study, the use of multi-temporal Landsat imagery from 1993, 2002 and 2014 were utilized to determine the different land use and land cover types in the Sta. Cruz Watershed (SCW) and monitor the changes that happened between these periods. An object-based image classification technique was employed in producing the various land cover maps of SCW. The overall accuracy of land cover maps that were generated for 1993, 2002 and 2014 were 82.10 percent, 85.81 percent and 90.97 percent, respectively. The results showed that between 1993 and 2014, forest areas decreased by 59 percent and grassland areas declined by 16 percent. On the other hand, the range of increase in the built-up areas, annual and perennial crops from 1993 to 2014 was about 12 percent to 42 percent. Significant decline in the forests was mainly attributed to the conversion of these lands into perennial and annual crops. Around 1,685 ha of forest were converted to perennial crops between 1993 and 2002 while an area of about 796 ha was converted between 2002 and 2014. In the same manner, most grassland areas, about 60 percent, were converted into perennial crops from 1993 to 2014. These changes suggest that agricultural production in the watershed is given utmost importance by the different municipalities inside SCW. Meanwhile, built-up areas increased by only 13 percent from 1993 to 2014. Most of these conversions can be ascribed to the cultivation of annual and perennial crops. Given these current trends of land cover changes in SCW and the impending impacts of climate change and food security, further degradation in the area such as conversion of remaining fragile forest areas to other land uses, may aggravate the future state of the watershed. Therefore, it is recommended that the results of this study be further utilized as inputs in the development of a comprehensive land use plan for SCW and in formulating policies related to food security and climate change issues.

Keywords: land use and land cover change, object-based image classification, change detection analysis, climate change, food security

INTRODUCTION

Land use and land cover change (LULCC) has been regarded as one of the most important alterations of the earth's land surface (Lambin et al. 2001). This is mainly driven by the interaction in space and time between biophysical and social dimensions (Veldkamp and Verburg 2004). Land use is described by how humans use the biophysical or ecological properties of the landscape while land cover refers to the physical and biological cover of the land surface, including vegetation, bare soil, water, and/or artificial structures (Ellis 2013). Yadav, Kapoor, and Sarma (2012), on the other hand, stated that land cover is a basic parameter that evaluates the content of earth surface as an important factor that affects the condition and functioning of the ecosystem while land use mostly relates to the utilization of land resources by human beings. To better understand the dynamics of LULCC, both historical and present data should be accounted properly to identify patterns that would provide comprehension of how these changes happened. One method of addressing such phenomenon is through the use of remotely sensed images.

In this particular study, the use of satellite imagery at three different periods was utilized to determine several land use and land cover types in the area. Change detection analysis was then employed across these periods to further assess what has evolved over the years. According to Anderson (1977), as cited by Yadav, Kapoor, and Sarma (2012), change detection is the process of identifying difference in the state of an object or phenomenon by observing it at different times. These landscape changes are mainly attributed to anthropogenic activities such as a rapid growth of population and demands of food resources (Gibson and Power 2000). In particular, the change detection analysis in this study will mainly focus on land use and land cover types that are related to food security such as agriculture and perennial crops in the area.

An emerging technology in image classification that was utilized in the study is the use of object-based image classification techniques (Hay et al. 2003; Laliberte et al. 2004; Walter 2004; Bontemps et al. 2008; Hussain et al. 2013). This particular method tends to aggregate adjacent pixels into image objects or segments by considering spectral and geometric characteristics through a pair-wise clustering process (Conchedda, Durieux, and Mayaux 2008). This implies that segments or objects do not only capture spectral properties but also region-based metrics such as shape, texture, structure, size and context.

RESEARCH OBJECTIVES

The primary objective of the research is to analyze the land use and land cover changes in the Sta. Cruz Watershed at three different periods using remotely sensed images. Specifically, it aims to:

1. Perform image classification of remotely sensed data using object-based image analysis;
2. Evaluate the classified images using accuracy assessment;
3. Conduct change detection analysis at different periods; and
4. Identify potential impacts of these changes to food security and climate change

DATA AND METHODS

Landsat Data

The remotely sensed images that were utilized in the study are Landsat images with Path no. 116 and Row no. 50. The first image was a Landsat 5 TM image dated 02 April 1993, the next image was a Landsat 7 ETM+ and was taken on 03 April 2002, and lastly, the third image was a Landsat 8 OLI/TIRS image that was captured on 07 February 2014. These three images were downloaded from the USGS Earth Explorer website (<http://earthexplorer.usgs.gov/>) and were pre-processed and analyzed using remote sensing and GIS software.

Landsat 5 Thematic Mapper (TM) was launched on 01 March 1984. It consists of seven spectral bands, with a spatial resolution of 30 meters for Bands 1-5 and 7. Band 6 (thermal infrared) has a spatial resolution of 120 meters, and re-sampled to 30 meters pixel after 25 February 2010. Table 2.1 shows the characteristics, wavelength and spatial resolution of Landsat 5 TM.

Table 2.1. Landsat 5 Thematic Mapper (TM)

Band	Wavelength (micrometers)	Resolution (meters)
Band 1 – Blue	0.45-0.52	30
Band 2 – Green	0.52-0.60	30
Band 3 – Red	0.63-0.69	30
Band 4 – Near Infrared	0.76-0.90	30
Band 5 – Mid Infrared	1.55-1.75	30
Band 6 – Thermal Infrared	10.40-12.50	120* (30)
Band 7 – Mid Infrared	2.08-2.35	30

*TM Band 6 was acquired at 120-meter resolution, but products processed before February 25, 2010 are re-sampled to 60-meter pixels. Products processed after February 25, 2010 are re-sampled to 30-meter pixels.

Table 2.2. Landsat 7 Enhanced Thematic Mapper Plus (ETM+)

Band	Wavelength (micrometers)	Resolution (meters)
Band 1 – Blue	0.45-0.52	30
Band 2 – Green	0.52-0.60	30
Band 3 – Red	0.63-0.69	30
Band 4 – Near Infrared	0.77-0.90	30
Band 5 – Mid Infrared	1.55-1.75	30
Band 6 – Thermal Infrared	10.40-12.50	60 * (30)
Band 7 – Mid Infrared	2.09-2.35	30
Band 8 - Panchromatic	0.52-0.90	15

*ETM+ Band 6 is acquired at 60-meter resolution. Products processed after February 25, 2010 are re-sampled to 30-meter pixels.

Landsat 7 Enhanced Thematic Mapper Plus (ETM+) was launched on 15 April 1999. It is the seventh satellite mission under the Landsat program that was first initiated in 1972. It is mainly managed and distributed by USGS. It consists of eight spectral bands with a 30 meter spatial resolution for Bands 1-7 and 15 meters (panchromatic) for Band 8. Table 2.2 shows the characteristics, wavelength and spatial resolution of Landsat 7 ETM+.

The Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) are instruments onboard the Landsat 8 satellite, which was launched in February 2013. The satellite collects images of the earth with a 16-day repeat cycle, referenced to the Worldwide Reference System-2, and has an 8-day offset to Landsat 7. The set of Landsat OLI image data consists of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and Band 9. The resolution of Band 8 (panchromatic) is 15 meters. The set of Landsat TIRS image data consists of two thermal bands with a spatial resolution

of 100 meters (re-sampled to 30) for Bands 10 and 11. Majority of the time, the TIRS data are packaged with the OLI for data distribution. There are only a few number of only-OLI or only-TIRS scenes that are available on the network. Table 2.3 shows the characteristics, wavelength and spatial resolution of Landsat 8 OLI/TIRS.

Image Preprocessing

Image pre-processing techniques are necessary to calibrate the images into radiance or reflectance. This is also made to remove unwanted effects of atmospheric scattering and path radiance. An initial processing of the images that was applied in the study was to mask the satellite scene to the boundary of the Sta. Cruz Watershed. After masking, the Landsat images underwent SPEAR Pan Sharpening process to increase contrast and to generate a more accurate and comprehensive coverage. Landsat 7 and 8 images have a spatial resolution of 30 m for bands 1-7 (Multispectral) while band 8 (Panchromatic) has 15 m. Pan sharpening is a method where high resolution panchromatic data are fused with lower resolution multispectral data to produce more contrast and a clearer image. This process enhances the images and will be very useful during image classification.

Another pre-processing technique that was employed in the different images is radiometric correction. This technique enables one to calibrate the DN (digital number) values of a remotely sensed image into radiance and/or reflectance. Radiance is the variable that is directly measured by remote sensing instruments and is usually expressed in terms of Watts ($\text{W m}^{-2} \mu\text{l sr}^{-1}$). Part of radiometric calibration is atmospheric correction. Its main purpose is very important because the surface reflectance is mostly affected by various properties in the atmosphere such as water vapor, presence of aerosols, and scene visibility, among others. One method in implementing atmospheric correction is the Dark Object Subtraction (DOS) approach. It assumes that the reflectance of the darkest object in the image is essentially zero, and any observed reflectance in the pixel is due to atmospheric effects (e.g., scattering, haze, etc.).

Image Classification, Accuracy Assessment and Change Detection

When all pre-processing techniques were done, the images were then ready to use as inputs for image classification. This study employed the object-based image classification technique. An object-based image approach classifies not on single pixels but on a group of pixels that represent the objects in a GIS database. This classifier was developed relatively to the pixel-based (Burnett and Blaschke 2003). Object-based is rooted on the supervised maximum likelihood classification (Walter 2004). The pixel-based and object-based work almost in the same way, however, the latter combines the pixels to

Table 2.3. Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensors (TIRS)

Band	Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal Aerosol	0.43 - 0.45	30
Band 2 - Blue	0.45 - 0.51	30
Band 3 - Green	0.53 - 0.59	30
Band 4 - Red	0.64 - 0.67	30
Band 5 - Near Infrared	0.85 - 0.88	30
Band 6 - SWIR 1	1.57 - 1.65	30
Band 7 - SWIR 2	2.11 - 2.29	30
Band 8 - Panchromatic	0.50 - 0.68	15
Band 9 - Cirrus	1.36 - 1.38	30
Band 10 - Thermal Infrared 1	10.60 - 11.19	100
Band 11 - Thermal Infrared 2	11.50 - 12.51	100

*TIRS bands are acquired at 100-meter resolution, but are re-sampled to 30 meter in delivered data product.

their corresponding object before they are subjected for classification. Image objects are grouped together based on the similarities in spectral properties (i.e., color), size, shape, and texture, especially in the neighboring pixels (Roostaei et al. 2012). This approach is founded on fuzzy theory, wherein an object can be classified into more than one class with different membership values (Baatz et al. 2004). Spectral information and spatial information are combined in this approach, where the texture and context information are also considered in the classification (Flanders, Hall-Beyer, and Pereverzoff 2003). Object-based compared to pixel-based carries much more useful information that can be characterized to more properties (Yoon et al. 2004).

Prior to classification, an object-based process initially performs segmentation. This is a process by which pixels are grouped into segments or objects based on their homogeneity. The algorithm that is usually applied is a multi-resolution segmentation, which is also considered as the most common segmentation in object-based image classification. The scale parameter in the study was set to 100 and 150. And in the composition of homogeneity criterion, the shape was set into 0.5 and the compactness was set into 0.8. Figure 2.1 illustrates the work flow of the different processes applied in the study.

After the images were classified into segments, different land cover and land use classes were generated and associated to some of the segments. In this particular study, the image classification scheme was mainly based on land cover and land use types defined in the DENR Memorandum Circular No. 2005-005 (Adopting Forestry Definitions Concerning Forest Cover/Land Use). The land cover classes that were included in the study are forest, annual crop, perennial crop, built-up, grassland and water (table 2.4).

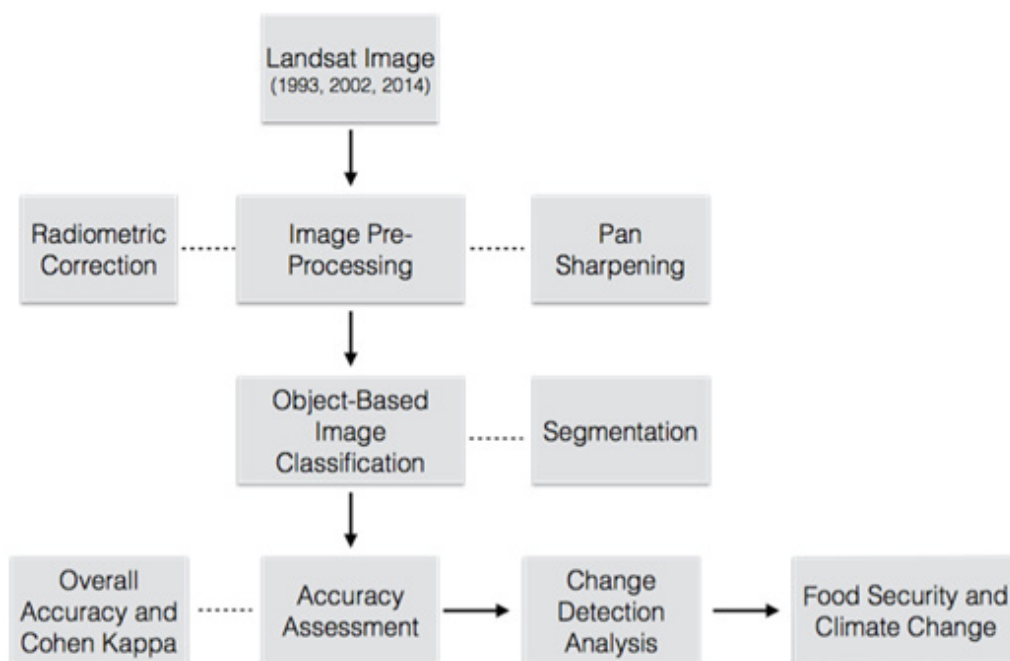


Figure 2.1. Process work flow of the study

Table 2.4. Land cover classification scheme

Land Cover	Description
Forest	Land with an area of more than 0.5 ha and tree crown of more than 10 percent.
Annual Crop	Land cultivated with crops with a growing cycle under one year, which must be newly sown or planted for further production after harvesting
Perennial Crop	Land cultivated with long term crops that do not have to be replanted for several years after each harvest; harvested components are not timber but fruits, latex and other products that do not significantly harm the growth of the planted trees or shrubs; orchards, vineyards and palm plantations, coffee, tea, sisal, banana, abaca, etc.
Built-Up	Composed of areas of intensive use with much of the land covered by structures; it includes cities, towns, villages, strip developments along highways, transportation, power and communication facilities and areas occupied by malls, shopping centres, industrial and commercial complexes and institutions
Grassland	Areas predominantly vegetated with grasses such as <i>Imperata</i> , <i>Themeda</i> , <i>Saccharum spp.</i> , among others
Water	Water bodies such as lake, river, sea, and ocean, among others

To validate the results of the images, independent validation samples were randomly generated to assess the accuracy in classification. These samples were acquired using both ground truth data and Google Earth. A total of 162 sample points were used for the 1993 image, 148 sample points for the 2002 image, and 155 sample points for the 2014 image. Error matrices were tabulated to assess classification accuracy and these involved calculation of commissions, omissions, overall accuracies and the Kappa statistics. The commission error simply calculates the probability that a sample from the classified data actually represents that category on the ground while omission error calculates the probability that a reference sample has been classified correctly. The overall accuracy, on the other hand, provides the total classification accuracy and the Kappa coefficient is a multivariate technique that measures strong agreement between variables.

After the images were classified and evaluated, a post-classification comparison change detection algorithm was used to determine changes in the land cover in three different scenarios - 1993 to 2002, 2002 to 2014, and 1993 to 2014. This technique is regarded as the most common approach in change detection studies (Jensen 2004).

RESULTS AND DISCUSSION

Land Cover Distribution and Classification Accuracy

The total area of SCW is estimated at around 14,858 ha. Figure 2.2 shows the distribution of the different land cover classes in SCW in 1993. Based on this image and table 2.5, about 33 percent (4,907 ha) of the area was still covered with forest, followed by perennial crops (28 percent or 4,118 ha) while grassland, aside from water, revealed to be one of the land cover classes that has the least area (9 percent or 1,372 ha). As for the classification accuracy, the image received an overall classification accuracy of 82.10 percent and a Kappa statistics of 77.83 percent (table 2.6). The two other images, on the contrary, showed that perennial crops has the highest areas covering about 4,932 ha (33 percent) and 5,848 ha (39 percent) for 2002 and 2014, respectively (tables 2.7 and 2.9). Similar to the 1993 image, grassland had the least areas in both periods (1,364 ha in 2002 and 1,151 ha in 2014). The spatial distributions of these land cover classes are also presented in figures 2.3 and 2.4. In terms of their classification accuracy, the overall accuracies for 2002 and

2014, respectively, were 85.81 percent and 90.97 percent with Kappa statistics of 88.29 percent and 88.65 percent (tables 2.8 and 2.10). These consistently high classification accuracies suggest that the images are relatively reliable and can be used for change detection analysis.

Table 2.5. Land Cover Classes in Sta. Cruz Watershed in 1993

Land Cover	Area (Ha)	Percentage
Annual Crop (AC)	1,710.19	11.51%
Built-up (BU)	2,576.10	17.34%
Forest (FO)	4,907.27	33.03%
Grassland (GL)	1,371.96	9.23%
Perennial Crop (PC)	4,117.81	27.71%
Water (WA)	173.88	1.17%
Cloud/Shadow/Noise	0.94	0.01%
TOTAL	14,858.14	100.00%

Table 2.6. Error matrix of land cover classification in 1993

Land Cover	AC	BU	GL	PC	FO	WA	Total	Commission	Omission
AC	16	4	0	1	0	0	21	23.81%	0.00%
BU	0	41	1	2	0	2	46	10.87%	8.89%
GL	0	0	10	6	1	0	17	41.18%	16.67%
PC	0	0	1	28	2	0	31	9.68%	39.13%
FO	0	0	0	9	19	0	28	32.14%	13.64%
WA	0	0	0	0	0	19	19	0.00%	9.52%
TOTAL	16	45	12	46	22	21	162	Overall Accuracy 82.10% Kappa Coefficient 77.83%	

Table 2.7. Land cover classes in Sta. Cruz Watershed in 2002

Land Cover	Area (Ha)	Percentage
Annual Crop (AC)	2,838.79	19.11%
Built-up (BU)	2,684.71	18.07%
Forest (FO)	2,281.61	15.36%
Grassland (GL)	1,364.28	9.18%
Perennial Crop (PC)	4,931.80	33.19%
Water (WA)	284.02	1.91%
Cloud/Shadow/Noise	472.94	3.18%
TOTAL	14,858.14	100.00%

Table 2.8. Error matrix of land cover classification in 2002

Land Cover	AC	BU	GL	PC	FO	WA	Total	Commission	Omission
AC	19	2	0	1	0	0	22	13.64%	26.92%
BU	7	40	0	1	0	0	48	16.67%	4.76%
GL	0	0	9	0	0	0	9	0.00%	35.71%
PC	0	0	3	26	1	0	30	10.00%	18.75%
FO	0	0	1	4	18		23	21.74%	5.26%
WA	0	0	1	0	0	15	16	6.25%	0.00%
TOTAL	26	42	14	32	19	15	148	Overall Accuracy 85.81% Kappa Coefficient 82.29%	

Table 2.9. Land cover classes in Sta. Cruz Watershed in 2014

Land Cover	Area (Ha)	Percentage
Annual Crop (AC)	1,919.34	12.92%
Built-up (BU)	2,915.41	19.62%
Forest (FO)	1,995.51	13.43%
Grassland (GL)	1,151.37	7.75%
Perennial Crop (PC)	5,847.78	39.36%
Water (WA)	448.09	3.02%
Cloud/Shadow/Noise	580.64	3.91%
TOTAL	14,858.14	100.00%

Table 2.10. Error matrix of land cover classification in 2014

Land Cover	AC	BU	GL	PC	FO	WA	Total	Commission	Omission
AC	24	0	0	3	0	0	27	11.11%	14.29%
BU	3	38	2	1	0	2	46	17.39%	0.00%
GL	0	0	8	0	1	0	9	11.11%	20.00%
PC	0	0	0	38	1	0	39	2.56%	9.52%
FO	1	0	0	0	21	0	22	4.55%	8.70%
WA	0	0	0	0	0	12	12	0.00%	14.29%
TOTAL	28	38	10	42	23	14	155	Overall Accuracy 90.97% Kappa Coefficient 88.65%	

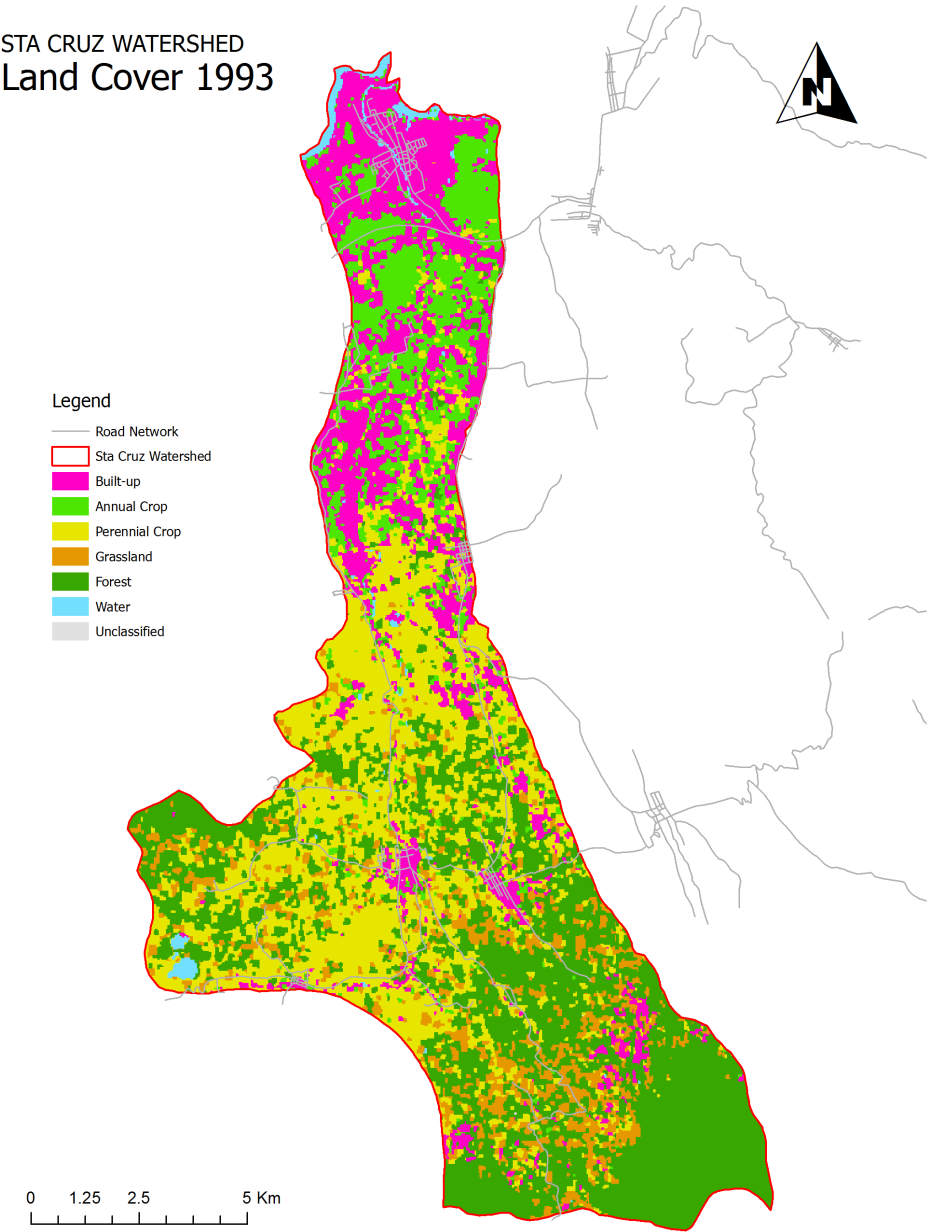


Figure 2.2. Land cover map of Sta. Cruz Watershed in 1993

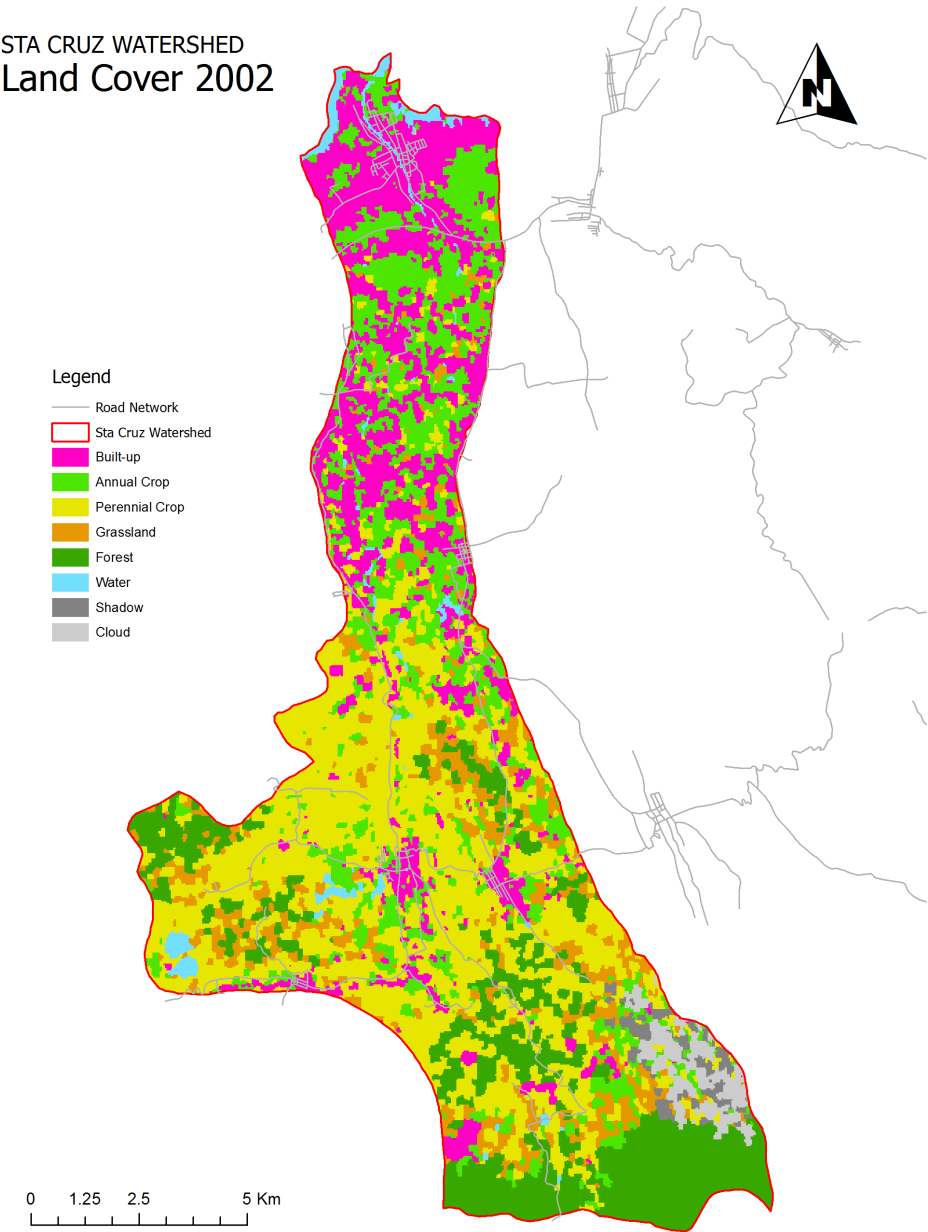


Figure 2.3. Land cover map of Sta. Cruz Watershed in 2002

STA CRUZ WATERSHED
Land Cover 2014

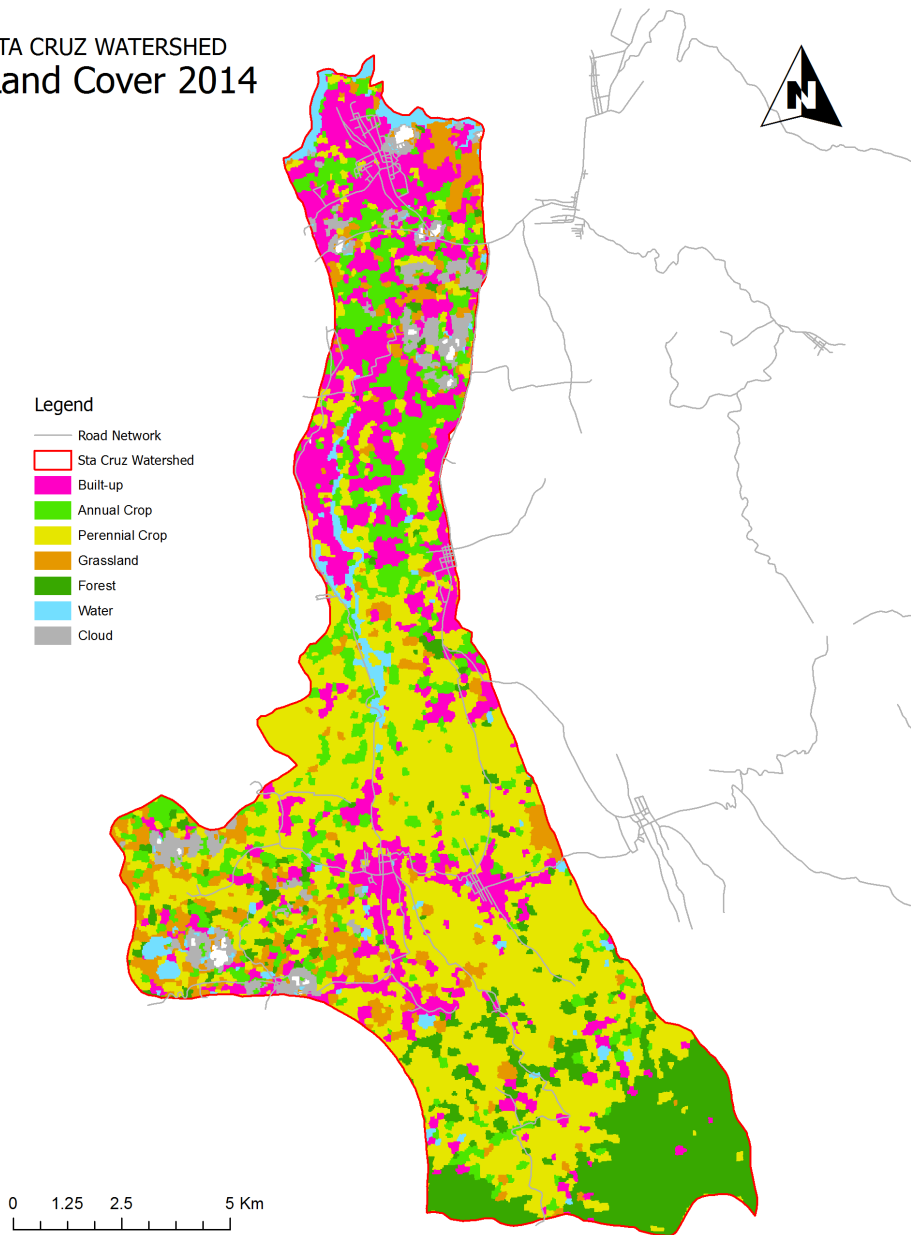


Figure 2.4. Land cover map of Sta. Cruz Watershed in 2014

Relative Changes of Land Cover in SCW

The relative changes of land cover in SCW are illustrated in figure 2.5. From 1993 to 2014, forest and grassland areas decreased by approximately 2,912 ha (59 percent) and 221 ha (16 percent), respectively, while annual crop increased by 209 ha, built-up area increased by 339 ha, perennial crop increased by 1,730 ha and water increased by 274 ha. Based on table 2.11, it can also be noted that forest has its greatest loss from 1993 to 2002 accounting to about 2,626 ha (54 percent) as compared to its loss from 2002 to 2014, which is only around 286 ha (13 percent). Grassland, on the other hand, experienced a higher decrease from 2002 to 2014 (213 ha or 16 percent) than from 1993 to 2002 (8 ha or 1 percent). The difference in perennial crops and built-up areas between 1993-2002 and 2002-2014 is relatively close in each period. Perennial crops had a relative increase of 814 ha (20 percent) from 1993 to 2002 and 916 (19 percent) from 2002 to 2014. As for the built-up areas, an increase of 109 ha (4 percent) was experienced from 1993 to 2002 while an increase of 231 ha (9 percent) from 2002 to 2014 was observed. Meanwhile, the annual crops showed a relative increase of approximately 1,129 ha (66 percent) from 1993 to 2002 while a relative decline of about 919 ha (32 percent) from 2002 to 2014. Meanwhile, the extent and changes of water in the area can be attributed to the annual variation in temperature and precipitation, and is usually affected also by the date the image was taken by the satellite. This can also be related to the varying water levels of the lake during the time the image was acquired.

Table 2.11. Relative changes of land cover classes of Sta. Cruz Watershed from 1993 to 2014

Land Cover	1993	2002	2014	Relative Change	Relative Change	Relative Change
	Area (Ha)	Area (Ha)	Area (Ha)	1993-2002	2002-2014	1993-2014
Annual Crop	1,710.19	2,838.79	1,919.34	65.99%	-32.39%	12.23%
Built-up	2,576.10	2,684.71	2,915.41	4.22%	8.59%	13.17%
Forest	4,907.27	2,281.61	1,995.51	-53.51%	-12.54%	-59.34%
Grassland	1,371.96	1,364.28	1,151.37	-0.56%	-15.61%	-16.08%
Perennial Crop	4,117.81	4,931.80	5,847.78	19.77%	18.57%	42.01%
Water	173.88	284.02	448.09	63.34%	57.77%	157.70%
Cloud/ Shadow/ Noise	0.94	472.94	580.64	NA	NA	NA

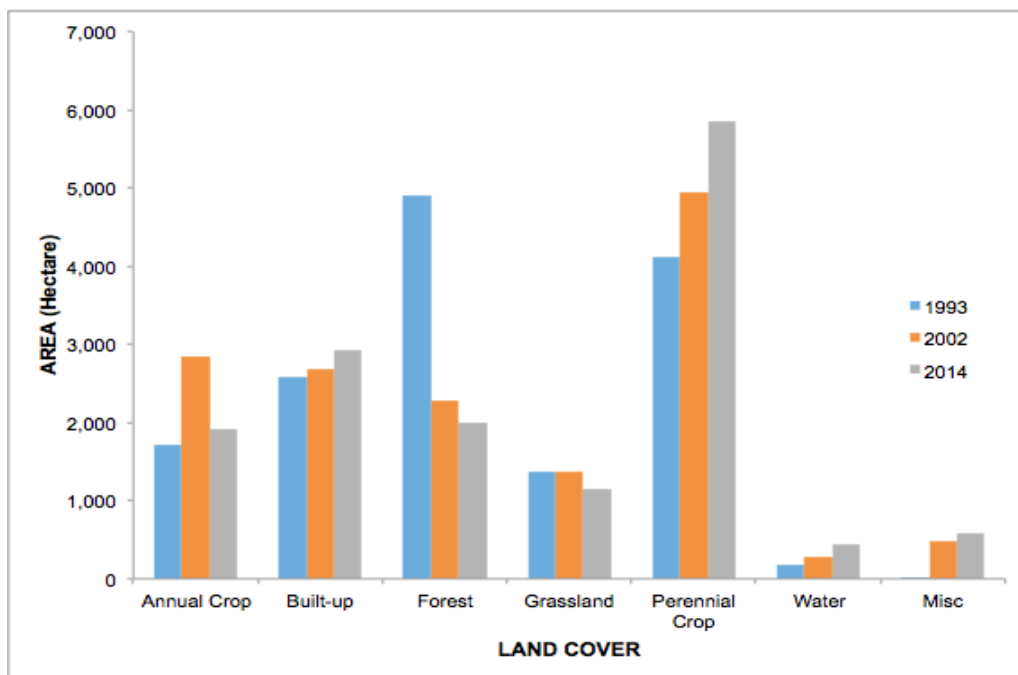


Figure 2.5. Trends of land cover classes in Sta. Cruz Watershed from 1993 to 2014

There are 6 municipalities in SCW, mostly being covered by Nagcarlan, Liliw, Santa Cruz, Magdalena, Majayjay and Rizal. Figures 2.6 to 2.8 show the area distribution of different land cover classes across different municipalities located within SCW. In 1993, Nagcarlan and Liliw showed high coverage of forest areas with 2,209 ha and 1,841 ha, respectively. While in Santa Cruz, built-up (1,223 ha) and annual crops (927 ha) dominated the area in this period. However, a significant decrease in forest areas in Nagcarlan (1,195 ha) and Liliw (527 ha) was observed already in 2002. Most of these areas were converted into perennial crops that imply increased activities on agriculture in the watershed. From 2002 to 2014, Nagcarlan further demonstrated a decrease in forest cover (480 ha) while an increase in built-up area (367 ha) was evident in the same period. Liliw, on the other hand, experienced a decline in its annual crops and an increase in built-up areas and perennial crops from 2002 to 2014. Meanwhile, Santa Cruz showed some reduction of about 445 ha already in its annual crops from 1993 to 2014, which were converted into perennial crops.

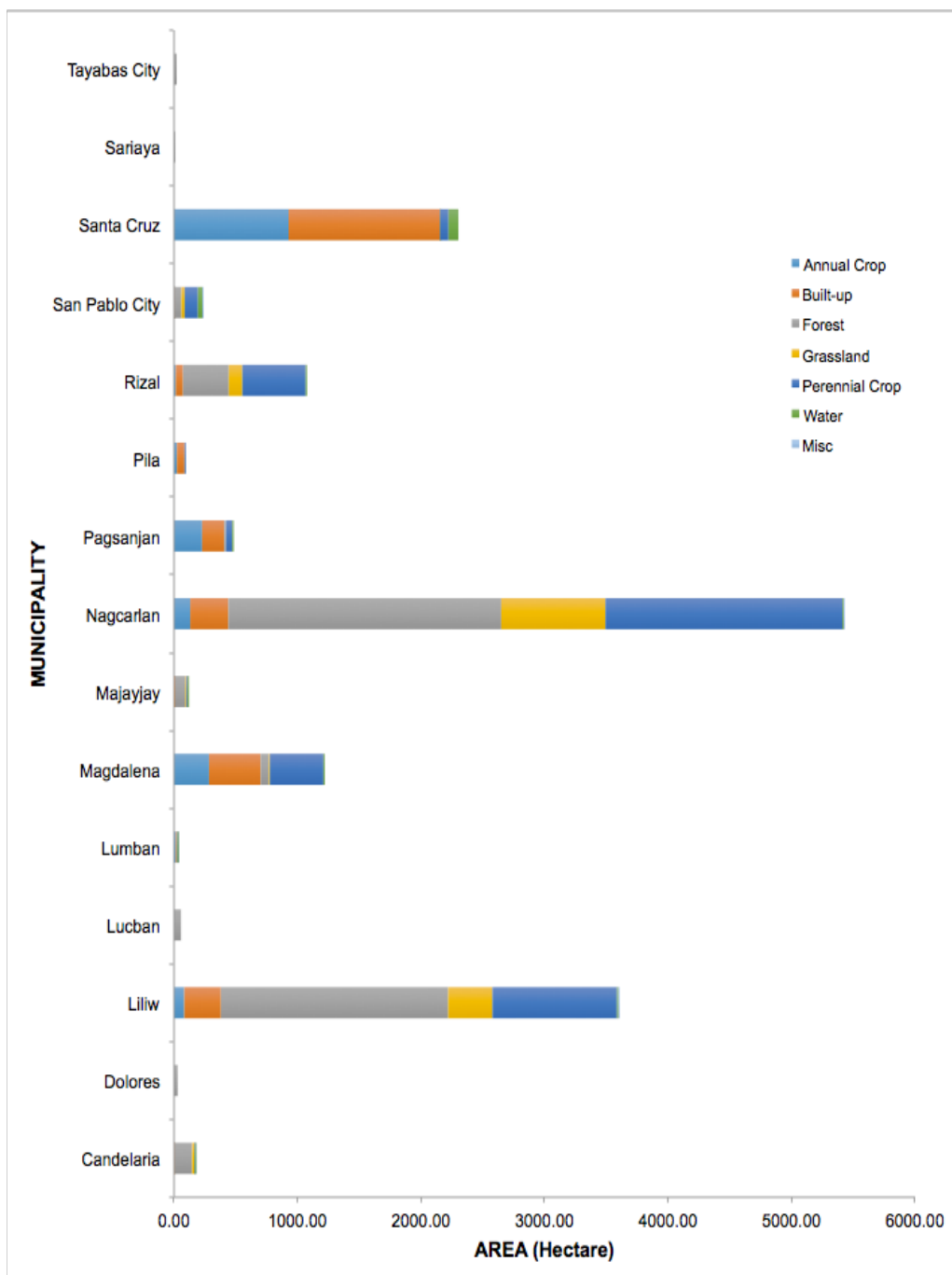


Figure 2.6. Area distribution of land cover classes in different municipalities within the Sta. Cruz Watershed in 1993

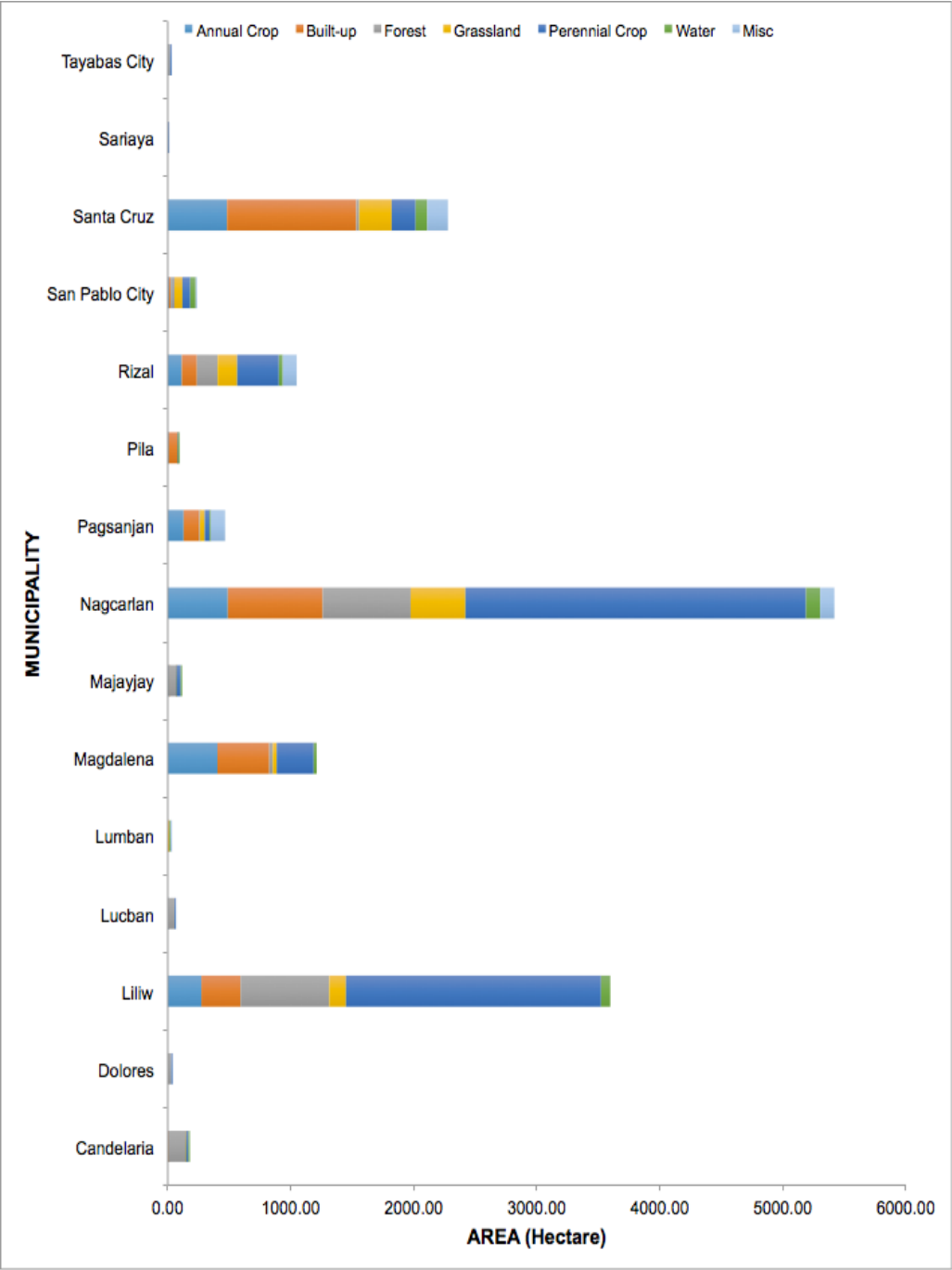


Figure 2.7. Area distribution of land cover classes in different municipalities within the Sta. Cruz Watershed in 2002

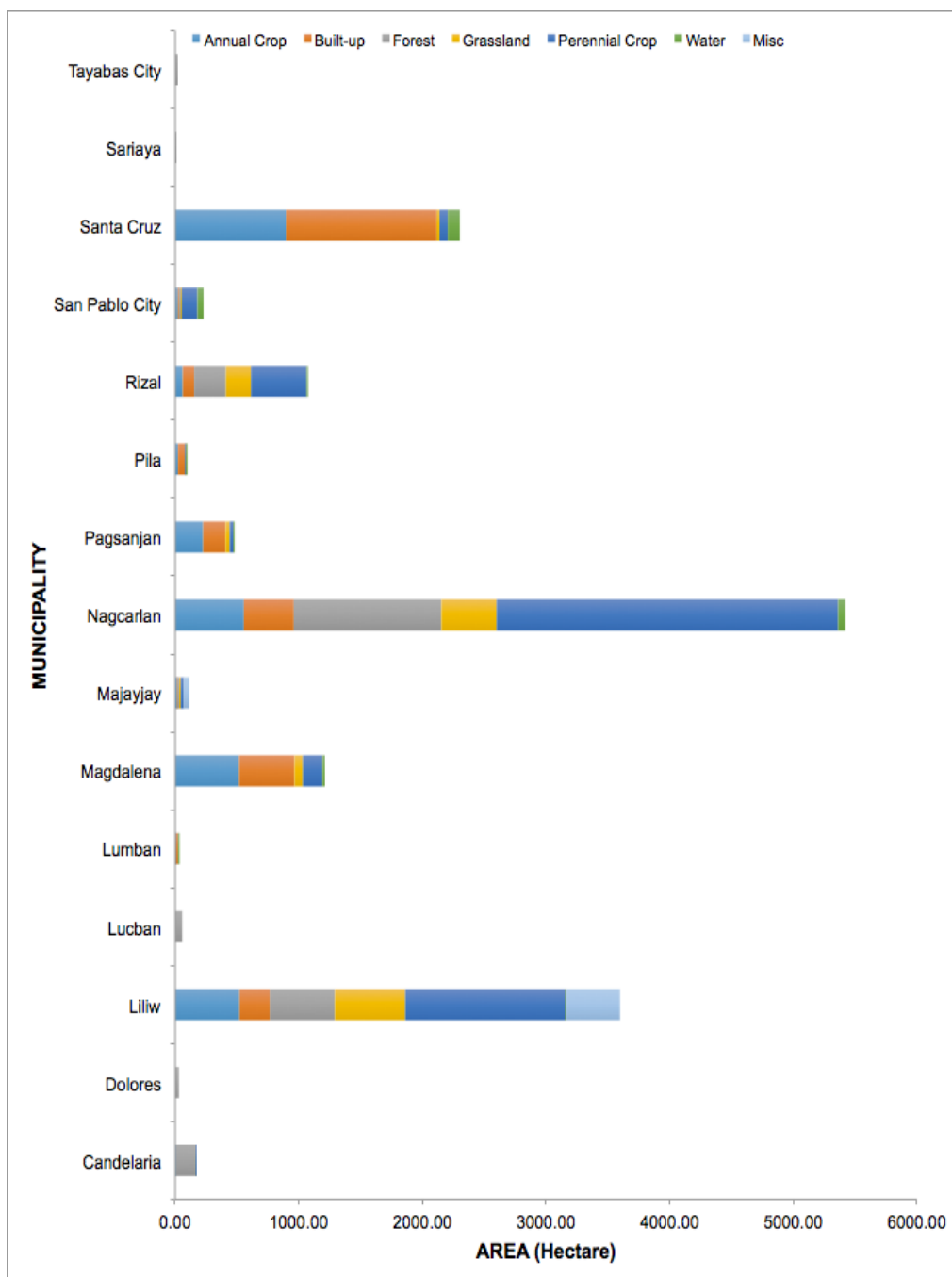


Figure 2.8. Area distribution of land cover classes in different municipalities within the Sta. Cruz Watershed in 2014

Change Detection Analysis in SCW

Several classification maps were produced and the individual land cover class area and change statistics are summarized in tables 2.12 to 2.14. These are further depicted spatially in figures 2.9 to 2.11. From 1993 to 2014, a significant decline of about 2,912 ha in forest area was attributed to perennial crop (45 percent) and annual crop (7 percent) conversions. Around 1,685 ha of forest were converted to perennial crops between 1993 and 2002 while an area of 796 ha was altered between 2002 and 2014. These results indicate that conversion of forest was mainly driven because of the need for more lands to be cultivated for agriculture. On the other hand, about 9 percent of the forest cover in 2014 came from grassland areas. This may be attributed to efforts of both the government and private institutions to rehabilitate some portions of the watershed especially in Mt. Banahaw. Grassland areas also decreased from 1993 to 2014, mostly converted into perennial crops (60 percent) and forest areas (13 percent). However, between 2002 and 2014, about 159 ha of grassland areas were also converted to annual crops. Again, this may imply the necessity for more space for agricultural production.

Perennial and annual crops, on the other hand, increased from 1993 to 2014. The increase in perennial crops was mainly due to the conversion of forest, grassland and built-up areas. Among these land cover types, forest areas had the highest contribution of approximately 2,222 ha or about 38 percent to the total area of perennial crops in 2014. Highest conversion of forest to perennial crops though occurred from 1993 to 2002, which accounts to about 1,685 ha. On the other hand, conversion of grassland (755 ha) and built-up (444 ha) areas into perennial crops was found highest from 2002 to 2014. Meanwhile, annual crops compared to perennial crops had a relatively small increase, amounting to about 209 ha only, from 1993 to 2014. It was observed though that from 1993 to 2002, annual crops gained significant growth from conversion of perennial crops (769 ha) and built-up areas (652 ha). But from 2002 to 2014, annual crops were found to have declined by 919 ha, mostly converted into perennial crops and built-up areas.

Built-up areas have also increased by about 339 ha or 13 percent from 1993 to 2014. Most of these changes were from the conversion of annual and perennial crops. Highest contribution to built-up areas were from the conversion of annual (28 percent) and perennial (20 percent) crops from 2002 to 2014.

Table 2.12. Land cover changes in Sta. Cruz Watershed from 1993 to 2002

Land Cover	Annual Crop	Built-up	Forest	Grassland	Perennial Crop	Water	Misc
Annual Crop	906.26	557.78	5.92	65.04	156.15	17.94	1.09
Built-up	651.81	1580.96	14.41	71.63	151.37	68.21	37.71
Forest	348.77	131.71	1754.28	570.00	1684.52	32.00	385.99
Grassland	145.40	48.23	273.09	200.81	652.03	13.96	38.45
Perennial Crop	768.51	341.44	233.26	455.09	2273.42	36.43	9.66
Water	17.97	24.34	0.64	1.68	13.74	115.47	0.04
Misc	0.07	0.24	0.01	0.04	0.57	0.00	0.00

Table 2.13. Land cover changes in Sta. Cruz Watershed from 2002 to 2014

Land Cover	Annual Crop	Built-up	Forest	Grassland	Perennial Crop	Water	Misc
Annual Crop	623.48	804.68	125.51	276.06	803.90	63.00	130.05
Built-up	447.72	1294.05	43.48	164.55	443.73	118.53	150.62
Forest	108.49	73.15	1073.77	134.85	795.51	12.91	77.34
Grassland	159.35	106.05	125.27	116.40	755.02	24.12	67.66
Perennial Crop	533.24	576.86	334.28	430.17	2887.35	76.52	86.02
Water	22.59	42.91	1.10	26.60	31.45	147.91	10.64
Misc	24.48	17.71	292.11	2.73	130.81	5.09	0.00

Table 2.14. Land cover changes in Sta. Cruz Watershed from 1993 to 2014

Land Cover	Annual Crop	Built-up	Forest	Grassland	Perennial Crop	Water	Misc
Annual Crop	455.51	561.34	29.45	183.74	289.16	41.98	137.63
Built-up	414.32	1291.92	32.74	152.39	398.13	123.94	140.02
Forest	334.92	294.25	1596.25	304.85	2222.38	47.53	99.60
Grassland	106.80	121.92	171.74	90.06	825.61	21.59	29.56
Perennial Crop	601.27	620.90	164.06	405.75	2097.37	103.24	113.12
Water	6.52	24.81	0.97	14.50	14.86	109.82	2.40
Misc	0.00	0.29	0.31	0.07	0.27	0.00	0.00

STA CRUZ WATERSHED
Change Detection [1993-2002]

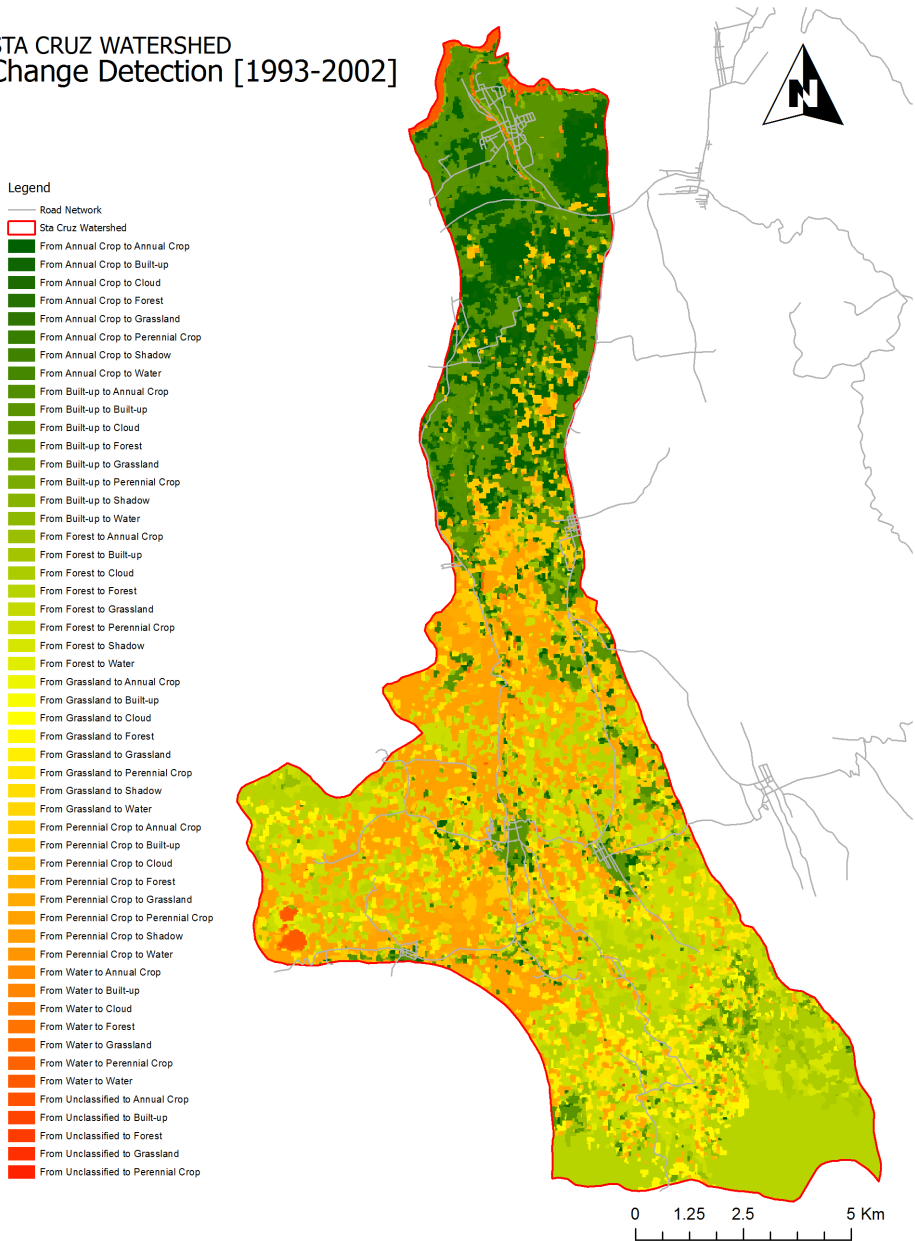


Figure 2.9. Change detection map of Sta. Cruz Watershed from 1993 to 2002

STA CRUZ WATERSHED
Change Detection [2002-2014]

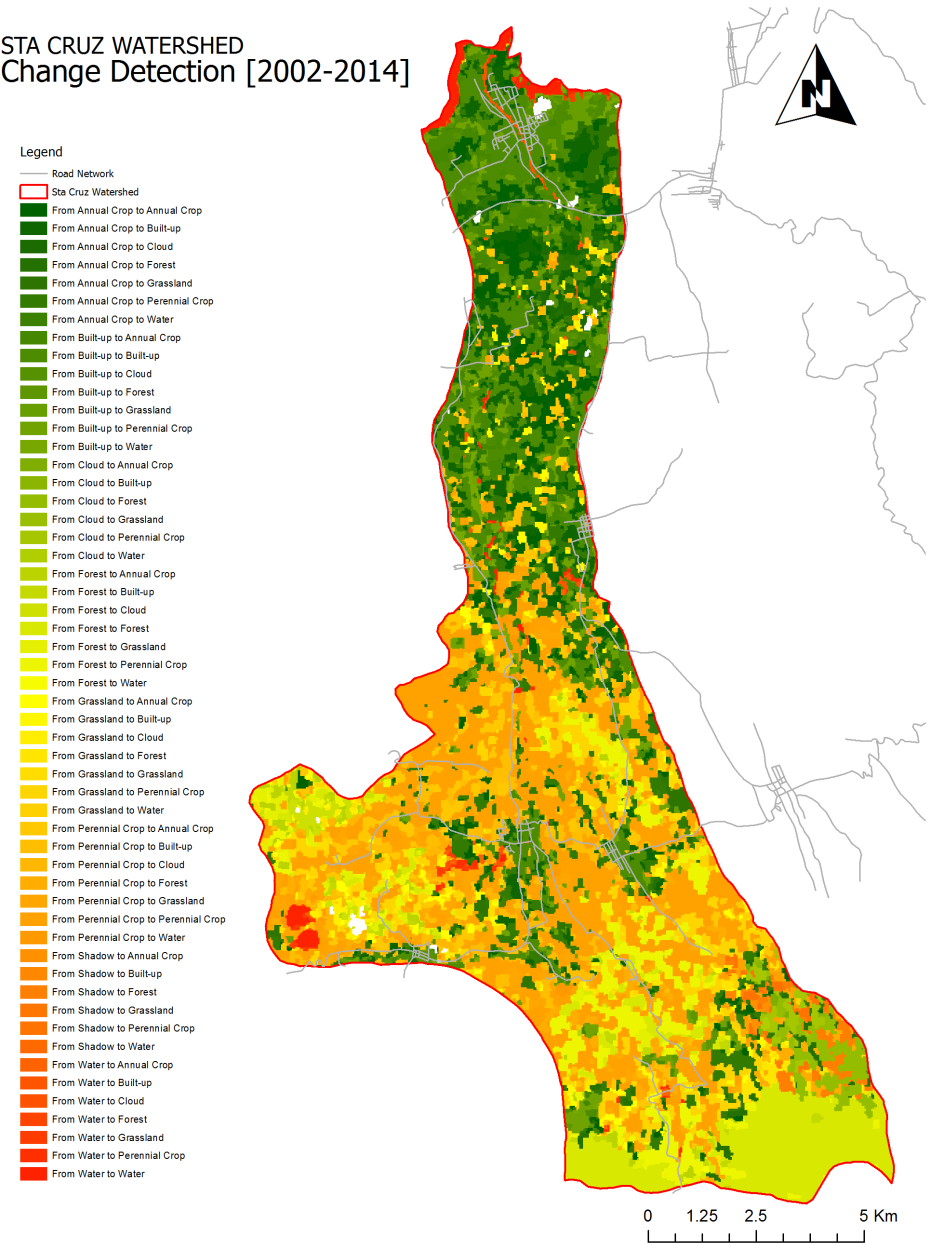


Figure 2.10. Change detection map of Sta. Cruz Watershed from 2002 to 2014

STA CRUZ WATERSHED
Change Detection [1993-2014]

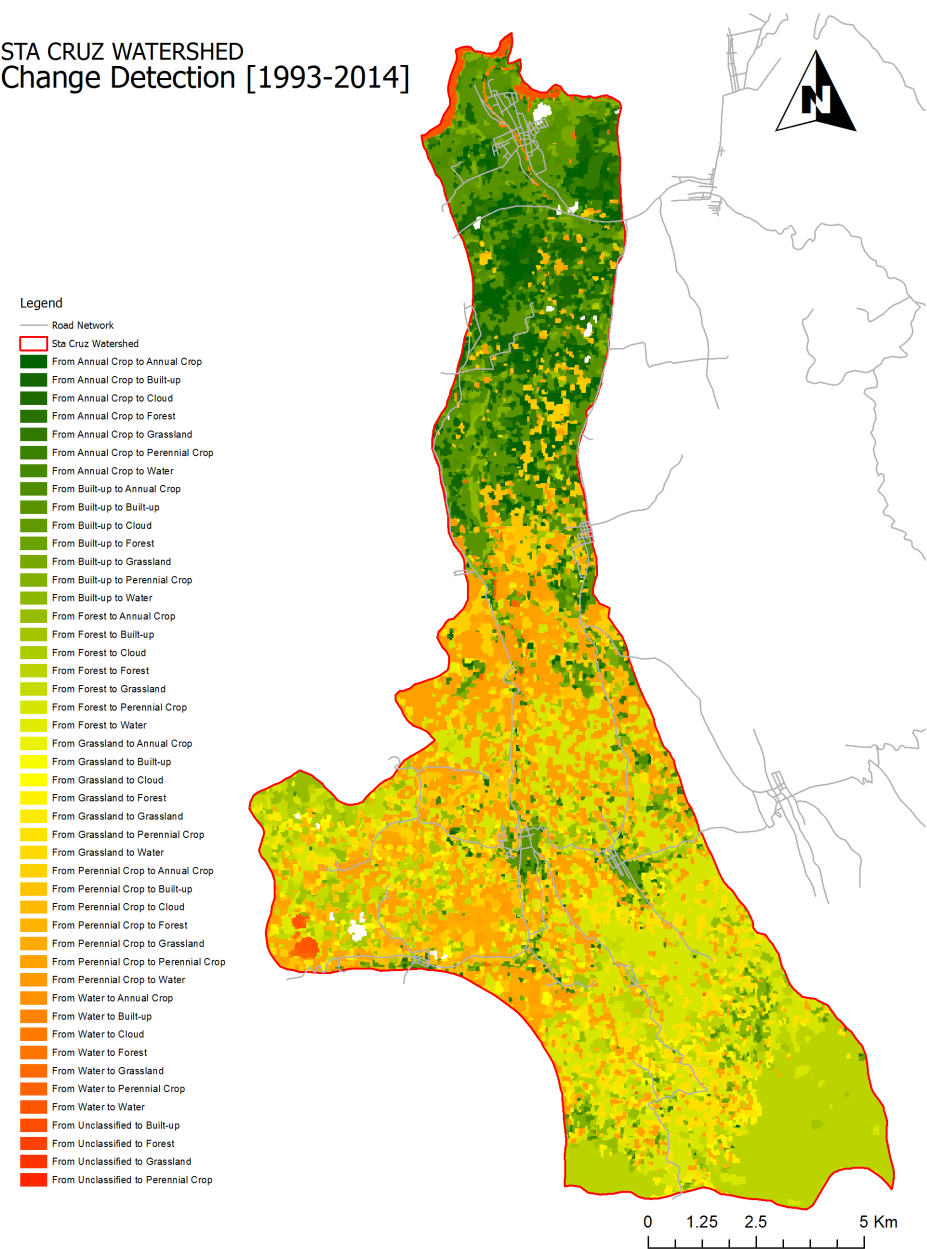


Figure 2.11. Change detection map of Sta. Cruz Watershed from 1993 to 2014

POTENTIAL IMPACTS TO FOOD SECURITY UNDER CLIMATE CHANGE

The increase in built-up areas from 1993 to 2014 in SCW may have been attributed to the increasing population in the different municipalities within the watershed. This continued growth in population also signifies more demand for food and this can be addressed by further expanding agricultural areas or increasing agricultural productivity and quality. In SCW, it is already evident in the change detection analysis that annual and perennial crops have significantly increased from 1993 to 2014. Most of the conversions into these land cover classes were from forest and grassland areas. This increase in area for agricultural production may be viewed as a solution to food security issues on the one hand but may also be perceived as a negative development that can exacerbate the adverse impacts of climate change on the other. It is significant to note, however, that conversion of areas, especially grassland areas, to perennial crops may be somehow beneficial compared to converting them into annual crops. This is due to the increase in vegetation cover that may help in the reduction of erosion rates and landslide risk in the area.

According to the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the projected annual rainfall change in 2020s (2006-2035) using the PRECIS (Providing Regional Climates for Impact Studies) model is about -7.8 mm. The highest decrease of rainfall is expected to be observed in the months of March, April and May (34.0 mm) and in the months of December, January and February (21.9 mm). However, the model also projected that there will be an increase of 3.3 mm and 2.4 mm in the months of June, July and August and in the months of September, October and November, respectively. In terms of mean temperature, PAGASA has projected an annual increase of approximately 1.0 °C in 2020s (2006-2035). This implies that further degradation or conversion of the remaining forest areas into other land cover classes would significantly aggravate the future state of the watershed. Given the current trend of land cover changes from 1993 to 2014, and with the projected annual and seasonal changes in rainfall and in mean temperature in Laguna, SCW may experience severe drought during the dry season and a significantly higher rainfall amount during the rainy season that may cause flooding in low lying areas. It is therefore recommended that a comprehensive watershed management plan of SCW be crafted to abate future adverse impacts of climate change and, at the same time, address issues on food security. Furthermore, future climate scenarios also indicate that it may affect the growth, productivity and quality of agricultural crops in the area. Hence, more climate-resistant crops should be used and appropriate adaptation strategies must be developed to wane the effects of climate change.

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CHAPTER 3

WATER RESOURCES ISSUES AND ADAPTATION STRATEGIES

MANOLO G. VILLANO, DULCE D. ELAZEGUI AND PRECIOUS R. ZARA

This chapter discusses the interaction between water, food security and environment in Sta. Cruz Watershed, one of the major watersheds contributing runoff to Laguna de Bay. It also recommends adaptation measures and policies to minimize the adverse effects of these interactions on the welfare of the watershed communities.

Rice self-sufficiency in the watershed communities is below 50 percent, and there are manifestations of pronounced rainfall variability and reduction in the output of water resources. The impacts of previous typhoons and habagat (southwest monsoon) on livelihood apparently was not so serious or permanent for the communities to restore agricultural productivity or acquire food from other sources. However, if the present rate of deforestation and non-sustainable agricultural production practices are not effectively controlled in the near future, frequent occurrences of extremely climate-related events may result in irreversible damages to agricultural production systems since such undesirable practices will most likely lead to more intense and persistent flooding, water quality degradation, sedimentation, and reduced replenishment of water sources hence, less productive irrigation systems.

A number of strategies could help the communities in mitigating or adapting to the impacts of climate change. These include protection and reforestation of the declared forest reservation or protected areas and establishment of a National Knowledge Park on Upland Natural Resources Conservation and Management. Sustainable agriculture through the enforcement of conservation farming technologies in sloping agricultural lands should be promoted. Improving the performance of existing irrigation systems and promotion of on-farm water management technologies would also be crucial. Climate change should be integrated in planning, design, and rehabilitation of water resources projects. For effective implementation of the above measures, there must be a favorable policy environment and enhanced institutional capacity to support the above climate change adaptation strategies.

Keywords: climate change, watershed, water resources, rice self-sufficiency, typhoons, habagat, protected areas, conservation farming, hydrologic information

INTRODUCTION

With a nationwide average annual rainfall of about 2,400 mm, water is not supposed to be a problem in the Philippines. Unfortunately, such rainfall is not uniformly distributed in time and space, thus limiting its direct availability for agriculture. As such, in some farms, rice can be planted for only one season while other crops are planted depending on rainfall, which could allow for harvests at least two times a year. In other farms, however, planting is limited to only one season unless water (from springs, rivers, lakes, or groundwater) could be tapped through irrigation systems.

In some parts of the country where rainfall is more or less distributed throughout the year, farmers may plant two or more croppings per year thus maximizing the use of their farm lands without irrigation. For other regions, however, most of the annual rainfall occurs during the wet season with very limited or none at all falls within the dry season. As such, only one cropping may be possible during the wet season which could still be damaged by strong typhoon or habagat. Assurance of a second or even third cropping (to maximize annual production per farm) during the dry season in these regions or province may only be realized with the presence of adequate water supply (from springs, rivers, lakes, or groundwater) and development of irrigation facilities.

In the hydrologic cycle, precipitation recharges common water supply sources—springs, rivers, lakes, and groundwater—via the watershed. But considering their generally degraded condition, our watersheds' capacity to retain and absorb rainfall to recharge the aquifers are drastically reduced, resulting in a decreasing water supply from the springs, rivers, and groundwater. Consequently, too, most of the rainfall moves down as runoff causing soil erosion, landslides, sedimentation, and flooding problems, which the country often experiences during strong typhoons. The magnitude of these problems will be aggravated if the intensity and frequency of strong typhoons and droughts are worsened by climate change, which, in turn, can cause more problems for food security.

Indeed, there is a need to readjust our normal criteria for analyzing and managing our climate and water resources in relation to agricultural development to factor in the threat of more intense and more frequent hydrologic extreme events. And due to the differences in geographic location and land features, each region, province, municipality, or even barangay, may experience different climatic hazards and differ in levels of vulnerability. The effectiveness of a climate change adaptive measure may also differ from one locality to another.

Within a watershed, resources are shared; trans-boundary impacts will be felt upstream to downstream and from one local government unit to another. Sustainability of the watershed resources, therefore, requires sustainable environment and natural resources management programs through an effective policy and governance system. It should address the following dimensions: how resources are shared—access and rights to use; how responsibilities are distributed or shared to protect, conserve, and sustain resources; and how benefits, risks, and burdens are shared and allocated (Gupta and Lebel 2010).

This chapter attempts to explore and explain, in a watershed context, issues on water and food security-environment interactions within a dynamic setting brought about by climate change. The goal of the study is to formulate strategies and policy recommendations that can minimize the adverse impacts of climate change on the well-being of people within the watershed or on those depending on its natural resources for livelihood. Specifically, it seeks to answer the following questions:

1. How do the changes in climate affect water resources and food security among inhabitants dependent on the life support of the watershed in general and among the three types of communities under study in particular?
2. What water adaptation measures may be undertaken to minimize the adverse effects of these interactions on the welfare of communities?
3. What policies may be recommended to minimize these adverse effects and improve the well-being of the communities?

THE HYDROLOGY AND WATER RESOURCES OF THE WATERSHED

The Sta. Cruz Watershed is situated on the southeastern part of Laguna de Bay and lies between 14° 2'47" N to 14° 18'21" N and 121° 21'18" E to 121° 29'32" E. As shown in table 3.1, the watershed has an approximate area of 14,858 ha, which covers the whole or a portion of the municipalities of Lumban, Sta. Cruz, Pagsanjan, Pila, Magdalena, Majayjay, Liliw, Nagcarlan, San Pablo, and Rizal in Laguna and the municipality of Lucban in Quezon. About 141 barangays are wholly or partly within the watershed (LLDA 2012). On its southwestern side lies Mt. San Cristobal while on its eastern side is the Pagsanjan Watershed. Both watersheds are along the northern slopes of Mt. Banahaw.

Table 3.1. Municipalities covered by the Sta. Cruz Watershed basin

Municipality	Number of Barangays Covered	Area (ha)	% of total sub-basin area	Population	% of total sub-basin population
Liliw	33	3600.31	24.64	32,469	17.64
Lucban	1	75.17	0.11	-	-
Lumban	1	63.83	0.44	-	-
Magdalena	15	1325.29	9.07	8,248	4.48
Majayjay	7	264.18	1.81	654	0.35
Nagcarlan	45	5260.36	36.00	48,101	26.14
Pagsanjan	4	559.94	3.83	8,359	4.54
Pila	1	70.54	0.48	171	0.09
Rizal	10	909.26	6.22	9,762	5.30
San Pablo	3	197.82	1.35	2,678	1.45
Sta. Cruz	21	2284.30	15.63	73,550	39.97
Total	141	14611.00	100.00	183,992	100.00

Source: LLDA 2012

Topographic and Land Use Features

Table 3.2. Elevation-area relationship of the Sta. Cruz Watershed

Description	Elevation (MASL)*	Area (ha)	Percent of total (%)
Low	≤ 20	3,026.44	20.37
Medium	21 – 470	8,427.78	56.73
High	> 470	3,402.14	22.90

*MASL= meters above mean sea level

Table 3.3. Area per indicated slope ranges for the Sta. Cruz Watershed

Slope range (%)	Area per slope range		Cumulative area	
	(ha)	%	(ha)	%
0 – 3	1,726.19	11.69	1,726.19	11.69
3 – 8	4,349.69	29.46	6,075.88	41.15
8 – 18	4,832.01	32.73	10,907.89	73.88
18 – 30	1,974.63	13.37	12,882.52	87.25
30 – 50	1,386.55	9.39	14,269.07	96.65
>50	495.27	3.35	14,764.34	100.00
Total	14,764.34	100	-	100.00

Table 3.4. Land use change within the Sta. Cruz Watershed from 1993 to 2014
(Adapted from Tiburan et al. 2014)

Land Use/ Cover	1993		2014		Difference*	
	Area (ha)	% of total	Area (ha)	% of total	Ha	%
Forest	4,907.27	33.03	1,995.51	13.43	- 2,911.76	-59.34
Grassland	1,371.96	9.23	1,151.37	7.75	- 220.59	- 16.08
Agriculture**	5,828.00	39.22	7,761.12	52.28	+ 1,939.12	+ 33.27
Built-up	2,576.10	17.34	2,915.41	19.62	+ 339.31	+ 13.17
Others***	174.81	1.18	1,028.73	6.92	- 88.92	-
Total	14,858.14	100.00	14,858.14	100.00		

* Negative sign (-) means a decrease from 1993 to 2014; positive (+) means an increase.

** Agriculture = land area occupied by annual crops + land area planted with perennial crops

*** Others = Water area + Cloud/shadow noise

Factors affecting the vulnerability of the water supply from a watershed include topography, soils, and land uses or land cover. The Sta. Cruz Watershed and the adjacent Pagsanjan Watershed are located on the northern side of Mount Banahaw. From the topographic map (see Chapter 2), land elevations within the Sta. Cruz Watershed ranges from near zero on the lake shore to more than 1,400 m near the top of Mount Banahaw. The highest peak of Mount Banahaw is 2,160 m. Table 3.2 shows that about 20.4 percent of the total watershed area is at low elevation, 56.7 percent at a medium elevation, and

22.9 percent at a high elevation. Based on the slope map (table 3.3), about 73.9 percent of the watershed area has less than an 18 percent slope, 23.7 percent is within an 18 to 50 percent slope, and just 3.4 percent has a slope greater than 50 percent.

In terms of land use and cover, table 3.4 shows that forest and grassland areas decreased between 1993 and 2014 by about 59 percent and 16 percent, respectively. On the other hand, agriculture and built-up areas increased by close to 33 percent and 13 percent, respectively (Tiburan et al. 2014).

Climate and Rainfall

Based on the Corona climate classification method, most areas on the southwestern portion of the Sta. Cruz Watershed are under Type III, which resembles Type I. That is, the seasons are not very pronounced but have a short dry season. This is somewhat confirmed by the rainfall data of Nagcarlan (table 3.5) which shows that only three months (February to April) are considered dry (Corona classifies a month as dry if its average monthly rainfall is less than 50 mm). Based on focus group discussions (FGDs), the high-elevated barangays of Nagcarlan, specifically Barangays Bucal and San Francisco, do not usually experience dry months, enabling the planting of vegetables two times a year. Indeed, the number of rainy days throughout the year (table 3.5) supports this observation. The southeastern areas of the watershed are classified as Type IV resembling the Type II climate since rainfall is more or less evenly distributed throughout the year with no dry season.

Table 3.5. Average monthly rainfall and number of rainy days for Sta. Cruz and Nagcarlan, Laguna

Month	Average rainfall (mm)		Average number of rainy days	
	Sta. Cruz ^a	Nagcarlan ^b	Sta. Cruz ^c	Nagcarlan ^d
January	47.6	57.7	4.1	10.4
February	28.8	31.1	2.6	7.0
March	40.3	17.2	2.9	4.8
April	40.8	41.1	2.3	7.2
May	112.1	193.6	5.5	14.4
June	179.1	226.3	8.5	18.9
July	214.4	353.9	10.3	24.4
August	191.1	365.1	8.5	18.9
September	183.7	397.5	9.3	20.1
October	195.3	251.2	9.3	18.8
November	219.6	231.4	9.1	18.2
December	143.4	129.6	7.3	14.4
ANNUAL	1,596.1	2,297.0	79.7	176.9

^{a/, c/} Average for 19 years (1994- 2012), computed from PAGASA daily rainfall data

^{b/, d/} Source: Nagcarlan 2009 CLUP

The climate of the low-elevated barangays of the watershed is quite different as shown in the 19-year (1994 to 2012) average monthly rainfall records of the PAGASA weather station in Sta. Cruz, Laguna (table 3.5). Using the Corona method, on the average there are four dry months from January to April and eight wet months from June to December.

River Systems and Springs

The Sta. Cruz Watershed, one of the 24 sub-basins of the Laguna Lake, is endowed with numerous rivers, springs, and groundwater. The Sta. Cruz River is the main stream of the watershed; the other major tributaries are listed in table 3.6. Unfortunately, the discharge or stream flow rates of most of these rivers are not currently being measured. There may be some measurements being done by some agencies but they are yet to be published for public use. The Department of Public Works and Highways (DPWH) used to measure the discharge rate of the Sta. Cruz River at the Sta. Cruz River Irrigation System (SCRIS) diversion dam in Barangay Calumpang, but, for some reason the department discontinued it. Subjecting the DPWH data from 1950 to 1977 to flow-duration analysis and reciprocal method, National Water Resources Council (NWRC) (1983) estimated the spatial 80 percent dependable streamflow of the Sta. Cruz River Watershed to range from 12 to 15 liters per second/sq km. At the SCRIS diversion dam (drainage area is 10,300 ha), this amounts to about 1,200 to 1,500 liters per second of dependable flow. The 80 percent dependable streamflow may be used to estimate the potential farm area to be irrigated by a river.

There are also several springs within the Sta. Cruz Watershed that are the main sources of domestic water supply of high elevation barangays. In the municipality of Nagcarlan, for instance, several barangays get their domestic water supply from 15 springs. However, water supply has been affected especially during dry months. For example, there is a storage tank for water from a spring a few meters above that used to be a source of domestic water supply for some households in the barangay, but no water comes from it now especially during the summer months. Almost all households now depend on a water supply pipe abstracting water from another spring quite far from the poblacion.

Table 3.6. Major rivers passing each municipality within the Sta. Cruz Watershed

Municipality	Bodies of water	Catchment Area (ha)
Liliw	Liliw River Bungkol River Mamalin River Lapad River Aoy River	55,4627
Magdalena	Maimpez River	3,450
Nagcarlan	Nagcarlan River Rio Bunga River Talahibing River	
Rizal	Mayto River May-it River Lake Calibato Springs mentioned (no name)	
Sta. Cruz	Sta. Cruz River	14,858

Data sources: CLUPs of Municipalities

Groundwater

Based on a rapid ground water supply assessment made by the NWRC (1982), the flood plain portions of Sta. Cruz are classified as shallow well areas where the static water level is generally within six meters below ground surface and the depth of wells constructed is normally not more than 20 m. Water from most of the areas leading up to the mountains need to come from deep wells; there are also areas where groundwater abstraction through wells is difficult. The groundwater properties of observed wells in the different municipalities within the Sta. Cruz Watershed are given in table 3.7 below.

Table 3.7. Groundwater data of municipalities with land area within or near the Sta. Cruz Watershed

Municipality	Number of wells observed	Average Well Depth (m)	Average Normal SWL (m)	Average Specific Capacity (lps/m)
Sta. Cruz	101	37	3.47	0.81
Pagsanjan	11	37	4.35	0.86
Pila	7	34	1.29	0.4
Victoria	11	57	2.61	0.96
Liliw	6	30	8.34	NA
Magdalena	6	23	11.38	NA
Nagcarlan	13	18	7.08	0.51
Rizal	1	62	36.59	NA

Source: NWRC, 1983

Manifestations of Rainfall Variability in the Study Area

Pronounced climate variability in the Philippines may be gleaned from the experienced and recorded occurrences of strong typhoons, southwest monsoons, and the El Niño phenomenon. From 1972 to 2003, not less than nine El Niño episodes affected the country; most notable of which was the 1997-98 occurrence, with a very warm period lasting more than nine months. In 1994 onwards, the passage of destructive typhoons in the province of Laguna has become more frequent, as seen in table 3.8. The more recent ones are Typhoon Mirinae (Santi) in 2010 and Typhoon Rammasun (Glenda), which directly hit Quezon and Laguna in July 2014.

Analyzing the 19-year (1994 to 2012) rainfall data of Sta. Cruz, Laguna, there appears to be marked variations in the average monthly rainfall and maximum daily rainfall per month between the 10-year period of 1994-2003 to the nine-year period from 2004 to 2012, as shown in tables 3.9 and 3.10. The percent variations indicate that the deviation ranges from a decrease of 13.5 percent in July to an increase of 447.3 percent in April with an annual increase of 36.0 percent. In the case of maximum daily rainfall per month, there was a decrease in the months of March and July but for the other months, the percent increase is from 2.3 percent to 177.5 percent. The annual increase is 42.5 percent.

Table 3.8. Destructive typhoons that affected Laguna area, 2004-2006

Name		Population Affected		Properties Damaged (in Million Pesos)		Total Cost (in Million Pesos)
	Year	Family	Persons	Agriculture	Infrastructure	
TY Yoyong	2004	1,665	6,748	-	-	-
ITCZ and LPA	2005	150	750	-	-	-
TYCaloy (Chanchu)	2006	517	2,589	111	-	111
TS Florita (Bilis)	2006			.160		.16
TY Milenyo (Xangsane)	2006	59,810	335,415	597	160	757
TY Reming (Durian)	2006	930	4,156	16	8	24

Source: Office of Civil Defense-Department of National Defense

Table 3.9. Percent deviation of 2004-2012 average monthly rainfall from the 1994-2003 period

Month	Average monthly rainfall (mm)		Percent deviation
	1994-2003	2004-2012	
January	38.45	63.74	65.77
February	11.90	45.62	283.36
March	31.60	49.06	55.25
April	13.92	76.18	447.27
May	103.43	147.81	42.91
June	145.46	212.80	46.29
July	229.96	198.83	-13.54
August	159.34	222.83	39.85
September	166.65	200.72	20.44
October	175.06	233.01	33.10
November	196.47	242.63	23.49
December	105.66	181.11	71.41
Total	1377.90	1874.34	36.03

Table 3.10. Percent deviation of 2004-2012 maximum daily rainfall per month from the 1994-2003 Period

Month	Max. daily rainfall per month (mm)		Percent deviation
	1994-2003	2004-2012	
January	51.6	52.8	2.33
February	27.2	54.7	101.10
March	94.8	56.6	-40.30
April	28.9	80.2	177.51
May	80.2	92.2	14.96
June	53.2	136.2	156.02
July	116.2	96.6	-16.87
August	106.4	164.4	54.51
September	85.9	119.4	39.00
October	102.6	152.4	48.54
November	101.6	164.6	62.01
December	61.5	127	106.50
Total	910.1	1297.1	705.31

Pronounced climate variability in the Philippines may be gleaned from the experienced and recorded occurrences of strong typhoons, southwest monsoons, and the El Niño phenomenon. From 1972 to 2003, not less than nine El Niño episodes affected the country; most notable of which was the 1997-98 occurrence, with a very warm period lasting more than nine months. In 1994 onwards, the passage of destructive typhoons in the province of Laguna has become more frequent, as seen in table 3.8. The more recent ones are Typhoon Mirinae (Santi) in 2010 and Typhoon Rammasun (Glenda), which directly hit Quezon and Laguna in July 2014.

Based on 50-year rainfall data at the PAGASA-UPLB Agro-meteorological Station in Los Baños, Laguna, and using the Third Generation Coupled Global Climate Model (CGMCM3), Combalicer et al. (2014) made simulations and projections of rainfall under two scenarios in the province of Laguna. The results indicate that, in general, precipitation will increase from the present (2001-2010) to the 2080 period.

The information above indicates that in the study area, there was a marked difference in the rainfall magnitudes between the last two decades. Consideration of these magnitudes of variability as indicators of climate change may depend on further deviations and long-term consistency in the future. Nonetheless, it could serve as a tool in increasing the knowledge of the local executives and members of the community on the meaning and risk of climate change.

UTILIZATION OF WATER SUPPLY FROM THE WATERSHED

Water extracted from the Sta. Cruz Watershed is used for the following major purposes: domestic, irrigation, power generation, and recreation, particularly by resorts with swimming facilities. Except for the mini hydropower plant that uses water flow from rivers, all other users get water from rivers, springs, or underground. In the hydropower plant, water is diverted from the river and is used to run the turbines after which the water is returned to the downstream section of the river with insignificant losses. The water used in swimming pools is also returned to the river with minimal reduction in quantity and quality if chlorine is not used. In the medium to high elevated communities (e.g., Barangays Bukal and San Francisco of Nagcarlan; Barangay Bungkol of Liliw), domestic water supplies are generally from springs either developed by the community or by water districts. For the low elevation communities such as Patimbao and San Pablo Sur of Sta. Cruz, most sources of domestic water are from deep tube wells operated by water districts.

Approximately close to 80 percent of the water being abstracted from the watershed is devoted to agriculture through irrigation. Tables 3.11 and 3.12 list the National Irrigation System (NIS) and Communal Irrigation Systems (CIS), respectively, that abstract water from the Sta. Cruz Watershed. The Sta. Cruz River Irrigation System (SCRIS) is the lone NIS abstracting water from the watershed for irrigation. At present, it is irrigating about 2,160 hectares benefiting around 1,577 farmers. However, not all farms irrigated by the system are within the Sta. Cruz Watershed such as irrigated farms in the municipalities of Pila and Victoria. On the other hand, the Balanac River Irrigation System (BRIS) draws water from the adjacent Pagsanjan Watershed but irrigates some rice farms in San Pablo Sur and San Pablo Norte, which are within the Sta. Cruz Watershed.

Table 3.11. NIS serving rice farms within the project area

NIS System	Municipality served	Original Service Area (ha)	Ave. area irrigated 2011-2014	
			Dry	Wet
1. Scris Div. I	Liliw, Nagcarlan, Sta. Cruz, Pila,	3,100 (FUSA= 2,160)	948.47	950.67
Div. II	Victoria		1,030.19	1,005.31
Total area irrigated (ha)			1,978.66	1,955.97
Ave. % CI based on OSA			63.46	63.10
Ave. annual % CI based on OSA			126.56	
Ave. % CI based on FUSA			91.60	90.55
Ave. annual % CI based on FUSA			182.15	
2. BRIS	Magdalena, Lumban, Sta. Cruz, Pagsanjan	1,056 (FUSA=1,000)	878.50	859.28
Ave. % CI based on FUSA			83.19	81.37
Ave. annual % CI based on FUSA			164.56	

Notes: a) CI = Cropping intensity

b) FUSA = Firmed-up Service Area

Source: NIA

In addition to the NIS irrigated area, around 400 ha of rice farms are served by the 10 CIS (table 3.12) that also abstract water from the watershed. These are constructed with the assistance of NIA but totally managed by the farmers. The water sources are streams or springs near the upland communities.

Table 3.12. CIS abstracting water from the Sta. Cruz Watershed

CIS System	Municipalities Served	FUSA (ha)	2013 Ave. Cropping Intensity (%) ^{a/}			2013 Average Annual Yield (tons/ha) ^{a/}
			Dry	Wet	Annual	
1. Arjona CIS	Liliw	34	100	100	200	5.50
2. Bungkol CIS	Liliw	63	100	100	200	3.75
3. Calumpang CIS	Liliw	26	100	100	200	5.25
4. Maimpez CIS	Magdalena	97	100	100	200	5.50
5. Maravilla CIS	Magdalena	40	100	100	200	5.25
6. Masikap CIS	Liliw	44	100	100	200	3.75
7. Palayan CIS	Nagcarlan	28	100	100	200	5.00
8. Tala CIS	Rizal	24	100	100	200	4.50
9. Talaga CIS	Rizal	12	100	100	200	5.25
10. Taytay CIS (no data)	Nagcarlan	42	ND	ND	ND	ND
Total		410				
Average						4.86

^{a/}Computed based on the 2013 NIA CIS Inventory

Source: NIA

From the Comprehensive Land Use Plans (CLUP) of municipalities within the Sta. Cruz Subwatershed, rice yield level ranges from 3.9 to 5.75 t/ha or an average of 4.83 t/ha. Potential yield of traditional varieties may range from 6 to 7 t/ha. Using the firm-ed-up service areas, the average annual cropping intensity of the SCRIS and BRIS are 182.15 percent and 164.56 percent, respectively. These are just satisfactory since the potential annual cropping intensity of rice farms, according to David (2003), ranges from 160 to 220 percent. Based on the FGDs and key informant interviews (KIIs), however, some farmers on the downstream sections of both NIS are claiming that irrigation water does not normally reach their farm during the dry season. They say that those personnel managing the water supply schedule are giving priority to some favored farms and that NIA also allow newly opened farms upstream to be irrigated even if these were not included in the original service area of the system. The above issues indicate some potential of increasing the annual rice productivity of farms irrigated by the two NIS through better management by the NIA and the corresponding irrigators' association.

Based on cropping intensities (tables 3.11 and 3.12), not all firm-ed-up service areas in both NIS are irrigated either during the wet or dry seasons, while all nine CIS farms (though with just one-year data) are irrigated in both seasons. As such, even if their rice yield levels per hectare are almost the same, the computed annual rice productivity per hectare are 8.80, 7.95, and 9.72 t for the SCRIS, BRIS, and CIS (average of nine systems), respectively. An increase of 1 t/ha per year is a significant boost to food security.

Among others, the reasons for the higher cropping intensities of CIS over the NIS in the project area include the following: shorter dry months; farms are nearer to the water source avoiding high water losses through long canals; smaller systems with lesser members are easier to manage; and, smaller structures are promptly repaired. Nevertheless, bulk of the water being abstracted annually from the Sta. Cruz watershed is devoted to the present 2,160-ha firm-up service area of the Sta. Cruz Irrigation System.

POTENTIAL IMPACTS OF CLIMATE CHANGE ON WATER RESOURCES AND CROP PRODUCTION

Climate change will lead to a decrease in the return period (more frequency of occurrence) of certain hydrologic events such as rainfall and runoff or flood water. Or, for a given return period, there will be an increase in the magnitude of a certain hydrologic event. Plotting the maximum daily rainfall per year of Sta. Cruz, Laguna on a Log-Probability graphing paper shows that the return period of a maximum daily rainfall of 120 mm was 10 years during the 10-year period of 1994-2003, while the same magnitude has a return period of just two years during the nine-year period of 2004-2012. For a 15-year return period, the maximum daily rainfall was 125 mm for the 1994-2003 period and 180 mm for the 2004-2012 period. There is no available streamflow data of Sta. Cruz for analysis but it is expected to behave similarly albeit at a different magnitude.

Historical records of damages to agriculture, local people's experiences, and rainfall data analysis all indicate that the increasing frequency of strong or super typhoons and the habagat (southwest monsoon) affect the Sta. Cruz Watershed and the nearby communities. Besides causing direct physical damages to crops, forest trees, fruit trees, animals, and buildings, super strong winds, a very high rainfall intensity, and a long duration of rainfall contribute to the occurrence of severe floods, sedimentation, water pollution, and water supply scarcity. To identify adaptation measures appropriate to the area, the vulnerability and occurrence of impacts in the study area are briefly discussed below.

Flooding and Sedimentation

High rainfall intensity and rainfall erosivity are associated with strong typhoons and intense habagat. The rainfall behavior in Nagcarlan indicates increasing rainfall intensity and erosivity in the study area. When forest trees are cut or logged and the land is converted to agriculture without conservation measures, as observed in Bukal, Nagcarlan and in Luquin, Liliw (figure 3.1), the soil is exposed to the erosive power of the rainfall. If the rainfall intensity exceeds the soil infiltration capacity, runoff occurs, causing more detachment and transport of soil particles. The erosivity of runoff is further magnified by the increase in land slope. Severe erosion removes the fertile top soil, reducing its crop productivity and exposes the soil layer with less infiltration capacity. As a result, more fraction of the rainfall occurs as surface runoff. And without trees and vegetation to restrain the movement of water on sloping land, the increased runoff travels faster reaching areas at low elevation in a shorter time and causes flooding as rivers and canals overflow. Some of the eroded soil particles are carried by the runoff as sediment downstream. Streambank erosion is also a potential source of sediments that could be easily carried downstream by high river flows.

The damage to the diversion dam of the Sta. Cruz River Irrigation (SCRIS) brought about by Typhoon Milenyo in 2006 was due in part to the heavy volume of sediments

carried along the stretch of the riverbed by the strong water flow. The new diversion dam (figure 3.2) constructed a few meters above the previous location in 2007 is already filled up with sediments carried by heavy river flow during Typhoons Ondoy and Santi in 2010. The intake channels of the Calumpang CIS and Bungkol CIS were also blocked by big rock boulders brought down by a very strong river flow during Typhoon Santi in 2010.

As discussed earlier, the land area of the Sta. Cruz Watershed considered as forest decreased from 33 percent (4,907.3 ha) in 1993 to 13.4 percent (1,995.5 ha) in 2012, while the area devoted to agriculture increased from 39.2 percent (5,828 ha) in 1993 to 52.3 percent (7,761 ha). Considering that about 60 percent of the watershed area has a slope greater than 8 percent and that conservation farming is not generally practiced in the area, it is likely that the severity of flooding and sediment problems in the study area will be further aggravated by climate change.



Figure 3.1. Rill erosion in a kaingin (slash and burn) in Barangay Loquin, Liliw



Figure 3.2. The present Sta. Cruz River Irrigation System (SCRIS) diversion dam

Water Scarcity

Based on the FGDs and KIIs, drought due to a long dry season is not so common in the study area. This is confirmed by the rainfall analysis presented earlier, which shows that the average number of dry months is four in Sta. Cruz (low elevation) and three in Nagcarlan (high elevation). There is also an increase in the amount of dependable rainfall from the 1994-2003 period to the 2004-2012 period. There is, however, a possibility that the occurrence of a number of El Niño phenomena in the 1994-2003 period may recur in the future.

A more serious potential impact on water sustainability will be the further reduction in the recharge of aquifers if the present rate of deforestation and conversion to agricultural and built-up areas shown in table 3.4 is not seriously and adequately addressed. As pointed out above, deforested watershed coupled with an increasing area of non-sustainable practices of farming and occurrences of strong typhoons and intense habagat will cause severe and widespread soil erosion, removing the top soil and decreasing the soil infiltration rate. With less soil infiltration, more of the rainfall will move as surface runoff and less will percolate to recharge the aquifers underground. Such a situation will eventually lead to reduced water out from springs, decreased dependable river flow, and a drop in the groundwater table especially during the dry months, thereby affecting the availability and adequacy of water supply for the different uses.

The situation above partly explains the observation in Barangay Bukal, Nagcarlan that a spring (figure 3.3) below their kaingin area dries up during summer time. While there is no reported drying up of most of the springs supplying domestic water to the majority of the upland communities, there were reports at the FGDs that the summer discharges of the springs show significant reductions. Consequently, the same situation is also the major reason why both the Sta. Cruz River Irrigation System and the Balanac River Irrigation System could not irrigate considerable portions of their service area during the dry season. A significant fraction of the summer flows of the streams are coming from the accumulated water outputs from the springs.



Figure 3.3. Spring water storage tank in Barangay Bukal, Nagcarlan

The FGDs also revealed that in the earlier decades, when much of the watershed was still forested, the water flow of the Sta. Cruz River was still sufficient even during the dry months. While no historical streamflow record of the river could be used to ascertain such claim, an interview with Engr. Virgilio M. Yorro of the National Irrigation Administration (NIA) in Pila, Laguna revealed that the decrease in the irrigable area of the Sta. Cruz River Irrigation System from 3,725 ha in 1977 to 2,160 ha in 2012 may be in part due to the decrease in the dependable flow of the river overtime. And as mentioned earlier, irrigation water does not reach a significant fraction of the system's tail-end service area during the dry months.

Landslide

The potential threat of landslides should not be disregarded in the formulation of hazard mitigation and adaptive measures. Some portions of the watersheds have highly steep slopes (>30 percent slopes), making them highly vulnerable to landslides under extremely intense and long duration rainfall and, most especially, if such extreme rainfall event is preceded by an earthquake similar in intensity to those that occurred in Bohol in 2013 and in Baguio in 1991. The development of deep gullies, which may start with severe soil erosion and formation of rills such as in figure 3.1, may cause landslides once the gully head reaches the base of the steep side of the mountains. Uncontrolled scouring of riverbanks due to extreme peak river flow during super typhoons or intense habagat is another initiation of landslides.

Water Quality Degradation

Eroded soil particles brought down the streams by runoff is the main potential source of sediments that degrade the physical quality of water. Another cause of poor water quality is the indiscriminate garbage disposal by residential and commercial areas (Nepomuceno 2010); the waste materials are carried by surface runoff and irrigation water, as observed in Barangay San Pablo Sur of Sta. Cruz (figure 3.4).



Figure 3.4.
Garbage-filled
irrigation
canal in Brgy.
San Pablo Sur,
Sta. Cruz

Possible sources of chemical and biological contaminants include fertilizer and pesticides residues from agricultural areas, existing waste water treatment plants, tanks of poultry and piggery businesses, and even household septic tanks, which abound along the banks of the watershed stream networks. These structures can be reached and washed out by extremely strong and overflowing runoffs. This will then further add to the influx of contaminated water in downstream communities and to the Laguna Lake.

THREATS TO ENSURING FOOD SECURITY

Crop Production Vulnerability According to Elevation

The vulnerability of a community's agricultural production systems to a strong and intense habagat varies with respect to their relative location within the watershed. In high elevation (more > 470 masl) communities like Barangays Bukal and San Francisco in Nagcarlan, Garcia et al. (2014) reported that the main agricultural products are vegetables (tomato, radish, beans, cucumber, cabbage, cassava, sweet potato, chayote, and mustard). Perennial crops such as lanzones and rambutan were also observed, which are usually planted under coconut trees. Typhoons, especially if accompanied by strong winds, can cause lodging in vegetable crops and felling of perennial crops like lanzones, coconut palms, and banana. Perennial crops like coconut and lanzones can withstand strong winds but a considerable yield reduction has been observed. The recovery period of perennial crops is around two to three years. Rejuvenation of felled trees requires additional cost, which causes delay in fruit bearing (Garcia et al. 2014).

According to Garcia et al. (2014), the farmers in the medium elevation areas (21-470 masl) grow diverse crops that are adapted and grown in both the low and high elevation areas. The major crops planted include rice, vegetables, fruit trees, banana, and coconut. Except for rice, the other crops grown in high elevation areas are also grown in the medium elevation areas; hence, they have similar sensitivities to the climate hazards. Irrigated farms within the mid-elevation areas like Barangays Bungkol and Calumpang of Liliw with CIS are also threatened by strong typhoons or intense habagats. With inadequate intake gate control structures, extremely high river flow could damage the canals or add too much water to the farms, causing lodging of rice or even the collapse of rice terraces. Sediments and rock boulders may also destroy or choke their diversion structures. As mentioned earlier in this paper, the intake canals of the Barangay Bungkol and Calumpang CIS were blocked by big boulders due to Typhoon Santi. This has obstructed water entry to the irrigable farms causing a disruption in rice production.

Low elevation barangays such as Patimbao and San Pablo Sur of Sta. Cruz are mainly irrigated rice-producing areas with small portions planted with coconut and fruit trees. Garcia et al. (2014) noted that around 90 percent of the respondents in both barangays were planting rice. Strong typhoons or intense habagat normally inundate rice plants, causing them to lodge or be submerged. This results in heavy production losses. Garcia et al. (2014) noted that in a focus group discussion, the farmers estimated a reduction in the yield of around 51-100 percent and 30 percent in San Pablo Sur and Patimbao, respectively. During extreme drought or severe El Niño episodes when there is a significant decrease in irrigation water, tail-end farms of irrigation systems, as experienced by the two barangays above, become non-productive.

Rice self-sufficiency level

With rice as the staple food of the country, food security may be equated to having enough rice to meet the requirements of the growing population. Using the results of the Survey on Food Demand for Agriculture Commodities, NIA estimated the rice self-sufficiency in the Province of Laguna as follows: 27.44 percent in 2007; 29.71 percent in 2008; and 23.63 percent in 2009. For the communities within the Sta. Cruz Watershed, however, rice self-sufficiency level was estimated to be 46.44 percent for 2013. This was based on the following data and assumptions: population of 184,000; estimated rice farm area within the watershed of 1,900 ha (assuming about 70 percent of SCRIS FUSA is within the watershed (as indicated in tables 3.8 and 3.9); average annual cropping intensity at 180 percent (based on FUSA); BAS per capita rice consumption of 116 kg/yr; and 60 percent milling recovery. While this is quite a conservative estimate (due to some doubts on the accuracy of reported irrigated area), this is an indication that in 2013, the irrigated farms produced less than half of the rice requirements of communities within the watershed of Sta. Cruz. That is, more than 50 percent of the rice requirements within the Sta. Cruz Watershed come from outside sources.

Vulnerability of existing irrigation systems

With the potential threat of climate change, the productivity of the existing irrigation systems could be drastically reduced through infrastructure damages by extreme floods and sediments, as what Typhoon Milenyo did to the SCRIS diversion dam in 2006. Further reduction in the dependable flow of river feeding these irrigation systems will soon follow if degradation of the watershed will go on unabated by the combination of highly erosive rain and runoff coupled with the current non-sustainable farming and watershed product utilization practices.

It was pointed out above that the irrigation systems (servicing a total area of about 2,570 ha) abstracting water from the Sta. Cruz Watershed was not performing well. Based on its original or design service area, the average cropping intensity of SCRIS during the dry season is 63.5 percent and only 63.1 percent in the wet season. That means the irrigation system cannot supply water to about 47 percent of its designed service area in both cropping seasons. The major reasons for the low dry season cropping intensity include significant reduction in the dry season flow of the Sta. Cruz River and the inability of the system management to control irrigation by upstream farmers, thus denying the downstream farmers of their fair share of water. On the other hand, damages to planted rice crops due to severe flooding during the rainy days is the main culprit for the low wet season performance of the system.

Based on the FGDs, farmers also claimed that when the SCRIS diversion dam was severely damaged by Typhoon Milenyo in 2006, the system was not operational for about two cropping seasons until its reconstruction. The tremendous river flow, brought about by high intensity and prolonged rainfall, carried down volumes of sediment including big boulders, which caused the collapse and washing out of the dam structures. Uncontrolled quarrying along the river bed and sides was also cited as contributing to the weakening of the dam foundation.

WATER ADAPTATION STRATEGIES AND TECHNOLOGIES

For the specific case of the Sta. Cruz Watershed and the communities benefiting from its natural resources, super typhoons and intense and long-duration habagat are the climate change hazards identified by the representative communities and their

residents as having great impacts on their lives, livelihood (specifically agriculture), and to the environment in general. Presented below are the technologies and strategies which could help the communities in mitigating or adapting to the occurrence of severe flooding, sedimentation, and water scarcity (Laaser et al. 2009).

Protect and Enhance the Watershed's Capacity to Nurture its Water Resources

The capacity of the watershed to absorb and store rain water in its aquifers is dependent on a number of factors: kind, extent, and density of vegetation; soil properties affecting its infiltration and percolation rates; topography; and, geology. The first three factors determine the amount of rain water added to the aquifer, while geology dictates the amount of water which the aquifer could store and release by gravity. Of these factors, it is only geology which cannot be practically influenced by man. The rest could be affected in varying degrees by man's activities. The following techniques, practices, and strategies can help the watershed enhance its capacity to store rain water thereby conserving water and at the same time reduce flood waters and sedimentation problems in the downstream communities.

Protect and reforest declared forest reservation or protected areas

The upstream portion of the Sta. Cruz Watershed is within the Mount Banahaw-San Cristobal Protected Landscape (MBSCPL), which was officially declared on 11 December 2009 as a Protected Area under Republic Act No. 9847 (DENR n.d.). The MBSCPL covers an area of 11,133.30 ha within the political jurisdiction of the provinces of Laguna and Quezon. The same area had been declared in 1921 as a national park. Indeed, it should be less problematic to seriously pursue natural resources conservation and protection interventions within government-controlled lands. It is suggested that the following measures be considered:

- Identify and delineate the Sta. Cruz Watershed area that is within the MBSCPL and characterize the existing land uses for the planning of appropriate intervention measures.
- Support and pursue effective implementation of the MBSCPL Master Plan being implemented by the Protected Area Management Bureau of the (PAMB) of the DENR. The plan envisions that by the year 2020, the protected area will be a "sacred and unique place rich in biodiversity, energy, food, fresh air, water and livelihood cared for by the community in a balanced manner based on history and sustainability for the benefit of many generations to be showcased to the world." The plan should focus on the promotion of doable and sustainable livelihood-enhancing measures within the community (DENR n.d.).
- Give priority concern to the protection of the remaining 2,000 ha of forest cover within the Sta. Cruz Watershed even if these are not within the Protected Area.
- Delineate also the 1,150 ha of grassland within the watershed and consider the feasibility of pursuing its reforestation under existing programs such as the Community-Based Forest Management and National Greening programs of the government.

Promote sustainable agriculture

- Subdivide the 7,760 ha (52 percent of the watershed area) being used for agriculture into micro-watersheds or catchments for a community and for catchment-based resources development and management. A good starting point can be the catchments of the CIS within the watershed. Develop and implement conservation farm plan with the people of the community.
- Consider the feasibility of catchment-wide promotion of the following soil and water conservation (SWC) technologies and practices in the upland agricultural lands (field testing and demonstration farms may be established prior to wide-spread promotion):
 - » Sloping Agricultural Land Technologies (SALT)—the strategy of using tree legumes to control soil erosion and improve the fertility and stability of sloping agricultural lands. It is a low-cost method of upland farming developed by the Mindanao Baptist Rural Life Center (MBRLC) based in Bansalan, Davao del Sur. These are briefly defined below (Laquihon and Pagbilao 2013).
 - SALT-1—A form of alley farming where field and perennial crops are grown in bands four to five meters wide between contoured rows of leguminous trees and shrubs. The trees are thickly planted in double rows to form hedgerows.
 - SALT-2—Sloping Agro-Livestock Technology. A goat-based agro-forestry project with land use comprising 40 percent agriculture, 20 percent forestry, and 40 percent livestock
 - SALT-3—Sustainable Agroforestry Land Technology. A small-scale reforestation technology with 40 percent of the farm area devoted to agriculture and 60 percent to forestry.
 - SALT-4—Small Agro-fruit Livelihood Technology. A system of planting fruit trees and short-term crops in a 75 to 25 ratio.
 - Note: All variants utilize shrubs and tree legumes in contour hedgerows.*
 - » Promote conservation practices such as: contour cultivation and planting; crop diversification; multiple cropping; contour hedgerows; agro-forestry system; conservation tillage; terraces (bench terrace, “eyebrow” terrace, etc); and slopeland wind breaks.
 - » Promote alternative water management technologies such as rainwater harvesting and runoff impoundment ponds such as small farm reservoir (SFR) and small water impoundment (SWIP).
 - » Monitor and maintain the irrigation system; check dams along gullies and tributaries of streams; gully and check dams and plugs; runoff diversion ditch; hillside ditch; grass waterways; stone ditches and walls; stream bank stabilization (e.g., use of gabions); and artificial recharge pits (JCRR and MARDB 1997).

Establish a National Knowledge Park on Upland Natural Resources Conservation and Management

The effectiveness and significance of on-site field demonstrations of appropriate natural resources conservation and management technologies and strategies cannot be over-emphasized. It is suggested that a portion (about 500 to 1,000 hectares) of the 11,133.30 ha MBSCPL area be identified, delineated and declared as a Knowledge Park where appropriate technologies and strategies can be tested, developed and demonstrated. It could serve as a national center for research and extension and training on natural resources conservation and management.

Protect and Improve the Performance of Existing Irrigation Systems

The following mitigating and adaptive measures may help improve the performance and sustainability of the irrigation systems and avoid the disruption of rice production in the area:

- Promote and support the implementation of appropriate measures and strategies for the protection and enhancement of the watershed's capacity to nurture its water resources as presented above. Measures explained above will help recharge the aquifers and consequently increase the summer flow of the Sta. Cruz River. They will also contribute to modulating the volume of flood waters to delaying the arrival of flash floods in the flood plains. Sediments will likewise be controlled thus avoiding the choking of irrigation systems intake gates. These will eventually contribute to increasing both the dry and wet season cropping intensities of the irrigation system. There is an interrelationship between communities on the upstream part of the watershed with the downstream communities in terms of runoff behavior and water resource availability and adequacy. Thus, the manner by which upland communities manage the upper portion of the watershed will either be a boon or a bane to the lowland communities. Hence the merit for a watershed-based, interdisciplinary, and comprehensive approach to the development and management of natural resources, particularly water, will have been shown.
- Consider the feasibility of constructing “sabo dams” upstream of an irrigation system's diversion dam. This will minimize the amount of sediments and boulders which damage the dam and choke the intake structures.
- Consider the promotion of tested appropriate on-farm water management technologies when irrigation water is either limited or in excess; the Alternate Wetting and Drying (AWD) technique when irrigation water is dwindling and the use of flood-resistant crop varieties when there is too much water.
- Develop appropriate and sustainable strategies to convince and encourage farmers, especially those on the upstream of irrigation systems, to use irrigation water efficiently.
- Installation of more shallow tube wells (STW) in farms at the tail-end of the SCRIS and BRIS that frequently experience irrigation water shortages during the dry season cropping. This is one of the coping measures being practiced by farmers in San Pablo Sur which is at the tail-end of the BRIS. The tail-end farms of the SCRIS and BRIS are fortunately within shallow well areas. Groundwater, especially those within the flood plains, is less affected by a long drought as compared to rivers or streamflows and springs.

Avert the Possible Occurrence of Landslides

Stabilization of critical river banks by means of ripraps or gabions is the first and immediate defense. The long-term and sustainable measures, however, are the strategies discussed above for the protection and enhancement of the watershed's capacity to nurture its water resources. Such measures will help minimize the volume of runoff that cause the swelling of rivers and control the formation of gullies.

Control Water Quality Degradation

- An immediate measure to control surface water degradation is the strict enforcement of existing laws and ordinances on the proper treatment and disposal of waste and garbage. Disposal of garbage in or near creeks and rivers should not be allowed as this could be easily entrained by flash floods. Existing waste treatment plants near riverbanks should be relocated to higher grounds beyond the reach of extremely high river flow.
- Reduction of chemical contaminants from agricultural areas can be achieved by strictly enforcing existing protocols for their use.

Factor Climate Change in the Planning, Design, and Rehabilitation of Water Resources Project

- Climate change will decrease the return period (more frequency of occurrence) of certain hydrologic events such as rainfall and runoff or flood water. Or, for a given return period, there will be an increase in the magnitude of a certain hydrologic event. Indeed, there is a need for re-computation in the design peak runoff and dependable rainfall to be used in conducting feasibility studies, planning, design, and management of new irrigation systems and rehabilitation of existing systems.

Improve the Generation and Sharing of Climatic and Hydrological Information

- Sound management of the water resources nurtured by the Sta. Cruz Watershed is dependent to a great extent on long-term climate and hydrologic data from monitoring networks within and nearby the watershed. In addition to the PAGASA weather station in Sta. Cruz, another weather station should be installed in the upstream part of the watershed, probably in Nagcarlan. There appears to be no streamflow gauging station along the Sta. Cruz River at present. Government agencies, including government-owned and -controlled corporations (GOCCs) should be transparent in terms of basic information needed for better management and policy formulation.
- “Better access to information and transparency of its use for more rational decision-making. As most decisions on water would have to be made at the basin and local levels, accurate, consistent, timely, and relevant information about water and climate needs to be widely available. Information and knowledge for local adaptation must be improved and considered a public good to be shared at all levels. Better information, communication and public awareness—reinforced by the right incentives and sanctions—are required to produce changes in the behavior of water users and consumers” (UN Water 2010).

POLICY AND GOVERNANCE ISSUES

The successful implementation of the identified adaptation measures is highly dependent on the adequacy of appropriate policies and effective governance. The influence of social and political factors (i.e., social relations and processes, capabilities,

power, and interest) cannot be ignored. In the case of the Sta. Cruz Watershed and Basin, the challenge lies in getting stakeholders to contribute resources for the protection and conservation of the watershed resources (e.g., Laguna de Bay) for its sustainability both from operational and policy perspectives.

The Sta. Cruz Watershed is one of the 21 subwatersheds of the Laguna de Bay Basin. In the policy-making and regulatory arena, the Laguna Lake Development Authority (LLDA) is the primary institution that exercises policy, regulatory, and developmental functions covering the entire lake and its watershed (Nepomuceno 2010). Based on a review of the LLDA-related policies and programs, reports and CLUPs of local government units (LGUs) inside the Sta. Cruz Watershed, as well as KIIs, the issues arising in relation to the watershed governance system include the following:

- Based on the delineation of watershed boundary, the Sta. Cruz Watershed does not cover the whole area of the municipalities as shown in table 3.1 (e.g., portions of Majayjay and Magdalena lie within the Pagsanjan Subwatershed). This complicates comprehensive watershed planning of LGUs.
 - » There are no explicit policies and programs at the watershed scale, usually at the LGU level.
 - » Each LGU municipality has its own policies and programs on food security, e.g., Sta. Cruz and Rizal have a food security components in their CLUP;
 - » Each LGU municipality has its own policies and programs on climate change but is not expressly from a food security perspective, e.g., Nagcarlan and Rizal have mainstreamed climate change adaptation in their plans and programs;
 - » Climate change-related actions are in compliance with national policies, e.g., the Climate Change Act and Disaster Risk Reduction and Management (DRRM) Act. This includes putting up Municipal DRRM Office and the installation of a rain gauge.
- There are limited institutional arrangements among LGUs on food security and climate change programs at the watershed level. Memoranda of Agreement among government agencies should be clear on institutional coordination. For example, the case involving Majayjay, Nagcarlan, and Liliw municipalities to address the issue of cutting coconut trees was not resolved because issuing the permit to cut trees is the role of the Department of Environment and Natural Resources (DENR) while coconut planting is a program of the Department of Agriculture (DA). In another case, Nagcarlan has linkages with NGOs on sustainable farming practices. Agriculture programs and projects focus on farmers' training and seed distribution while watershed conservation is generally focused on tree planting. Municipal ordinances usually cover solid waste management, tree planting and deforestation.

To avoid conflicts with the National Irrigation Administration (NIA), it is a policy under the Small Scale Irrigation Program of the Department of Agriculture (DA) that no irrigation system be installed within the service area of NIS. As such, farmers within the tail-end of some NIS with an inadequate water supply during the dry season could not avail STWs from the DA.

SUMMARY AND CONCLUSION

This study aimed to explain the water and food security-environment interactions in a dynamic setting brought about by climate change. Focusing on the Sta. Cruz Watershed, the study had the end goal of identifying water adaptation measures and policy recommendations that could minimize the adverse effects of climate change and improve the welfare of communities. Based on available secondary information, focused group discussions, key informant interviews and field ocular inspections, an indicative assessment was made of the watershed's water resources conditions and water supply utilization, and manifestations of climate change and potential impacts of climate change on water resources and crop production. Water adaptation strategies and technologies to minimize the potential impacts of climate change were identified, including policy recommendations for their implementation.

The average annual rainfall in Nagcarlan, a high elevation barangay, is 2,297 mm, while that in Sta. Cruz (low elevation) is 1,596 mm. Nationwide, it is about 2,400 mm. The watershed is endowed with several springs, rivers, and moderately good aquifers in the flood plains. A moderately good aquifer could be defined as a geologic formation dominated by silt with sand and gravel, where sand is good to excellent and clay is poor. Springs are the main sources of the domestic water supply in the mid- and high elevation communities. Rivers supply irrigation water to CIS in the mid elevation farms, and to NIS in the low elevation farms. In addition, some farms in the flood plains abstract irrigation water from underground, through shallow tube wells. Deep wells are the major source of domestic water supply in the low elevation communities. Roughly, close to 80 percent of the water abstracted from the Sta. Cruz Subwatershed goes to agriculture through the irrigation systems (CIS, NIS, and STWs). NIA data and farmers' complaints indicate that these systems, in general, are not irrigating their original designed service areas due to the decreasing dependable flows of the rivers and the inefficient use of irrigation water.

Based on historical records of climate-related damages to agriculture, the local people's experiences, and rainfall data analysis, the increasing frequency of strong typhoons and intense habagat affect the study area. This claim was somewhat validated by a simple analysis of the 19-year (1994–2012) rainfall data from the PAGASA weather station in Sta. Cruz, Laguna. The results have shown a pronounced increase in the average monthly rainfall for the last nine years (2004–2014) compared with the previous decade (1994–2003). Plotting the maximum daily rainfall per year in a Log-Probability graphing paper, the return period of a given maximum daily rainfall count decreased from 10 years in the previous decade to just two years in the last decade. And for a given return period, the expected maximum daily rainfall was higher in the last decade by about 24 percent. These could be an initial quantification of the impact of climate change on the water sector.

With the generally degraded conditions of the Sta. Cruz Watershed and the prevalent non-sustainable farming practices, extremely high rainfall intensity could cause severe and widespread soil erosion; this will not only decrease the productivity of the lands, it will also create more runoff and sedimentation problems. Erosion also causes the reduced recharge of the aquifers, which eventually lead to water scarcity affecting crop productivity. Based on the present performance of existing irrigation systems, the rice self-sufficiency level of communities within the watershed was estimated at 46.45 percent for 2013. With the threat posed by extreme climatic events to the existing irrigation systems, there is very little assurance of having enough rice supply in the market at any time of the year.

Averting this grim scenario includes the following “no-regrets” adaptation measures: the protection and enhancement of the watershed’s capacity to nurture its water resources through the protection and reforestation of declared forest reservation or protected areas, the promotion of sustainable agriculture mainly through the enforcement of conservation farming technologies in sloping agricultural lands, the establishment of a National Knowledge Park on Upland Natural Resources Conservation and Management within the Mount Banahaw-San Cristobal Protected Landscape (MBSCPL); the improvement of the performance of existing irrigation systems; the modification of policy plans and design to factor in climate change, underscoring projects for the rehabilitation of water resources; and the improvement in the generation and sharing of climate and hydrologic information.

For the effective and timely implementation of the above measures, the LGUs, being mandated as frontline agencies for addressing issues on climate change, should undergo more intensive “education” on climate change so that they are able to pass needed relevant resolutions and executive orders. Policy and institutional concerns would include the following: strengthening the river councils; promoting and supporting the implementation of the existing Mount Banahaw-San Cristobal Protected Landscape; creating policies to encourage adoption of soil and water conservation technologies; creating economic/financial schemes for farmers to cope with impacts of climate change-related events; and forming policies and programs on livelihood to improve household resilience.

POLICY RECOMMENDATION

Improving the system of governance at a watershed level with a consideration for shielding food security from impacts of climate change should take the following policy and institutional propositions into consideration:

- Create a massive educational campaign on the issue of climate change starting with the Sangguniang Panlalawigan and concerned units of the province, then to the municipalities and barangays. The Sangguniang Pambayan will pass needed resolutions and the Governor will issue executive orders for the adoption of policies and strategies, their institutionalization, and the provision of financial resources to strengthen the municipalities against the impacts of climate change.
- Fast track the creation of DRRM offices and integrate and institutionalize climate change adaptation and DRRM planning at the watershed level and address trans-boundary impacts from climate-related risks and other disasters.
- Enhance institutional partnerships through institution building, public-private partnerships, and watershed conferences and summits.
- Strictly enforce the regulatory system on development activities in the watershed
- Formulate and enhance policies on soil and water governance in response to food security, livelihood, and climate change adaptation.
- Support the implementation of the MBSCPL Master Plan coordinated by the PAMB of the DENR.
- Create policies to promote better/improved agricultural drought and flood management, cropping patterns and crop varieties suited to drought and flood conditions such as the use of an early warning system.

- Formulate a national policy for the NIA to delineate areas within NIS service area that could not normally be supplied by the system during the dry season so as to allow the concerned farmers to avail other irrigation facilities such as STW's from the DA or from non-government organizations. However, no irrigation fees should be charged to such farms.
- Create economic and financial schemes for farmers to cope with impacts of climate change-related events.
- Create policies and programs on livelihood to improve household resilience/ food security.
- Formulate policies that give the public access to basic information, such as climate and hydrologic data gathered through the use of government funds; authorize LGUs to require private entities that monitor climate and hydrologic data in their political jurisdiction to provide them with such data.

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CHAPTER 4

FOOD SECURITY IMPLICATIONS OF CHANGES IN CROPPING SYSTEMS DUE TO CLIMATE CHANGE

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AND RAEM DOMINIC BRION

Crops grown in all elevations were exposed to two closely related climate hazards: typhoon and flooding. In the low elevation areas (10-20 meters above sea level or masl), annual crops like rice and vegetables were at higher risks due to flooding. Submergence of annual crops for more than five days can result in a high yield reduction or even total crop loss. In the medium (20-470 masl), and high (above 480 masl) elevation areas, typhoons with strong winds are of greater concern. This causes “lodging” of annual crops and felling of perennial crops. In most cases, perennial crops like coconut, lanzones and rambutan might withstand typhoons, but there may be a tremendous reduction in their yields and it may take them a longer time to recover. Frequent felling of fruit trees and slow replanting can eventually cause a reduction in the tree population.

Changes in temperature and rainfall patterns tend to influence rice black bug infestations in the low and medium elevation areas and coconut scale insect infestations in the medium and high elevation areas. Fruiting pattern has also been inconsistent due to changes in rainfall patterns. Crops grown and cropping patterns have remained the same for the past 20 years but modern varieties have now also been widely adopted.

It is evident in the three elevation areas that typhoons and heavy rains increase the potential for soil erosion and reduced soil quality leading to lower agricultural productivity, which can have a negative impact on food security.

Farmers in the watershed continue to experience crop losses due to climate hazards but have yet to develop effective adaptation measures to reduce the negative effects of these hazards, particularly the typhoons and flooding that occur in the low and medium elevation areas. Adaptation strategies that will allow rice to withstand flooding, reduce soil erosion in the higher elevation areas, maintain soil productivity over time, and contribute to the resilience of cropping systems should be introduced so that farmers can respond to the challenges of climate change and food security.

Keywords: climate change, agricultural systems, food security, soil erosion

INTRODUCTION

It is widely recognized among researchers and stakeholders that anthropogenic activities are responsible for the observed and projected climate change (Eggleston et al. 2006; Ramanathan and Xu 2010). US Secretary of Agriculture Tom Vilsack has reported that “climate change is one of the greatest threats facing our planet” (USDA NRCS 2010). Several scientists have reported on the connection between climate change, soil and water resources, and population growth, and have noted that these issues will pose severe challenges that can potentially impact on food security (Montgomery 2007; Lal 2002; Verdin et al. 2005; Bryan et al. 2009; Morton 2007). According to Godfray et al. (2010), feeding the increasing population will also be a challenge. Implementing management decisions that maximize agricultural production and increase yields while conserving soil and water quality along with mitigating and/or adapting to climate change will be important in helping address this century’s emerging food security issues. Management decisions, both on and off the field, have the potential to contribute to climate change mitigation and adaptation. For example, management decisions about soil C, an element that is tied to soil quality functions (Doran and Jones 1996), can contribute to conservation and C sequestration. Additionally, N management, which considers the N cycle and the potential to reduce direct and indirect emissions of nitrous oxide (N_2O), can also contribute to climate change mitigation and adaptation. Sustainable land management and efforts to restore degraded lands can also contribute to climate change mitigation and adaptation.

For whatever agricultural system, the best management decisions for maximizing conservation and mitigating and adapting to climate change while considering the site-specific situation need to be applied. It is important to stress good management practices, not only for the specific activities that may be employed by the farmers or managers but also more generally for the decision-making process that managers must go through as they determine what methods are best suited for the conditions specific to their sites or fields.

It is widely understood that land degradation is reducing the productive capacities of croplands, rangelands and woodlands during a time of rising demand for food, fiber, fuel, freshwater, fodder, household energy and income. As stated by Food and Agriculture Organization (2009): “Whether the problem is expressed as soil or forest loss, reduced water availability, or poor yields on tired soil, such impoverishment of the land is being driven by inefficient or unsustainable land management practices, and inappropriate or competing land uses. Human activities are compromising natural processes and this dynamic is being further amplified by increasing climate variability.”

This study aims to explain the food security-environment interactions in a dynamic setting brought about by climate change, with its focus on the Sta. Cruz Watershed. In particular, this study seeks to:

1. describe the climate hazards confronting the watershed at the different elevation classes;
2. describe the agricultural systems practices in the watershed;
3. examine the changes in the agricultural systems in the last 20 years that were the result of the climate hazards;
4. determine the impacts of the climate hazards on the agricultural performance; and
5. examine the adaptation measures implemented by the farmers in the watershed

Toward this end, the results and findings of this study are meant to provide policy implications for improving the resilience of the agricultural systems and improved food security of farm households.

AGRICULTURAL SYSTEMS IN THE STUDY SITES

Low Elevation Area

Crops and Cropping Patterns

The low elevation areas in both Barangay San Pablo Sur and Barangay Patimbao are practically lowland rice areas with a small portion used for coconut and fruit trees. Around 90 percent of the respondents in both sites plant rice. The others are raising swine. Rice is continuously planted all year round. Some farmers plant watermelon or eggplant after the first rice crop. The time of rice planting is dependent on the availability of irrigation water, which is provided by the irrigators' association. The first rice crop is usually planted in June or July and harvested in October or November while the second rice crop in December or January (figure 4.1).

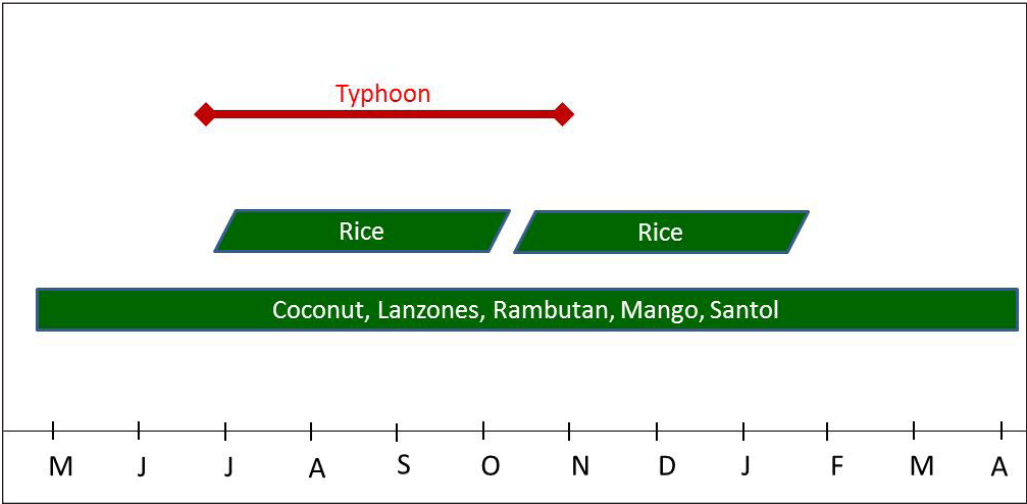


Figure 4.1. Seasonal cropping and climate hazard calendar in the low elevation area

Variety Use

The rice varieties used in the irrigated lowland ecosystem for the dry and wet seasons are modern varieties. In general, the modern varieties adopted by farmers are high yielding and are consistently tender when cooked and have a good taste. Among the modern rice varieties grown, NSIC RC 222 is the most preferred due to its high yielding characteristics. Interestingly, PSBRC 1, Makiling, an upland variety, is planted by farmers in the low, medium and high elevation areas; it has lower yields compared to the other lowland varieties but is believed to be more stable in normal and extreme conditions. For irrigated lowland rice, varieties used are limited to those that are distributed through the LGUs. Other farmers access seeds from seed growers and private seed companies, especially for hybrid rice varieties.

Soil Management

All respondents in both sites use fertilizers for their crops during the dry and wet seasons. The most common fertilizers used in the planting of rice are urea, complete 14-14-14 and ammonium sulfate. Only a few are using organic fertilizers mostly during the wet season. The fertilizers are mostly applied through the broadcast method.

Sensitivity to Climate Hazards

Typhoons can cause damage to the crops when there is high wind velocity, high rainfall intensity, and flooding. Depending on the gustiness of the typhoon, high wind velocity can destroy both annual and perennial crops. Rice, as a crop, is sensitive to typhoons, winds and rains, which cause rice plants to lodge. Lodging and felling of annual crops cause yield reductions or total yield loss due to submergence. During the focus group discussion, the farmers estimated a reduction in the yield of around 51-100 percent in Barangay San Pablo Sur and 30 percent in Barangay Patimbao. A black bug infestation in the area also caused around 65 percent reduction in yield.

Productivity Levels

Rice yields in Barangay Patimbao are higher than that of Barangay San Pablo. There is also a yield difference during the wet and dry seasons. Average rice yield was 7.52t/ha in Barangay Patimbao and 4.56t/ha in Barangay San Pablo Sur (table 4.1). This could be attributed to the frequent flooding during the wet season in Barangay San Pablo. Consequently, the income of farmers in Barangay Patimbao is higher by 100 percent and 133 percent in the dry and wet season, respectively, than the income of Barangay San Pablo Sur.

Table 4.1. Yields and estimated net income of farmers in the low elevation area

Particulars	San Pablo Sur		Patimbao		Sig.	
	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Yield (t/ha)	3.39 (9)	4.56 (7)	4.75 (13)	7.52 (25)	NS	NS
Estimated net income (PHP)	29,571 (7)	23,623 (7)	69,000 (20)	47,250 (20)	-	NS

Medium Elevation Area

Crops and Cropping Patterns

The farmers in the medium elevation areas grow various crops. They grow crops that are adapted to and grown in both the low and high elevation areas. The major crops planted include rice, vegetables, fruit trees, banana and coconut. The cropping patterns in the medium elevation areas are shown in figure 4.2. Rice is planted once a year and is followed by upland crops like corn and vegetables. Corn is planted twice a year and is followed by cassava. The coconut areas are usually intercropped with lanzones or rambutan.

Variety Use

In medium elevation areas, 12 modern rice varieties, including hybrid rice varieties and three traditional varieties (in Barangay Calumpang), are planted. They also grow vegetables, lanzones, banana, and coconut. D max (tomato) and Galaxy (ampalaya) are the most commonly grown vegetable varieties by most farmers.

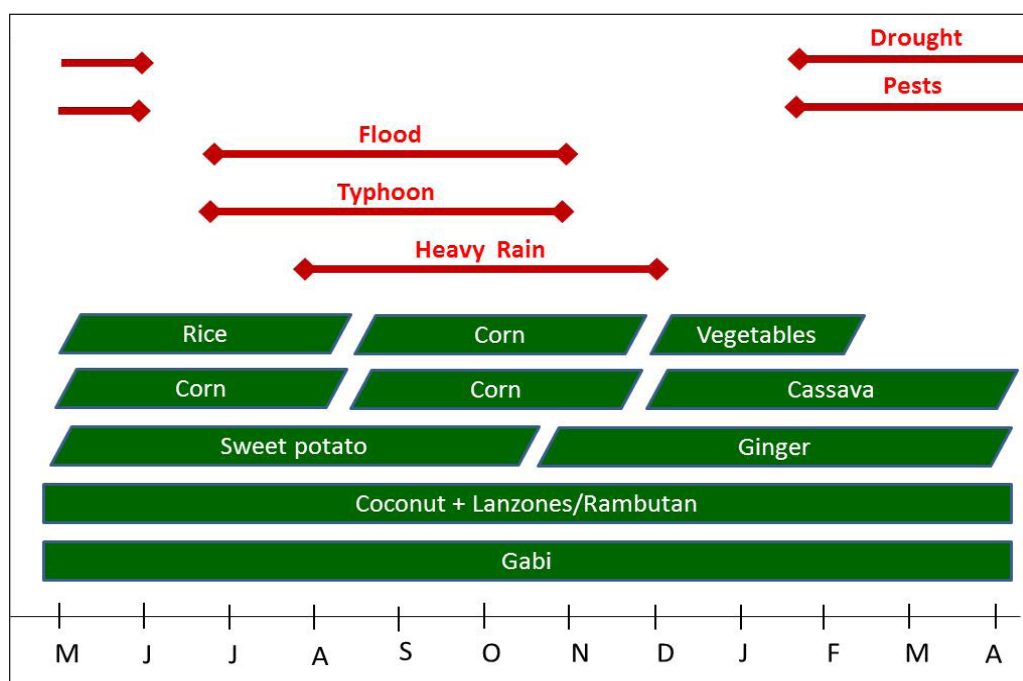


Figure 4.2. Seasonal cropping and climate hazard calendar in the medium elevation area

Soil Management

Rice

In Barangay Calumpang, most of the respondents use urea (50 percent) and complete 14-14-14 fertilizers (34 percent) during both dry and wet seasons. Other inorganic fertilizers applied include ammonium sulfate (8 percent during DS and 10 percent during WS) and ammonium phosphate (6 percent). Only 2 percent of the farmers apply organic fertilizers during the DS. These fertilizers are generally applied by the broadcast method. About 7 percent of the farmers apply foliar fertilizers during the DS and WS. In the Barangay Bungkol site, 44 percent of the farmers use urea, 29 percent use ammonium sulfate and 9 percent use complete fertilizers during both wet and dry seasons, which are applied by broadcasting.

Tomato

The respondents in Barangay Calumpang use urea only while farmers in Barangay Bungkol use urea, ammonium sulfate, complete and organic fertilizers. In both sites, fertilizers are applied by the broadcast method.

Bitter gourd

Only urea is applied by farmers in Barangay Calumpang while farmers in Barangay Bungkol use urea, ammonium sulfate, complete and organic fertilizers. Fertilizers are applied by broadcasting in both sites. In Barangay Calumpang, farmers apply fertilizers using the broadcast method while farmers in Barangay Bungkol use the broadcast, side-dress and foliar methods.

Eggplant

The farmers in Barangay Bungkol use urea, ammonium sulfate, complete and organic fertilizers. These are applied via the broadcast and side-dress methods.

Sensitivity to Climate Hazards

Almost all crops in the medium elevation areas are sensitive to typhoons. Depending on the strength of the typhoon, it may damage the lanzones, coconut palms, and banana and destroy vegetable crops. In general, perennial crops like coconut and lanzones can withstand strong winds brought about by typhoons. However, a considerable reduction in yield for these fruit crops has been observed. Furthermore, recovery time for these fruit-bearing trees would usually take around two to three years. Once felled, the reestablishment of these crops would entail high costs and will take a longer period to bear fruit. In both Barangay Bungkol and Barangay Calumpang, damage due to typhoons was estimated to range from 25 percent to 100 percent for vegetables and lanzones.

The recent attack of coconut scale insects (CSI) has become a concern of farmers in both sites. CSI is considered an emerging pest afflicting coconut trees. In the CALABARZON area, CSI devastated some 1.2 million coconut palms.

Productivity Levels

Rice yields in the medium elevation area are generally lower than those in the low elevation area (table 4.2). Yields of common vegetables, tomato, and beans are not significantly different between the two sites. Estimated net income is relatively higher in Barangay Calumpang but was not significantly different from that of the Barangay Bungkol site.

Table 4.2. Yields and estimated net income in the medium elevation area

Yield (t/ha)/ Income PHP)	Bungkol		Calumpang		Sig.	
	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Rice	2.50 (1)	2.50 (9)	3.04 (4)	3.22 (21)	NS	NS
Tomato	0.90 (3)	5.00 (1)	7.5 (1)	0.08 (1)	NS	NS
Beans		0.03 (1)		0.08 (1)		NS
Estimated net income (PHP)	33,927 (22)		43,592 (26)			

High Elevation Area

Crops and Cropping Patterns

In general, more crop species are planted in Barangay San Francisco than in Barangay Bucal. The most common crops planted in both sites are tomato, radish, beans, and cucumber. Other crops grown include cabbage, cassava, sweet potato, chayote, and mustard. There are no definite planting months for the vegetables; they are planted at the times of the year when rainfall permits, which is during the wet season.

Based on findings made from ocular observations and community mapping activities made during the focus group discussion, coconut was observed to occupy a greater land area in both sites. This observation, however, was not reflected in the survey since most of the respondents only considered the annual crops planted. Aside from coconut, other perennial crops observed were lanzones and rambutan, which are usually planted under the coconut (figure 4.3).

Variety Use

Farmers usually obtain some of the varieties of major vegetable crops from seed companies. Examples are Dmax or Diamante for tomato, Negrostar and Brillante for beans, Suprema for squash, Galaxy for bitter gourd, among others. Traditional varieties of chayote, sweet potato, taro are also planted and planting materials are taken from the previous harvest of the crops.

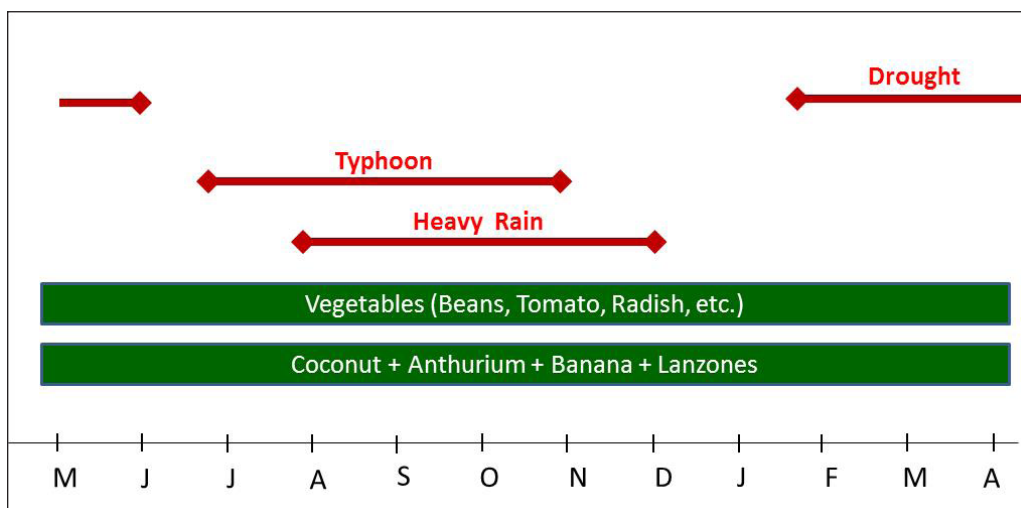


Figure 4.3. Seasonal cropping and climate hazard calendar in the high elevation area

Soil Management

Rice

In Barangay Bucal, most of the respondents use urea (67 percent) and other fertilizers (33 percent) in both dry and wet seasons. These fertilizers are generally applied using the broadcast method. In Barangay San Francisco, 50 percent of the respondents use urea, 17 percent use ammonium sulfate and 33 percent use complete fertilizers during both wet and dry seasons, which are applied by broadcasting.

Tomato

About 59 percent of the respondents in Barangay Bucal apply urea, 15 percent apply complete fertilizer, 7 percent ammonium sulfate, 7 percent ammonium phosphate and 11 percent organic. These fertilizers are generally added through broadcast and side-dress applications. In Barangay San Francisco, majority of the respondents (58 percent) applies urea, 17 percent complete, 8 percent ammonium sulfate and 17 percent organic. These fertilizers are generally applied by the broadcast and side-dress methods.

Beans

Majority of the respondents (65 percent) in Barangay Bucal apply urea, 11 percent complete, 8 percent ammonium phosphate and 15 percent organic. The methods of application include broadcast (76 percent), side-dress (12 percent) and foliar (6 percent). In Barangay San Francisco, 53 percent of farmers use urea, 12 percent ammonium sulfate, 18 percent complete and 18 percent organic fertilizers. Fertilizers are applied by the broadcast (60 percent), drill (20 percent) and side dress (20 percent) methods.

Radish

The respondents in Barangay Bucal use urea (57 percent), ammonium sulfate (21 percent), complete (14 percent) and organic fertilizers (7 percent) and 73 percent of them apply by the broadcast and 27 percent by the side-dress methods. In Barangay San Francisco, 57 percent use urea, 21 percent use ammonium sulfate, 2 percent use complete and 1 percent use organic fertilizer. Majority of the farmers (78 percent) apply by broadcasting and 22 percent use the drill method.

Cucumber

Majority of the respondents (54 percent) in Barangay Bucal apply urea, 8 percent ammonium sulfate and 38 percent organic. The methods of application include broadcast (38 percent), side-dress (38 percent) and foliar (25 percent). In Barangay San Francisco, 40 percent of farmers use urea, 20 percent ammonium sulfate, 20 percent complete and 20 percent organic fertilizers. Fertilizers are applied by broadcasting (50 percent), drilling (38 percent) and side-dressing (12 percent).

Sensitivity to Climate Hazards

In general, the crops grown in high elevation areas are similar to the crops grown in the medium elevation areas. Hence, the four barangays have similar sensitivities to the climate hazards. Typhoons, especially if accompanied by strong winds, can cause the lodging of vegetable crops and the felling of perennial crops like lanzones, coconut palms, and banana. Perennial crops like coconut and lanzones can withstand strong winds but a considerable yield reduction has been observed. Recovery period of perennial crops is two to three years. The rejuvenation of felled trees entails additional costs and causes a delay in fruit bearing.

Infestation of coconut scale insects (CSI) is a threat to coconut trees; this has been felt in the high elevation areas but is not as severe as the infestation in the low and medium elevation areas.

Productivity Levels

Except for radish, the yields of crops grown in the wet season are not significantly different between the two sites. Barangay San Francisco has a significantly higher radish yield in the wet season than Barangay Bucal (table 4.3). Estimated net income is higher in Barangay San Francisco but was not significantly different from that of Barangay Bucal.

Table 4.3. Yields of major crops and estimated net income in high elevation area

Yield (t/ha)/ Income (PHP)	Bucal		San Francisco		Sig.	
	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Tomato	1.22 (4)	1.22 (11)	1.70 (7)	1.96 (7)	NS	NS
Beans	1.03 (5)	0.96 (12)	4.07 (2)	1.04 (4)	NS	NS
Radish	0.93 (3)	0.65 (8)	2.52 (4)	3.21 (7)	NS	*
Cucumber	1.10 (3)	1.40 (3)	3.17 (3)	1.00 (3)	NS	NS
Estimated net income (PHP)	39,950 (22)		67,455 (24)		NS	

CHANGES IN THE AGRICULTURAL SYSTEMS DUE TO CLIMATE CHANGE

Low Elevation Area

Changes in Crops and Cropping Patterns

There has only been a little change in the kinds of crops being planted in the current years from the crops grown in the past 20 years. Rice is still the most common crop planted though most farmers now grow modern rice varieties. They also grow upland crops like watermelon and eggplant in Barangay San Pablo Sur. In Barangay Patimbao, a coconut area was converted into a rice area. Reasons for the change in crops planted were climate change, pest/disease outbreak, and the availability of planting materials (table 4.4).

The continuous planting of rice is still the dominant cropping pattern in both study sites in the low elevation areas. As light change was reported with the decline in the planting of upland crops after rice. The reasons cited for which are climate change (table 4.5).

For both study sites, planting months for rice remain the same, i.e., November to January for the dry season and July-August for the wet season (table 4.6). Only a few have changed their planting months and majority of the reasons cited are climate change related.

Table 4.4. Changes in the crops planted in the past 20 years in the low elevation area

San Pablo Sur			Patimbao		
Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Rice – 8	Rice – 5	- Climate change (1) - Disease/pest outbreak (1)	Rice – 19	Rice - 16	Availability of planting materials (1)
	Watermelon – 2		Coconut - 1		
	Eggplant – 1				

Table 4.5. Changes in the cropping patterns in the past 20 years in the low elevation area

San Pablo Sur			Patimbao		
Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Rice – rice (6)	Rice – rice (4)	- Continuous drought (2) - Climate change (1) - Pest infestation (1)	Rice – rice (19)	Rice – rice (18)	Continuous drought (1)
Rice + upland crops (1)	Rice – upland crops (3)		Coconut + upland crops (1)		

Table 4.6. Changes in the planting months in the low elevation area

Month	San Pablo Sur			Patimbao		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
January	3 (13.6)	2 (9.5)	• Availability of inputs (3) • Climate change (3) • Continuous drought (2) • Pest infestation (1)	3 (7.0)	4 (11.8)	• Climate change (6) • Continuous drought (6) • Availability of inputs (5) • Others (1)
February	1 (4.5)	2 (9.5)		1 (2.3)	1 (2.9)	
March		-		-	1 (2.9)	
May	1 (4.5)	1 (4.8)		-	2 (5.9)	
June	1 (4.5)	2 (9.5)		4 (9.3)	2 (5.9)	
July	4 (18.2)	2 (9.5)		14 (32.6)	10 (29.4)	
August	4 (18.2)	3 (14.3)		5 (11.6)	2 (5.9)	
September	1 (4.5)	-		-	1 (2.9)	
October	-	-		-	1 (2.9)	
November	3 (13.6)	6 (28.6)		-	-	
December	4 (18.2)	3 (14.3)		16 (37.2)	10 (29.4)	

Changes in the Use of Variety

The varieties of rice crops being planted have changed since the past 20 years. Traditional rice varieties are no longer used. The reasons for the change in the variety used are similar for both study sites, i.e., availability of seeds, and a higher yield from the modern varieties (table 4.7). Only a few mentioned climate change as the reason for the change.

Table 4.7. Reasons for the change in varieties in the low elevation area

Reason	San Pablo Sur		Patimbao	
	Freq	%	Freq	%
Seed availability	3	16.7	13	28.9
For higher yield	6	33.3	12	26.7
Pest infestation	2	11.1	7	15.6
For higher income	-	-	5	11.1
Imitate other farmers	3	16.7	4	8.9
Climate change	1	5.6	2	4.4
DA endorsement/Advice of technician	2	11.1	1	2.2
Soil suitability	-	-	1	2.2
For higher income	1	5.6	-	-
Total	18	100.0	45	100.0

Changes in Soil Characteristics and Management

Farmers' perceptions on the rate at which soil dries in the current years compared with the past 20 years generally shows a shift from "dries slowly" or "less quickly" to "dries quickly" or "more quickly" in the current years for both sites (table 4.8). The reasons cited for the change were related to climate change and soil characteristics, i.e. very high temperature and low water holding capacity. Some attributed the change to irrigation patterns.

Although their farms are located in the low elevation areas, the respondents still indicated that soil erosion occurs in their places; they have observed sediments being carried by water during periods of high rainfall. Generally though, there were more respondents in both sites who perceived “no erosion” or “low erosion” in both the past and the current years but there were more respondents who perceived “no erosion” in the past 20 years (table 4.9).

Table 4.8. Farmers’ perceptions on the changes on the rate at which soil dries in the low elevation area

Characteristics	San Pablo Sur			Patimbao		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Dries more quickly	0	0	▪ Very high temperature (4)	14	6	▪ Very high temperature (15) ▪ Irrigation patterns (3) ▪ Low water holding capacity (2)
Dries quickly	3	0		5	5	
Dries less quickly	0	3		3	9	
Dries slowly	4	4		1	3	
Total	7	7		23	23	

Table 4.9. Farmers’ perception on the changes on the rate of soil erosion in the low elevation area

Rate of soil erosion	San Pablo Sur			Patimbao		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
No erosion	4	5	▪ Heavy rain (2) ▪ Steep slope (1)	13	18	▪ Heavy rain (12)
Low erosion	2	1		9	4	
Moderate erosion	1	2		1	-	
High erosion	-	-		1	1	
Total	7	8		24	23	

With regard to the relative soil fertility status, more respondents perceived a moderate to high fertility status in the past 20 years and more perceived a low fertility status in the current years. This indicates a decline in the relative soil fertility from the past 20 years (table 4.10). The major reasons cited for the change are continuous cropping and non-application of fertilizer. Only a few cited soil erosion and climate change as the reasons.

No noticeable change in the kind of fertilizer used was noted. Urea and complete fertilizer are still the most common fertilizers used (table 4.11). Other respondents answered the brand of the fertilizer rather than the kind so this was left out of the tabulation.

Most of the respondents claimed that they used a lesser amount of fertilizer in the current years compared to the past 20 years and a considerable number claimed that they applied the same amount as before. The common reason cited was low soil fertility (table 4.12).

Table 4.10. Farmers' perception on the changes in the soil fertility status in the low elevation area

Soil fertility status	San Pablo Sur			Patimbao		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Low fertility	5	0	- Continuous cropping (5) - Non-application of fertilizer (3)	13	3	- Continuous cropping (15) - Non-application of fertilizer (6) - Climate change (2) - Soil erosion (1)
Moderate fertility	1	3		8	11	
High Fertility	1	3		2	9	
Total	7	6		23	23	

Table 4.11. Farmers' observation on the changes in the kind of fertilizer used in the low elevation area

Kind of Fertilizer	San Pablo Sur			Patimbao		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Urea	6	4	- Effectiveness (3) - Low soil fertility (2) - Climate change (1)	23	22	- Effectiveness (8) - Low soil fertility (5) - Availability (1)
Ammosul	1	1		5	3	
Complete 14-14-14	1			14	12	
Organic	-	-		1	1	
Others		5		-	-	
Total	8			43	38	

Table 4.12. Farmers observation on the amount of fertilizer used in the low elevation area

Amount of fertilizer used	San Pablo Sur			Patimbao		
	Freq	%	Reason(s) for the Change	Freq	%	Reason(s) for the Change
Less amount	6	75.0	- Low soil fertility (4) - Availability (1) - Climate change (1)	18	72.0	- Low soil fertility (15) - Effectiveness (3) - High price of fertilizer (1) - Availability (2)
More amount	1	12.5		-	-	
Same amount	1	12.5		7	28.0	
Total	8	100.0		25	100.0	

Effects of the Changes in the Agricultural Systems on Crop Production

Majority of the farmers in both sites claimed that they obtain the same crop yields even with the changes in agricultural systems (table 4.13).

Despite being continually subjected to the effects of hazardous climatic events, only a few of the farmers are implementing adaptation measures (table 4.14).

Table 4.13. Farmers' perceived effects of the changes in agricultural systems on crop production in the low elevation area

Effects	San Pablo Sur		Patimbao	
	Freq	%	Freq	%
Increase	1	20.0	2	22.2
Decrease	0	0	1	11.1
Same yield	4	80.0	6	66.7
Total	5	100.0	9	100.0

Table 4.14. Farmers' adaptation measures for different climate hazards in the low elevation area

Adaptation Measures	San Pablo Sur		Patimbao	
	Freq	%	Freq	%
Typhoon				
Pruning	2	50.0	-	-
Use of early maturing varieties	1	25.0	-	-
Early harvesting	-	-	6	100.0
Monsoon rains				
Early harvesting	0	-	2	100.0
Pruning	1	50.0	0	-
Use of early maturing varieties	1	50.0	0	-
Pest infestation				
Propping	5	100.0	7	100.0

Medium Elevation Areas

Changes in Crops Planted and Cropping Patterns

A greater number of crop species was planted in the current years than in the past 20 years for both sites. However, the number of farmers in Barangay Bungkol who are now planting rice has increased since the past 20 years while the number in Barangay Calumpang remains almost the same (table 4.15). The reasons cited for those who have switched crops are climate change, unavailability of planting materials, and a high market demand for the crop being planted.

Cropping patterns followed by farmers have remained the same for the past 20 years. Monoculture of rice remains the most dominant cropping pattern in both sites (table 4.16).

The planting months in Barangay Calumpang are the same as those in the current years compared to the past 20 years, e.g. in the months of May and December (table 4.17). For Barangay Bungkol, no definite planting months have been established for the past 20 years.

Table 4.15. Changes in the crops planted in the medium elevation area

Bungkol			Calumpang		
Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
▪ Rice (11) ▪ Coconut(4) ▪ Bitter gourd (4) ▪ Beans (3) ▪ Tomato (3) ▪ Eggplant (1) ▪ Radish (1) ▪ Papaya (1) ▪ Cucumber (1)	▪ Rice (6) ▪ Bitter gourd (4) ▪ Beans (2) ▪ Tomato (2) ▪ Cabbage (1)	▪ Change in Climate (2) ▪ Availability of planting materials (1)	▪ Rice (17) ▪ Coconut (2) ▪ Tomato (1) ▪ Beans (1) ▪ Bitter gourd (1) ▪ Pechay (1) ▪ Sweet potato (1)	▪ Rice (19) ▪ Tomato (1) ▪ Beans (1) ▪ Bitter gourd (1) ▪ Corn (1)	▪ Higher income (2) ▪ Change in Climate (1) ▪ High market demand (1)

Table 4.16. Changes in the cropping patterns in the medium elevation area

Bungkol			Calumpang		
Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Monoculture (9)	Monoculture (9)	▪ Soil fertility (1) ▪ Rotational Cropping (0) ▪ Intercropping (0) ▪ Multiple cropping (1)	Monoculture (18)	Monoculture (18)	
Rotational Cropping (3)	Rotational Cropping (3)		Rotational Cropping (0)	Rotational Cropping (0)	
Intercropping (3)	Intercropping (2)		Intercropping (0)	Intercropping (0)	
Multiple cropping (1)	Multiple cropping (0)		Multiple cropping (1)	Multiple cropping (1)	

Table 4.17. Changes in the planting months in the medium elevation area

Month	Bungkol			Calumpang		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
January	-	2 (12.5)	▪ Availability of inputs (6) ▪ Climate change (5) ▪ Pest infestation (2) ▪ Soil fertility (1) ▪ Heavy rains (1)	-	1 (2.6)	▪ Availability of inputs (5) ▪ Climate change (5)
February	-	-		-	2 (5.1)	
March	5 (20.0)	2 (12.5)		-	1 (2.6)	
April	-	-		1 (2.7)	1 (2.6)	
May	4 (16.0)	-		11 (29.7)	10 (25.6)	
June	2 (8.0)	6 (37.5)		3 (8.1)	2 (5.1)	
July	4 (16.0)	3 (18.8)		2 (5.4)	3 (7.7)	
August	-	1 (6.2)		1 (2.7)	1 (2.6)	
September	-	-		-	1 (2.6)	
October	2 (8.0)	2 (12.5)		2 (5.4)	2 (5.1)	
November	3 (12.0)	-		1 (2.7)	-	
December	5 (20.0)	-		16 (43.2)	15 (38.5)	

Changes in the Use of Variety

As in the low elevation area, the varieties used by farmers have changed in the last 20 years. The reasons cited by farmers for changing the varieties of their crops are for higher yield and the availability of seeds; other reasons are enumerated in Table 4.18. Only a few mentioned climate change as the reason.

Table 4.18. Reasons for the change in varieties in the medium elevation area

Reason	Bungkol		Calumpang	
	Freq	%	Freq	%
Seed availability	3	16.7	13	28.9
For higher yield	6	33.3	12	26.7
Pest infestation	2	11.1	7	15.6
For higher income	-	-	5	11.1
Imitate other farmers	3	16.7	4	8.9
Climate change	1	5.6	2	4.4
DA endorsement/Advice of technician	2	11.1	1	2.2
Soil suitability	-	-	1	2.2
For higher income	1	5.6	-	-
Total	18	100.0	45	100.0

Changes in Soil Characteristics and Management

When asked about the rate at which soil dries, many, in both sites, perceived the soil to “dry quickly” or “less quickly” in the past 20 years but for the current years, many perceived the soil to dry “more quickly” (table 4.19). The major reasons cited are high temperature and low water holding capacity of the soil.

Many of the farmers perceived “no erosion” in the current years and in the past 20 years. A few perceived “low” and “moderate erosion.” The major reasons cited are heavy rains, and steep slopes (table 4.20).

Table 4.19. Farmers’ perceptions on the changes in the rate at which soil dries in the medium elevation area

Characteristics	Bungkol			Calumpang		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Dries more quickly	14	3	▪ Very high temperature (15) ▪ Low water holding capacity (10) ▪ Crops more water demanding (2)	15	8	▪ Very high temperature (9) ▪ Low water holding capacity (5) ▪ Irrigation patterns (3) ▪ Crops more water demanding (1)
Dries quickly	9	11		4	10	
Dries less quickly	1	10		5	5	
Dries slowly	1	1		0	1	
Total	25	25		24	24	

Table 4.20. Farmers' perceptions on the changes in the rate of soil erosion in the medium elevation area

Rate of soil erosion	Bungkol			Calumpang		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
No erosion	14	15	- Heavy rain (8) - Steep slope (5)	14	17	- Heavy rain (9) - Low vegetative (1)
Low erosion	6	9		5	5	
Moderate erosion	2	2		1	-	
High erosion	3	-		4	2	
Total	25	26		24	24	

There are more farmers from both sites who perceive that their soil had lower fertility levels now than in the past 20 years (table 4.21). The major reasons cited are continuous cropping and non-application of fertilizers. Climate change was also cited by a few farmers in Barangay Bungkol and Barangay Calumpang as a cause.

The kind of fertilizer being used has remained the same for the past 20 years for both sites, but in recent years, farmers in Barangay Bungkol have increased the use of the complete fertilizer (table 4.22). Changes in the kind of fertilizer used are due to low soil fertility, effectiveness of the fertilizer, and high price of fertilizers.

In terms of the amount of fertilizer used, there is an indication that farmers in both sites have used less fertilizer in the past 20 years and more in the current years (table 4.23).

Table 4.21. Farmers' perceptions on the changes in soil fertility status in the medium elevation area

Soil fertility status	Bungkol			Calumpang		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Low fertility	17	10	- Continuous cropping (15) - Climate change (5) - Non-application of fertilizer (3)	17	6	- Continuous cropping (11) - Non-application of fertilizer (8) - Climate change (1)
Moderate fertility	8	10		1	15	
High Fertility	0	5		6	3	
Total	25	25		24	24	

Table 4.22. Farmers' observation on the changes in the kind of fertilizer used in the medium elevation area

Soil fertility status	Bungkol			Calumpang		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Urea	25	24	- Effectiveness (3) - Low soil fertility (2) - Climate change (1)	24	22	- Effectiveness (5) - High price of fertilizer (3) - Low soil fertility (1)
Ammonium sulfate	8	7		3	1	
Complete 14-14-14	10	1		14	14	
Organic	4	8		2	-	
Others	-	7		-	-	
Total	47	47		43	37	

Table 4.23. Farmers' observations on the changes in the amount of fertilizer used in the medium elevation area

Soil fertility status	Bungkol			Calumpang		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Less amount	4	17	- Effectiveness (10) - Low soil fertility (9)	5	13	- Low soil fertility (7) - Effectiveness (4) - High price of fertilizer (1) - Availability (1)
More amount	13	0		9	1	
Same amount	8	8		10	10	
Total	25	25		24	24	

Effects of the Changes in the Agricultural Systems on Crop Production

Despite the observed changes in the agricultural systems, most of the farmers did not observe a change in their crop production (table 4.24).

Despite being continually subjected to the effects of hazardous climatic events, only a few of the farmers are implementing adaptation measures (table 4.25).

Table 4.24. Farmers' perceived effects of the changes in agricultural systems on crop production in the medium elevation area

Effects on crop production	Bungkol		Calumpang	
	Freq	%	Freq	%
Higher yields	1	10.0	2	20.0
Bigger produce	1	10.0	0	0
Same yield	8	80.0	8	80.0
Total	10	100.0	10	100.0

Table 4.25. Farmers' adaptation measures for different climate hazards in the medium elevation area

Adaptation Measures	Bungkol		Calumpang	
	Freq	%	Freq	%
Typhoon				
Pruning	1	33.3	2	50.0
Early harvesting	1	33.3		
Others	1	33.3	2	50.0
Monsoon rains				
Propping	2	100.0	5	100.0
Drought				
Propping	5	100.0	4	100.0

High Elevation Areas***Changes in Crops Planted and Cropping Patterns***

The crops planted in the past 20 years are the still the same kinds planted at present, except for the addition of new perennial crops in Barangay San Francisco, namely

lanzones, avocado, rambutan, and rice (see table 4.26). Both barangays cite the availability of planting materials as the reason for changing crops; another reasons for Barangay San Francisco is the high labor requirement of the crops, while Barangay Bucal mentions high market demand, higher income and limited capital for the crops they plant.

Table 4.26. Changes in the crops planted in the high elevation area

San Francisco			Bucal		
Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
- Beans (14) - Tomato (12) - Radish (8) - Cucumber (6) - Squash (5) - Rice (3) - Sweet potato (2) - Chili (2) - Cabbage (1)	- Tomato (14) - Beans (12) - Radish (12) - Cucumber (6) - Sweet potato (4) - Cabbage (3) - Squash (3) - Chili (1) - Pechay (1) - Taro (1)	- Availability of planting materials (2) - Labor intensive (2)	- Beans (18) - Tomato (18) - Cucumber (8) - Radish (6) - Cabbage (5) - Chayote (4) - Sweet potato (3) - Eggplant (2) - Rice (2) - Coconut (1) - Bitter gourd (1) - Chili (1) - Cassava (1) - Pechay (1)	- Tomato (18) - Beans (15) - Radish (7) - Cucumber (5) - Cabbage (4) - Chayote (4) - Chili (2) - Bitter gourd (1) - Eggplant (1) - Banana (1) - Taro (1) - Squash (1)	- High market demand (3) - Availability of planting materials (2) - Higher income (2) - Limited capital (2)

There has been a general shift from the monoculture cropping pattern from the last 20 years to rotational cropping and intercropping in the current years. The common reasons cited for the change are availability of inputs and changes in soil fertility. A few farmers also gave reasons that are climate related, like continuous drought and heavy rains (table 4.27).

The planting months for most of the crops in the study sites have remained the same for the past 20 years. Vegetables, which are the common crops in both sites, are planted anytime of the year depending on the availability of moisture (rainfall). The planting months are June-July and December (table 4.28). The common reason cited for changes in planting time in both sites is related to the availability of inputs. Additional reasons for Barangay Bucal are climate change and heavy rains.

Table 4.27. Changes in the cropping patterns in the high elevation area

San Francisco			Bucal		
Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Monoculture (2)	Monoculture (7)	- Soil fertility (3) - Availability of inputs (2) - Continuous drought (1) - Rotational Cropping (19) - Intercropping (2)	Monoculture (4)	Monoculture (8)	- Availability of inputs (4) - Soil fertility (2) - Heavy rains (1) - Continuous drought (1)
Rotational Cropping (15)	Rotational Cropping (13)		Rotational Cropping (16)		
Intercropping (7)	Intercropping (4)		Intercropping (1)		

Table 4.28. Changes in the planting months in the high elevation area

Month	San Francisco			Bucal		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
January	7 (17.5)	7 (17.9)	▪ Availability of inputs (6)	7 (21.2)	6 (20.0)	▪ Climate change (5) ▪ Availability of inputs (5) ▪ Heavy rains (1)
February	-	-		1 (3.0)	1 (3.3)	
March	3 (7.5)	3 (7.7)		1 (3.0)	-	
April		4 (10.3)		2 (6.1)	-	
May	2 (5.0)	2 (5.1)		7 (21.2)	5 (16.7)	
June	13 (32.5)	13 (33.3)		7 (21.2)	11 (36.7)	
July	9 (22.5)	5 (12.8)		7 (21.2)	-	
August	2 (5.0)	1 (2.6)		-	-	
September	1 (2.5)	1 (2.6)		-	-	
October	2 (5.0)	2 (5.1)		-	1 (3.3)	
December	1 (2.5)	1 (2.6)		-	1 (3.3)	
Total	40 (100)	39 (100)		33 (100)	100)	

Changes in the Use of Variety

The varieties of crops planted have changed in the past 20 years. The major reasons cited for switching crops are “higher yield” and “higher income,” and “seed availability” (table 4.29). Climate change was also cited by around 15 percent of the respondents in Barangay San Francisco and 18 percent in Barangay Bucal.

The two sites have several and similar sources of planting materials but compared to Barangay San Francisco, Barangay Bucal sources more of their materials from government agencies and seed growers (table 4.30).

Table 4.29. Reasons for the change in varieties in the high elevation area.

Reason	San Francisco		Bucal	
	Freq	%	Freq	%
Seed availability	7	17.1	7	17.9
For higher yield	16	39.0	14	35.9
Pest infestation	1	2.4	2	5.1
For higher income	9	22.0	8	20.5
Imitate other farmers	2	4.9	1	2.6
Climate change	6	14.6	7	17.9
Total	41	100.0	39	100.0

Table 4.30. Source of planting materials in the high elevation area

Source	San Francisco		Bucal	
	Freq	%	Freq	%
Previous harvest	5	20.0	1	4.8
Other farmers	-	-	1	4.8
Seed growers	6	24.0	7	33.3
Government agencies	7	28.0	9	42.9
Agri-store	7	28.0	3	14.3
Total	25	100.0	21	100.0

Changes in Soil Characteristics and Management

The respondents from Barangay San Francisco have gauged that their soil dries “quickly” or “more quickly” in the current and past 20 years; in Barangay Bucal, more of the respondents perceive their soil dries “less quickly” in the current and past 20 years (table 4.31). The common reasons cited for the change in both sites are very high temperatures coupled with low water holding capacity. Respondents from Barangay Bucal also say that crops are more water-demanding.

The number of those who perceive that there is “no erosion” in their soil has remained the same for the past 20 years. However, there was a decrease in the number of respondents who perceived “low erosion” in the soil and an increase in those who perceived “moderate or high erosion” in the current years (table 4.32). The common reason cited in both sites is heavy rainfall. Other factors that have been cited for soil erosion are the steep slopes in Barangay San Francisco and low vegetation in Barangay Bucal.

Table 4.31. Farmers’ observed changes in the rate at which soil dries in the high elevation area

Characteristics	San Francisco			Bucal		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Dries more quickly	13	12	- Very high temperature (12) - Low water holding capacity (5)	6	6	- Very high temperature (11) - Low water holding capacity (6) - Crops more water demanding (5)
Dries quickly	8	11		4	5	
Dries less quickly	3	2		14	14	
Dries slowly	1	0		1	0	
Total	25	25		25	25	

Farmers from both sites show a general shift in perception regarding soil fertility—from a high fertility status in the past 20 years to a low fertility status in the current years (table 4.33). The same reasons were cited for both sites, i.e. continuous cropping and climate change.

Table 4.32. Farmers' observations on the changes in the rate of soil erosion in the high elevation area

Rate of soil erosion	San Francisco			Bucal		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
No erosion	7 (28.0)	7 (28.0)	- Heavy rain (10) - Steep slope (5)	7 (28.0)	6 (24.0)	- Heavy rain (10) - Low vegetative (7)
Low erosion	7 (28.0)	12 (48.0)		7 (28.0)	14 (56.0)	
Moderate erosion	6 (24.0)	5 (20.0)		7 (28.0)	4 (16.0)	
High erosion	5 (20.0)	1 (4.0)		4 (16.0)	1 (4.0)	
Total	25(100)	25 (100)		25 (100)	25 (100)	

Table 4.33. Farmers' observations on the soil fertility status in the high elevation area

Soil fertility status	San Francisco			Bucal		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Low fertility	15	4	- Continuous cropping (17) - Climate change (5)	15	1	- Continuous cropping (25) - Climate change (5)
Moderate fertility	8	9		9	11	
High Fertility	2	12		1	13	
Total	25	25		25	25	

The number of respondents using the urea fertilizer increased in the last 20 years. The use of complete and organic fertilizers has also increased among respondents in Barangay San Francisco but not in Barangay Bucal (table 4.34). The common reasons cited are low soil fertility, effectiveness of the fertilizers, and availability of the fertilizers.

Table 4.34. Changes in the kind of fertilizers used in the high elevation area

Soil fertility status	San Francisco			Bucal		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Urea	21(53.8)	15 (45.5)	- Low soil fertility (5) - Effectiveness (1) - Availability of fertilizers (1)	24 (61.5)	20 (58.8)	- Low soil fertility (4) - Effectiveness (4) - High price of fertilizer (1) - Availability of fertilizers (1)
Ammonium sulfate	3 (7.7)	2 (6.1)		1 (4.0)	1 (2.9)	
Complete 14-14-14	5 (12.8)	1 (3.0)		5 (12.8)	5 (14.7)	
Organic	10 (25.6)	6 (18.2)		9 (23.1)	8 (23.5)	
Others	-	9 (27.3)		-	-	
Total	39 (100)	33 (100)		39 (100)	34 (100)	

As for the amount of fertilizer used, a general shift in the farmers' practice has been observed; more fertilizer has been used in recent years. The common reasons cited are low soil fertility and the effectiveness of the fertilizers (table 4.35).

Table 4.35. Changes in the amount of fertilizer used in the high elevation area

Soil fertility status	San Francisco			Bucal		
	Current Years	Past 20 Years	Reason(s) for the Change	Current Years	Past 20 Years	Reason(s) for the Change
Less amount	1 (4.0)	17 (68.0)	- Low soil fertility (18) - Effectiveness (7)	3 (12.0)	19 (76.0)	- Low soil fertility (16) - Effectiveness (11) - High price of fertilizer (1)
More amount	18 (72.0)	4 (16.0)		18 (72.0)	0	
Same amount	6 (24.0)	4 (16.0)		4 (16.0)	6 (24.0)	
Total	25 (100)	25 (100)		25 (100)	25 (100)	

Effects of the Changes in the Agricultural Systems on Crop Production

Despite observed changes in the farming systems, majority of the respondents claimed that they still get the same yield as before (table 4.36). Around 38.5 percent and 27.2 percent of respondents in Barangay San Francisco and Barangay Bucal, respectively, claimed to have increased their yield in the past 20 years.

Meanwhile, farmers' adaptation measures to the climate hazards have been very limited (see table 4.37).

Table 4.36. Farmers' perceived effects of the changes in agricultural systems on crop production in the high elevation area

Effects	San Francisco		Bucal	
	Freq	%	Freq	%
Increase	5	38.5	3	27.2
Decrease	0	0	1	9.0
Same yield	8	61.5	7	63.6
Total	13	100.0	11	100.0

Table 4.37. Farmers' adaptation measures for different climate hazards in the high elevation area

Adaptation Measures	San Francisco		Bucal	
	Freq	%	Freq	%
Typhoon				
Early harvesting	1	100.0	4	100.0
Monsoon rains				
Early harvesting	1	100.0	-	-
Drought				
Propping	2	100.0	3	100.0

FOOD SECURITY IMPLICATIONS

The crops planted in all areas of the watershed are constantly exposed to climate hazards, particularly typhoons and flooding. All crops in the watershed are sensitive to typhoon onslaughts, though their sensitivities have varying degrees depending on the strength of the typhoons. The kinds of damage to crops caused by typhoons include

lodging, washing out by flash floods, and submergence from inundation, particularly in the low lying areas near the lake. While perennial crops can withstand the onslaught of moderately strong typhoons, the yields from these crops could be greatly reduced and can take two to three years to recover. Replanted perennial crops could take around five to seven years before they bear fruit. Annual crops can easily be replanted after being damaged. Farmers in the watershed claim experiencing two to three damaging typhoons each year. The frequent exposure to climate hazards and the high sensitivities of the crops in the watershed have great implications on food security. Every year, the watershed experiences damages to crops at least two to three times due to typhoons. Crop yields are greatly reduced when hit by climate hazards but farmers may be able to recover crop losses in times of good weather.

SUMMARY AND CONCLUSION

The climate hazards that the farmers in the Sta. Cruz Watershed are exposed to and are concerned with are basically the two related calamities: typhoon and flooding. Typhoons are experienced two to three times a year but respondents only remember the typhoons that cause heavy damage to their crops and properties.

Crops grown in all elevations are exposed to climatic stresses like typhoons and flooding. These stresses pose a greater risk to the annual crops like rice and vegetables; typhoons can cause lodging in rice and vegetables and result in yield reductions or total crop losses. Another concern with typhoons in the low elevation areas and partly in the medium elevation areas is flooding. Similarly, submergence of rice and vegetables from flooding for more than five days can cause a large yield reduction if not total damage. Flooding is also caused by continuous rain, causing the rise in the water level of the lake and subsequently inundating the low-lying areas near the lake.

For respondents in the medium and high elevation areas with more perennial crops, only typhoons with strong winds are of concern. Perennial crops like coconut, lanzones and rambutan might withstand typhoons but nonetheless suffer a reduction in their yield. Strong winds can damage the crops planted and can uproot many fruit trees. It will take two to three years for damaged trees to recover and regain their productivity. When coconut or fruit trees are felled, replanting may take some time, if at all these trees are replanted. Hence, frequent felling of trees from strong typhoons and slow replanting will cause a reduction in the population of the trees.

Another serious concern with the agricultural systems in the watershed is pest infestation. Rice, which is an important crop in the low and medium elevation areas, is always infected by rice diseases and infested by insect pests, including the rice black bug. The farmers' attempts at controlling the rice bug infestation have not been so effective. Coconut is an important crop in the medium and high elevation areas and coconut palms are now threatened because of the coconut scale insect infestation. Control measures have not yet been so effective.

The concern with fruit trees is the change in rainfall patterns. Fruiting is highly affected by changes in the rainfall pattern given that fruits are seasonal crops harvested from August to October. With unpredictable rainfall, fruit production may be inconsistent. For instance, the past five years have produced generally low fruit yields but during the 2013 season, there was a very high yield of rambutan.

The study has shown that climate hazards have brought much damage to crops yet most of the farmers in the watershed have said that their crop yields have remained the same as before and some have even claimed an increase in their yields. But this

perception has to be placed in a proper perspective. Farmers may think of their yield in terms of a single harvest event and fail to consider the losses they incurred during climate hazard occurrences—while a single cropping may produce high yields, the overall yield for the harvest year may still be less when losses are added to the equation.

There have been some changes in the cropping systems in the watershed in the last 20 years but only a few of the respondents attributed them to climate change. Crops cultivated in the past 20 years are still being cultivated in the current years, with an addition of a few new crops. While cropping patterns have remained the same, varieties used have changed; most of the reasons cited are related to the search for higher yields and better income, and the availability of seeds. Only a few farmers attributed the switch to climate change.

An increasing number of farmers note that their soil dries more quickly now than it had in the past 20 years; this phenomenon has largely been attributed to high temperatures. Generally, more farmers have also noted more erosion in the current years compared to that of the past 20 years; this was attributed to heavy rainfall. Soil fertility was generally observed to have decreased in the current years, seen as a result of continuous cropping. There was no noticeable change in the kind of fertilizer used but the amount of fertilizer used has increased compared to the past 20 years.

The data of this study indicate continuous crop loss in the watershed due to climate hazards. Despite these, members of the watershed community have not developed effective adaptation measures to reduce the negative effects of the hazards. While there may be technologies or measures that can be used to reduce the damage that the climate hazards may bring, these have not been brought to the farmers' knowledge. The use of rice varieties with submergence tolerance, for instance, has not been introduced or used in areas frequently inundated by flood waters. Hence, extension messages geared towards climate change literacy may be disseminated in the area so that farmers would know how to cope with the hazards and their effects.

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CHAPTER 5

PEST DYNAMICS AND CROP PRODUCTIVITY AMID A CHANGING CLIMATE

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Pest infestation has affected the crop productivity of Sta. Cruz, Liliw, and Nagcarlan—barangays representing low, medium and high elevation sites of the Sta. Cruz watershed in Laguna; pest incidence in the study area can be correlated to the different hazards brought about by extreme climatic events. There has been a documented increase in pest incidence and rate of infestation in the last 20 years; these have been attributed to climate change. In many instances, pest incidence and infestation increased in vegetables and other annual and perennial crops. Recently, the occurrence of new pests, like the Rigid coconut scale insect and the lanzones mussel scale insect, has also been observed in the study sites.

The use of pesticides against insect pests and diseases is still the most common intervention method employed by farmers. Sometimes, herbicides replace manual weeding. Rats are being controlled by acute or chronic baiting. Still, many farmers lack the knowledge on the nature and population dynamics of the pests and on the proper use of pesticides.

Other agricultural practices, however, have been successful in creating a degree of food security that can sustain household survival. The adaptation methods of farmers include changes in the crop, crop type and cropping system. High-yields, acceptability to market, resilience to the extremes of the environment, and a tolerance to pests were the crop characteristics given utmost consideration by growers.

Keywords: pest dynamics, crop productivity, farmers' practice, crop protection

INTRODUCTION

An additional 40 to 170 million people worldwide are in danger of being undernourished as a direct consequence of climate change; this is naturally because agricultural production is particularly vulnerable to these changes (Watson and the Core Writing Team 2001). Temperature increases, changes in precipitation volumes and regimes, elevated atmospheric carbon dioxide, and other weather hazards as a consequence of these factors can influence food production (Hatfield et al. 2004; de Guzman and Zamora 2012). As a mitigation measure, agriculture should produce high-yielding and well-adapted crops resilient to climatic hazards and pests.

Crop production is always constrained by the presence of pests. Growth, reproduction, and behavior of pests are particularly affected by weather and climatic changes (Sutherst 1990). Increased atmospheric carbon dioxide levels due to climate change can increase crop productivity levels especially for C3 crops (Abdallah, Moses, and Prakash 2004; Cure and Acock 1986). However, this will also increase weed growth (Hatfield et al. 2004; Ziska 2003), its invasiveness and its infestation capacity (Parmesan 1996; Patterson et al. 1999).

Insect reproduction, behavior and survival are also much affected by environmental conditions (Rosenzweig et al. 2001). Increasing temperature can result in increased infestation range (Sharma et al. 2010), migration (Musolin 2007) and early (Bale and Hayward 2010) and short periods of diapauses (Hahn and Denlinger 2007).

Crop losses in Asia due to plant diseases were estimated to be 14.2 percent (Oerke et al. 1994). The occurrence and development of plant disease is brought about by the combination of a susceptible host, a virulent pathogen, and a favorable environment (Agrios 2004); an absence of any of the three factors will not lead to disease. As mentioned, environment clearly plays a role in the severity of the disease (Woods, Coates, and Hamann 2005) as well as the pathogens' geographical distribution (Mina and Sinha 2008).

This study focuses on the Sta. Cruz Watershed and aims to:

1. compare the pest incidence and infestation rates on selected crops at different elevation; and
2. explain farmers' pest management interventions to minimize crop production losses.

This study provides some recommendations to minimize crop losses due to pests; the improvement of agricultural production through the use of tested crop protection technologies will no doubt help in the efforts for achieving food security.

PEST INCIDENCE AND INFESTATION RATES

Common names and scientific names of the different pests documented and identified by farmers are listed in appendix table 5.1. Only the common names of the pests, for brevity, are mentioned in the following sections.

Low Elevation Sites

The black bug and the rice stem borer are the common insect pests of rice in Barangays San Pablo Sur and Patimbao in Sta. Cruz (table 5.1). There has been a consistent increase in the incidences of the black bug and rice stem borer infestations and the affected areas in both localities are expanding. In some rice areas, the appearance of the rice stem

borer seems to be seasonal. The black bug is a fairly new rice pest; some species of which were only recently introduced into the country.

The common rice field rat and the Asian field rat are the prevalent vertebrate pest that attack rice at all stages of growth.

The golden apple snail infestation seems to have increased. The mollusks pose a problem for the early stages of growth of transplanted rice that use dapog-raised seedlings. The infestation, however, is reduced at the late vegetative stage.

Table 5.1. Pest occurrences and infestation rates in crops planted at Low Elevation sites

Crop	Pest/ Disease	San Pablo Sur				Patimbao			
		Pest Incidence		Infestation		Pest Incidence		Infestation	
		(%)		Rate (ha)		(%)		Rate (ha)	
		Past	Current	Past	Current	Past	Current	Past	Current
Rice	Insects								
	Rice black bug	44	79	0.3	3.6	33	63	1.6	7.8
	Rice stem borer	44	67	0.8	2.1	26	26	0.4	1.7
	Vertebrates								
	Common field rat/ Asian field rat	56	56	22.4	19.5	48	63	4.3	3.8
	Molluscs								
	Golden apple snail	44	78	0.3	36.4	37	67	3.1	9
	Diseases								
	Tungro	33	33	0.7	13.3	52	52	4.2	2.9
	Bacterial leaf blight	22	22	-	0.8	33	33	0.6	1.7
	Rice blast	-	-	-	-	15	15	0.5	2.5
	Sheath blight	-	-	-	-	11	11	0.8	0.5
	Weeds	-	-	33	41	-	-	7.7	3.5
	Barnyard grass	57	57	-	-	74	74	-	-
	Jungle rice	33	33	-	-	33	33	-	-
	Small-flower umbrella plant	22	22	-	-	18	18	-	-
	Rice flat sedge	11	11	-	-	22	22	-	-
	Pickerel weed	22	22	-	-	33	33	-	-
	Gooseweed	44	44	-	-	37	37	-	-
	Water Lettuce	33	33	-	-	4	4	-	-
	Knotgrass	67	67	-	-	56	56	-	-

Tungro and bacterial leaf blight are diseases that affect rice; these were reported to have caused yield reductions in the above mentioned barangays. Tungro is caused by the combination of two viruses transmitted by an insect vector, the green leafhopper. The disease can be recognized by the yellowing of rice plants and concomitant stunting. If not attended to, the disease can spread rapidly among rice plants. Bacterial leaf blight infection is also on the rise. It is caused by the bacterium *Xanthomonas oryzae*. The disease manifests itself as yellow, water-soaked leaves becoming necrotic over time. The disease can infect seedlings (diagnosed by the appearance of kresek symptoms) and mature

plants. Rice blast and sheath blight were reported in Patimbao; the infestation rate of the former was increasing while the latter was on the decline.

Weeds are also perennial problems in the lowland rice culture. Grasses, sedges and broadleaves in different proportions occur wherever rice is grown. Grasses like barnyard grass, jungle rice and knotgrass are set off by cultural practices though some species of broadleaves like pickerel weed, gooseweed, and sedges are also boosted by nutrient and water regimes. Generally, there was no increase in the weed infestation rates in both sites.

Medium Elevation Sites

Black bugs and rice stem borers have infested and are still infesting rice in Bungkol (table 5.2). Currently, 57 percent of the farmers claimed that an average of 3.6 hectares is infested with black bugs. There is also an increase in the rice stem borer infestation.

More farms are also infested with rats and golden apple snails.

Occurrences of tungro, bacterial leaf blight, and rice blast are also increasing.

Table 5.2. Pest occurrences and infestation rates in crops planted at Medium Elevation sites

Crop	Pest/ Disease	Bungkol				Calumpang			
		Pest Incidence		Infestation		Pest Incidence		Infestation	
		(%)		Rate (ha)		(%)		Rate (ha)	
		Past	Current	Past	Current	Past	Current	Past	Current
Rice	Insects								
	Rice black bug	21	57	-	3.6	37	52	0.6	7
	Rice stemborer	29	29	0.2	1	37	37	0.7	3.6
	Vertebrates								
	Common rice field rat/ Asian field rat	14	21	0.2	0.2	37	41	3.4	4.6
	Molluscs								
	Golden Apple Snail	29	63	0.2	5	48	63	3.8	11.2
	Diseases								
	Tungro	29	36	0.4	2.1	-	-	-	-
	Bacterial leaf blight	14	14	0.1	0.4	-	-	-	-
	Rice blast	14	14	0.3	0.4	22	22	0.5	3.4
	Rice sheath blight					11	11	0.3	3.4
	Weeds			1.6	2.2			9	6.2
	Barnyard grass	43	43	-	-	56	56	-	-
	Jungle rice	36	36	-	-	26	26	-	-
	Small-flower umbrella plant	14	14	-	-	26	26	-	-
	Rice flatsedge	7	7	-	-	22	22	-	-
	Pickerel weed	21	21	-	-	30	30	-	-
	Gooseweed	29	29	-	-	41	41	-	-
	Water lettuce	14	14	-	-	4	4	-	-
	Knotgrass	29	43	-	-	41	44	-	-

PEST DYNAMICS AND CROP PRODUCTIVITY

Tomato	Arthropods								
	Whitefly	33	33	0.3	0.6	100	100	0.1	0.3
	Fruitfly	33	33	0.2	0.5	100	100	0.1	0.2
	Mites	33	33	0.2	0.5	100	100	0.1	0.2
	Fruitworm	33	33	0.2	0.6	100	100	0.1	0.3
	Thrips	-	-	-	-	100	100	-	-
	Vertebrates								
	Common rice field rat/ Asian field rat	33	33	0.2	0.2	100	100	0.1	0.1
	Diseases								
	Bacterial wilt	33	33	0.2	0.6	100	100	0.1	0.3
	Blossom-endrot	33	33	0.2	0.6	100	100	0.1	0.3
	Weeds								
	Purple nutsedge	-	15	-	-	100	50	-	-
	Tropic ageratum	-	8	-	-	50	50	-	-
	Carabao grass	8	31	-	-	100	100	-	-
	Jungle rice	-	-	-	-	50	50	-	-
Radish	Insects								
	Cutworm	-	100	-	1	-	-	-	-
	Vertebrates								
	Common rice field rat/Asian field rat	-	100	-	-	-	-	-	-
	Weeds								
	Purple nutsedge	-	15	-	-	-	-	-	-
	Tropic ageratum	-	8	-	-	-	-	-	-
	Carabao grass	8	31	-	-	-	-	-	-
	Jungle rice, Goosegrass	-	-	-	-	-	-	-	-
Bitter gourd	Insects								
	Fruitfly	33	17	0.2	2	100	100	0.1	0.1
	Whitefly	33	17	0.2	0.7	100	100	0.1	0.1
	Aphids	67	17	0.6	0.4	100	100	0.1	0.2
	Cutworm	50	17	0.3	0.4	100	100	0.1	0.2
	Vertebrates								
	Common rice field rat/Asian field rat	33	17	0.2	0.2	-	-	-	-
	Diseases								
	Leaf spot	33	33	0.2	0.4	100	100	0.1	0.1
	Fruit rot	33	33	0.2	0.4	100	100	0.1	0.2
	Weeds								
	Purple nutsedge	-	15	-	-	100	50	-	-
	Tropic ageratum	-	8	-	-	50	50	-	-
	Carabao grass	8	31	-	-	100	100	-	-
	Jungle rice	-	-	-	-	50	50	-	-
	Goosegrass	-	-	-	-	-	-	-	-

Coconut	Insects								
	Coconut scale insect	20	40	0.1	1.1	-	-	-	-
	Vertebrates								
	Common field rat/Asian field rat	-	20	-	0.2	-	-	-	-
	Weeds								
	Jungle rice	20	20	0.3	0.3	-	-	-	-
Lanzones	Devil weed, Chinese burr, Carabao grass, Three-lobed morning glory, Cogon grass, Tropical kudzu, Lantana, Mallow, Chocolate weed, Common wire weed	-	-	-	-	-	-	-	-
	Insects								
	Scale insect	33	33	0.1	1.3	-	-	-	-
	Vertebrates								
	Fruit bats	-	67	-	0.3	-	-	-	-
	Crow	-	33	-	0.3	-	-	-	-
	Weeds	-	33	0.4	1.1	-	-	-	-
	Purple nuts edge, Sensitive plant, Carabao grass, Chocolate weed, Common wireweed, Balloon plant	-	-	-	-	-	-	-	-

Notably, from among the weeds, knotgrass, a perennial species propagating through seeds and stem fragments, has spread in many farms. Such spread of weed seeds may be caused by the use of farm implements in the preparation of succeeding paddies that have not been cleaned between operations. This is a common observation especially when land preparation activities are done by hired laborers. Broadleaves, sedges, and other grasses have long been present in their paddies.

Tomato, radish, and bitter melon were among the vegetables planted by most of the farmers and were produced in relatively high volumes. However, the presence and increase of pests and diseases have affected the production of these vegetables. Infestation rates of whitefly, fruit fly, mites, and fruit worm have doubled in the current year. The increasing ambient temperature could have induced the increased reproduction rate and activity of the insect pests.

The incidence of bacterial wilt and fruit rot also increased three-fold. Bacterial wilt, caused by *Ralstonia solanacearum*, is difficult to control by ordinary means since the organism is a soil inhabitant and can survive for many years. Many crop varieties that have been held to be resistant to bacterial wilt have shown only some degree of tolerance. Cutworm is now a problem for radishes and bitter melons. Fruit fly, whitefly and aphid infestation in bitter melons is also increasing compared to previous years. Leaf spot and fruit rot also affect the yields of bitter melon.

Upland species like purple nutsedge, tropic ageratum, and carabao grass were the most dominant weeds in tomato, radish and bitter melon plots although there was the occasional presence of lilac tassel flower, ragleaf, and goosegrass.

Rat damage was also noted by some farmers.

The rigid coconut scale insect is a recently introduced pest. It infests the underside

of the leaflets of fully-matured coconut leaves and sucks on the plant sap causing yellowing, drying, and the eventual death of the plant (Watson et al. 2014).

The most dominant weeds in the coconut area include jungle rice, devil weed, Chinese burr, and carabao grass. Minor weeds include three-lobe morning glory, cogon grass, lantana, mallow, chocolate weed, and common wire weed.

Lanzones, a perennial fruit tree, has also been infested with a new species of scale insect (Lit and Barbecho 2014). It causes significant yield loss due to the severe yellowing of leaves and, eventually, plant defoliation. Fruit bats and Philippine crows were also reported to have damaged the fruit sets of lanzones. Tropical kudzu, earlier introduced as a cover crop, and its other species have also been infesting areas around the lanzones.

Rice plants in Barangay Calumpang were infested with black bugs and rice stem borers. Infestation rates have increased tremendously in the past years. This might be due to ineffective management techniques employed by the farmers and the failure to consider the factors favoring the reproduction and spread of the insect pests.

Damages due to rats and golden apple snails are also alarming.

Tungro, bacterial leaf blight, rice blast, and sheath blight are the most commonly observed diseases of rice.

Common rice field weeds that have been observed to infest rice are being managed to some extent.

Tomatoes and bitter gourds are important vegetable crops of Calumpang. Tomato crops are infested with whiteflies, fruit flies, mites, thrips, and fruit worms, and are beset with bacterial wilt and fruit rot. Bitter gourd plants, meanwhile, are infested with fruit flies, whiteflies, aphids, and cutworms and are afflicted with leaf spot and fruit rot as well. Some farmers have suppressed the purple nutsedge growth in both crops.

High Elevation Sites

A rice stem borer infestation is the primary complaint of rice farmers in Bucal and San Francisco in Nagcarlan (table 5.3). The area devoted to rice is small compared to the areas planted with highland crops. Farmers grow lowland rice to take advantage of the available water for irrigation. Production is only for family consumption.

Rats and golden apple snail are the common animal pests that have been found in both locations; the rice in both barangays has also been infected with the viral disease tungro.

Barnyard grass, jungle rice, and water lettuce are the common weeds found in the rice areas of Bucal, while only jungle rice and water lettuce prevail in San Francisco.

Tomatoes, beans and radishes are the most common vegetables planted in Bucal and San Francisco, although there are some farmers who plant squash, chili, cabbage and other vegetable crops. Whitefly, fruit fly, fruit worm, and mites are the insects infesting tomatoes. These pests have been present since the early years of farming but now, the infestation rates of these pests seem to be generally increasing. Bacterial wilt and fruit rot or blossom-end rot are the most common diseases of the tomato plant at high altitudes. Diamond-back moth, whitefly, cutworm and leafminer are the common insect pests of radish; the infestation rates of these pests have tripled since the earlier years. Pod borer, leafminer, and aphids, and a pod rot infestation have also increased in both locations.

Table 5.3. Pest occurrences and infestation rates in crops planted at High Elevation sites

Crop	Pest/ Disease	Bucal				San Francisco			
		Pest Incidence		Infestation		Pest Incidence		Infestation	
		(%)		Rate (ha)		(%)		Rate (ha)	
		Past	Current	Past	Current	Past	Current	Past	Current
Rice	Insects								
	Rice stemborer	100	100	-	-	100	100	-	-
	Vertebrates								
	Common field rat/Asian field rat	100	100	-	-	100	100	-	-
	Molluscs								
	Golden Apple Snail	100	100	-	-	100	100	-	-
	Diseases								
	Tungro	100	100	-	-	100	100	-	-
	Weeds								
	Barnyard grass	100	100	-	-	-	-	-	-
	Jungle rice	100	100	-	-	100	100	-	-
	Water lettuce			-	-			-	-
		100	100			100	100		
Tomato	Arthropods								
	Whitefly	39	39	1.3	2.5	40	40	2.5	1.5
	Fruitfly	28	28	0.5	1.2	33	33	0.5	1.2
	Mites	39	39	1.3	2.3	40	40	0.5	1.2
	Fruitworm	39	39	2.9	2.3	40	40	0.5	1.5
	Vertebrates								
	Common field rat/Asian field rat	33	33	0.5	0.5	40	40	0.5	0.5
	Diseases								
	Bacterial Wilt	33	33	0.5	1.5	40	40	0.5	1.5
	Blossom-end rot	28	28	0.5	1.5	33	33	0.5	1.5
	Weeds	-	-	7.8	16.2	-	-	1.5	4
	Jungle rice	2	-	-	-	-	-	-	-
	Purple nutsedge	6	4	-	-	14	14	-	-
	Tropic ageratum	-	6	-	-	14	14	-	-
	Carabao grass	13	17	-	-	5	16	-	-
	Lilac tasselflower	-	-	-	-	-	-	-	-
	Ragleaf	-	-	-	-	-	-	-	-
	Crabgrass	-	-	-	-	-	-	-	-
	Goosegrass	-	-	-	-	-	-	-	-
	Spicy amaranth	-	-	-	-	-	-	-	-
	Slender amaranth	-	-	-	-	-	-	-	-

PEST DYNAMICS AND CROP PRODUCTIVITY

Radish	Insects								
	Cutworm	42	42	0.5	1.5	42	42	0.5	1.5
	Diamond-back moth	42	42	0.5	1.5	42	42	0.5	1.5
	Whitefly	42	42	0.5	1.5	42	42	0.5	1.5
	Leafminer	42	42	0.5	1.5	42	42	0.5	1.5
	Vertebrates								
	Common field rat/Asian field rat	42	42	0.5	0.5	42	42	0.5	0.5
	Diseases								
	Leafspot	-	-	-	-	42	42	0.5	1.5
	Weeds	-	-	7.8	16.2	-	-	1.5	0.5
	Purple nutsedge	6	4	-	-	14	14	-	-
	Tropic ageratum	-	6	-	-	14	14	-	-
	Carabao grass	13	17	-	-	5	16	-	-
	Jungle rice	2	-	-	-	-	-	-	-
	Pigweed	2	6	-	-	-	-	-	-
	Goosegrass	6	2	-	-	-	-	-	-
	Synedrella, Crabgrass, Ragleaf	-	-	-	-	-	-	-	-
Beans	Insects								
	Pod borer	29	29	0.8	2	20	20	0.3	0.8
	Leafminer	29	29	0.8	2	20	20	0.3	0.8
	Aphids	29	29	0.8	2	20	20	0.3	0.8
	Vertebrates								
	Common field rat/Asian field rat	29	29	0.5	0.5	-	-	-	-
	Diseases								
	Podrot	29	29	0.8	2	20	20	0.3	0.8
	Weeds	-	-	18	16.2	-	-	1.5	4
	Purple nutsedge	6	4	-	-	14	14	-	-
	Tropic ageratum	-	6	-	-	14	14	-	-
	Carabao grass	13	17	-	-	5	16	-	-
	Jungle rice	2	-	-	-	-	-	-	-
	Pigweed	2	6	-	-	-	-	-	-
	Goosegrass	6	2	-	-	-	-	-	-
	Synedrella, Ragleaf			-	-	-	-	-	-
	Lilac tasselflower								
Coconut	Insect								
	Coconut scale insect	-	-	-	-	50	50	0.1	0.5
	Weeds								
	Carabao grass, Javagrass, Common wireweed, Chocolate weed	-	-	-	-	-	-	-	-

Lanzones	Insects								
	Scale insect	100	100	-	-	-	-	-	-
	Vertebrates								
	Bats	100	100	-	-	-	-	-	-
	Crow	100	100	-	-	-	-	-	-
	Rats	100	100	-	-	-	-	-	-
	Disease								
	Fruit Rot	100	100	-	-	-	-	-	-
	Weeds								
	Carabao grass	100	100	1	1	-	-	-	-
	Three-lobed morning glory, Chocolate weed, Chinese burr, Common wire weed	-	-	-	-	-	-	-	-

Lanzones in Bucal and San Francisco suffer from scale insect infestations. The trees are also infested with mistletoe (*Scurrula atropurpurea*), a parasitic plant. This parasitic plant is totally dependent on its host for water and food, causing a severe yield reduction and the eventual death of the host tree. In both locations, rats, crow and fruit bats are the common pests affecting the fruit. Fruit rot is also common. The coconut area in both localities, which seemed to have been clear of the coconut scale insect in the past years, are now infested with the pest. Annual and perennial weeds also abound in the lanzones and coconut plantations.

FARMERS' INTERVENTIONS

Low Elevation Sites

Farmers in San Pablo Sur control black bug and rice stem borer through insecticide spraying (table 5.4). Several years back, farmers did not seem to mind the black bug infestation as no method of control was observed. But when most of the farms became infested (78 percent), chemical control through insecticide treatment was employed. Deltamethrin, carbofuran, and lambacyhalothin are among the most commonly used insecticides for the control of insect pests.

The control of the golden apple snail in rice fields in the past was achieved through handpicking, duck grazing, and chemical means; niclosamide, which comes in different brands, is very effective against the snails.

Rats have been controlled by trapping them or physically destroying their burrows; baiting and killing rats with acute poisons like zinc phosphide or with an anticoagulant or chronic poison like coumatetralyl has been done as well.

Control of the insect vector, which transmits the virus causing tungro in rice, has been done through insecticide treatments. The control of bacterial leaf blight employed by some farmers, however, has not proven to be effective; the chemical spray they use, Funguran-OH, is meant to fight fungi and molds and seems to do nothing to the bacterium that causes the disease.

Table 5.4. Farmers' practices to manage pests and diseases in Low Elevation sites

Location	Crop	Pest/Disease	Past Year	Current Year
San Pablo Sur	Rice	Insect Pests	Insecticides	Insecticides
		Rats	Trapping Baiting	Trapping Baiting
		Golden Apple Snail	Hand picking Duck grazing Molluscicides	Duck grazing Molluscicides
		Tungro/Green leafhopper	Insecticides	Insecticides
		Bacterial leaf blight	-	Fungicides
		Weeds	Hand weeding	Hand weeding Herbicides
Patimbao	Rice	Insect Pests	Light trapping Insecticides	Light trapping Insecticides
		Rats	Trapping Baiting	Baiting
		Golden Apple Snail	Hand picking Molluscicides	Hand picking Molluscicides
		Tungro/Green leafhopper	Roguing Insecticides	Roguing Insecticides
		Bacterial leaf blight, Rice blast, Sheath blight	Roguing Fungicides	Roguing Fungicides
		Weeds	Hand weeding	Hand weeding Weeders Herbicides

Weeds in lowland rice have been controlled by hand weeding in the past but currently, the method is used only as a supplement to herbicide treatments. Butachlor, 2,4-D, butachlor + 2,4-D, or metsulfuron-methyl+chlorimuron-ethyl are applied pre-emergence or early post-emergence.

Farmers of Patimbao have been using insecticides against rice stem borers and black bugs since the insect pests started infesting their rice crops; they have also used light traps to reduce the black bug population. Commonly used insecticides are cypermethrin, carbofuran, and lambda cyhalothrin, among others.

Besides duck grazing and the spraying of niclosamide, a molluscicide, farmers have controlled golden apple snails by picking them off by hand. Currently, however, handpicking has been abandoned in favor of the application of niclosamide, which is both time-saving and less laborious.

Tungro has been avoided by spraying insecticides that hit green leafhoppers. In instances where the rice plant has already been affected, roguing, or the removal of the infected plant, and subsequently burying it, is done. Other diseases are controlled through roguing and the spraying of chemicals.

Hand weeding was the only method used before the introduction of herbicides. Since then, farmers have opted to apply weed killers either as pre-emergence or post-emergence sprays. However, weeding by hand or by weeding tools are still being done by some farmers.

Medium Elevation Sites

Rice farmers in Barangay Bungkol use insecticides to control insect pests (table 5.5). Plants affected by rice stem borers are sprayed with insecticides. Farmers who cannot afford pesticides just remove infested plants from the field. Currently, however, with the introduction of more effective and affordable insecticides, more farmers use chemical controls, which is more efficient.

Chemical control is also the top choice against the golden apple snail, the green leafhopper and bacterial leaf blight of rice.

Lowland weeds are easily controlled by herbicides, which is much more cost-effective than hand weeding.

Insecticides are used to control insect pests in tomato, radish and bitter melon crops.

Fungicides have traditionally been used against diseases in vegetables.

Besides hand weeding, herbicides are used to control perennial and annual weeds. Glyphosate, a systemic herbicide that is effective against perennial weeds like purple nutsedge and carabao grass, is applied as a pre-plant treatment or as a post-emergence directed spray between crop rows. Paraquat, a contact herbicide, provides a knockdown control of annual and perennial weeds prior to planting or as a post-emergence directed spray between crop rows. Hand weeding or spot weeding is also practiced by some.

A coconut scale insect (CSI) infestation is controlled by spraying plants with a concoction of dishwashing detergent and coconut oil or vegetable oil in water. A similar mixture is used to control the lanzones scale insect.

Control of rats is done through poison baiting.

Black bug and rice stem borer infestations are controlled in Barangay Calumpang by spraying insecticide in addition to light trapping.

Handpicking and treating water with molluscicide were the methods previously employed by farmers to control the golden apple snail. With the introduction of more potent molluscicides, handpicking has been totally eliminated. Furthermore, the reduction of irrigation water to saturation level limits the mobility of the snail, thereby reducing its capacity to inflict more damage.

An increase in a tungro infestation has led farmers to use insecticides that limit the population of the green leafhopper, the insect vector that carries the virus. Sheath blight, rice blast, and bacterial leaf blight are managed through chemical treatment as well. In some instances, farmers rogue the infected plants to eliminate the source of inoculum, consequently minimizing further infection.

Insecticide and fungicide spraying are the most popular means of control for insect pests and diseases in vegetables. Farmers have a wide choice of chemicals for the control of specific pests for almost all of their crops.

Weed control is done through manual weeding and herbicide application.

Coconuts in Barangay Calumpang have recently been infested with CSI. Trunk injection of a systemic insecticide to temporarily minimize the further spread and damage was instituted by the local government units in CALABARZON. Previous spraying of chemicals was too hazardous for the applicator and failed to control the pest.

Table 5.5. Farmers' practices to manage pests and diseases in Medium Elevation sites

Location	Crop	Pest/Disease	Past Year	Current Year
Bungkol	Rice	Insect Pests	Roguing; Insecticides	Insecticides
		Rats	Baiting	Baiting
		Golden Apple Snail	Handpicking; Molluscicides	Hand picking; Molluscicides
		Tungro/Green leafhopper	Insecticides	Insecticides
		Bacterial leaf blight	Fungicides	Fungicides
		Weeds	Hand weeding	Hand weeding; Herbicides
	Tomato	Insect Pests	Insecticides	Insecticides
		Diseases	Fungicides	Fungicides
		Rats	Baiting	Baiting
		Weeds	-	Hand weeding; Herbicides
	Radish	Insect Pests	Insecticides	Insecticides
		Rats	-	Baiting
		Weeds	-	Hand weeding; Herbicides
	Bitter gourd	Insect Pests	Insecticides	Insecticides
		Rats	Baiting	Baiting
		Diseases	Fungicides	Fungicides
		Weeds	Hand weeding	Hand weeding; Herbicides
	Coconut	Coconut Scale insect	-	Dishwashing liquid + coconut oil + water
		Rats	-	Baiting
		Weeds	-	Hand weeding/Slashing
	Lanzones	Scale insect	-	Dishwashing liquid + coconut oil + water
		Bats	-	-
		Crow	-	-
		Rats	-	Baiting
Calumpang	Rice	Insect Pests	Light trapping; Insecticides	Light trapping; Insecticides
		Rats	Trapping; Baiting	Baiting
		Golden apple snail	Hand picking; Molluscicides; Water management	Molluscicides; Water management
		Tungro/Green leafhopper	Roguing; Insecticides	Roguing; Insecticides
		Bacterial leaf blight, Rice blast, Sheath blight	Roguing; Fungicides	Roguing; Fungicides
		Weeds	Hand weeding	Hand weeding; Weeders; Herbicides
	Tomato	Insect pests	Insecticides	Insecticides
		Rats	Baiting	Baiting
		Diseases	Fungicides	Fungicides
		Weeds	Hand weeding	Hand weeding; Mechanical weeding
	Bitter gourd	Insects	Insecticides	Insecticides
		Rats	Baiting	Baiting
		Diseases	Fungicides	Fungicides
		Weeds	Hand weeding	Hand weeding; Mechanical weeding

High Elevation Sites

Rice is a minor crop in Bucal so farmers just pick off golden apple snails by hand (table 5.6). Roguing is practiced for tungro-infected plants.

Vegetable growers use insecticide sprays and remove infested plants or plant parts. No attention is given to the lanzones scale insect probably because lanzones is simply a backyard crop and not a major source of income.

Methods for weed control in crops are manual weeding and the occasional application of herbicides. Glyphosate and paraquat are commonly used as directed post-emergence sprays to control weeds prior to planting or against weeds in-between crop rows. Using herbicide sprays is more economical than hand weeding, which is labor-intensive.

Apart from the occasional removal of infested plant or plant parts, vegetable growers in Barangay San Francisco spray insecticides to control major insect pests. Similarly, preventive sprays of fungicides and other chemicals are done on vegetables while removal of infected plants and plant parts are done as a supplementary method to prevent the further spread of the disease.

Weed control is by manual weeding and herbicide application. Systemic herbicide is used for the control of perennial weeds while contact knockdown herbicide is used against most annual weeds.

Table 5.6. Farmers' practices to manage pests and diseases in High Elevation sites

Location	Crop	Pest/Disease	Past Year	Current Year
Bucal	Rice	Insect Pests	Roguing	Roguing
		Rats	-	Baiting
		Golden apple snail	Hand picking	Hand picking
		Tungro/Green leafhopper	-	Roguing
		Weeds	Hand weeding	Hand weeding
	Tomato	Insect Pests	Roguing/Hand removal; Insecticides	Insecticides
		Diseases	Roguing/Hand removal; Fungicides	Roguing/Hand-removal; Fungicides
		Rats	Baiting	Baiting
		Weeds	-	Hand weeding; Herbicides
	Radish	Insect Pests	Insecticides	Insecticides
		Rats	Baiting	Baiting
		Weeds	Hand weeding; Herbicide	Hand weeding; Herbicides; Quarantine
	Beans	Insect Pests	Insecticides	Insecticides
		Rats	Baiting	Baiting
		Diseases	Fungicides	Fungicides
		Weeds	Hand weeding	Hand weeding; Herbicides; Quarantine
	Coconut	Coconut Scale insect	-	Dishwashing liquid + coconut oil + water
		Rats	-	Baiting
		Weeds	-	Hand-weeding/Slashing
	Lanzones	Scale insect	-	-
		Rats	-	Baiting
		Weeds	-	Hand weeding

Location	Crop	Pest/Disease	Past Year	Current Year
San Francisco	Rice	Insect Pests	-	Roguing
		Rats	-	Trapping
		Golden applesnail	Hand picking	Hand picking
		Diseases		
		Tungro/Green leafhopper	-	Roguing
		Weeds	Hand weeding	Hand weeding
	Tomato	Insect Pests	Roguing/ Handpicking; Insecticides	Roguing/ Handpicking; Insecticides
		Rats	Trapping; Baiting	Trapping; Baiting
		Diseases	Fungicides	Fungicides
		Weeds	Hand-weeding	Hand-weeding
	Beans	Insect Pests	Insecticides	Insecticides
		Diseases	Fungicides	Fungicides
		Weeds	Hand-weeding	Hand-weeding; Herbicides
	Radish	Insect Pests	Insecticides	Insecticides
		Diseases	Fungicides	Fungicides
		Weeds	Hand-weeding	Hand-weeding; Herbicides
	Coconut	Coconut Scale insect	-	-
		Rats; Weeds	-	-
	Lanzones	Scale insect; Rats	-	-
		Weeds	Hand-weeding	Hand-weeding

FOOD SAFETY AND FOOD SECURITY IMPLICATIONS

It is evident that farmers changed their crops and cropping patterns in response to the need for improving yields. The majority of the growers changed their original crops to crops that are market-dictated. For some, however, these changes were in response to climatic variations. Crop varieties or crop types that are resilient to environment extremes have been adopted by a number of farmers, an example of which is the short-statured rice, which can resist strong winds and the rush of floodwater during heavy and continuous rains. Crops of early-maturing varieties have also been adopted to escape the production losses that can be caused by an early onset of rains. Many farmers have likewise opted to change from monoculture to polyculture for food security reasons. Total failure is less likely with intercropping and multiple cropping than with single cropping. These techniques ensure harvest for the farmers.

Cultural practices change with the change in crop. Rotational cropping, as practiced by some farmers, may have been one of the approaches to manage pests because changes in the kind of crops from season to season within the same area can reduce the prevalence of pests; different crops have unique microclimates within their canopies and will, subsequently, affect the kind of pests that are able to survive. Additionally, some crops that the farmers chose were tolerant to insect pests and disease-causing organisms. Comparably, other farmers also use chemicals to control pests.

In addition to some of the age-old techniques, growers use herbicides to control weeds, fungicides to manage plant diseases, insecticides to minimize insect damage to crops, and other chemicals to keep the damage of the golden apple snail and vertebrate pests at a minimum.

Apart from the advice given by government personnel, many of the recommendations employed by farmers are from private companies that profit from the sales of their products. Many of farmers follow these recommendations without really understanding the nature of the pest and the damage it creates. Most of the information on pesticide usage is relayed through farmer-to-farmer communication. This has resulted in the use of the inappropriate pesticide against target pests. Another manner in which pesticides are misused is in the amount of pesticides used; many farmers may apply too much making it costly, or too little making it ineffective. This could also lead to the development of pest resistance and, eventually, the excessive application of pesticides, which can result in high residues in food crops rendering them unsafe for consumption. Information dissemination on pest and pesticide management is, therefore, necessary.

SUMMARY AND CONCLUSION

An increase in pest incidence and the degree of pest infestation were observed; in most instances, the numbers escalated because of changes in the environmental conditions. These weather changes might have prompted growers to change crops and varieties. For example, a tomato variety tolerant to flooding or heavy rains has replaced the traditional variety which could not tolerate continuous rains in the medium and high elevation sites. Some varieties that were advertised to be resistant to diseases or pest infestations were also adopted by growers.

Coconut scale insects, a new insect pest of the coconut tree, have infested palms in the low, medium and high elevation sites. To combat these, farmers have started spraying a mixture of dishwashing liquid, coconut oil, and water to the underside of the leaves where the insect is found. The presence of the lanzones scale insect was also observed but no control measures have been implemented, probably because lanzones is a minor and backyard crop.

Many farmers use chemicals to manage weeds (a serious problem in annual crops for many farms), insect pests, golden apple snails, rats, and diseases of rice, vegetables, and other perennials. They have a wide array of insecticides, fungicides, herbicides, and other chemicals from which to choose. While some farmers are completely dependent on pesticides, there are others who still employ the traditional ways of dealing with plant problems—like handpicking weeds or rouging diseased and infested plants; sometimes, though, these are done in conjunction with pesticide use. It was observed, however, that some farmers are not knowledgeable about the nature of pests and the appropriate pesticide to use so some apply these pesticides indiscriminately without regard to proper dosage or timing or even the hazards that these chemicals have.

Interestingly, most of the practices adopted by the farmers in the Sta. Cruz Watershed are adaptation mechanisms for the changing conditions of the environment brought about by climate change. Their ultimate objective is to attain food security and their techniques appear to be working.

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Appendix 5.1. Common and scientific names of plants, vertebrates and invertebrate pests and diseases and their causal organisms

Common Name	Scientific Name
Plants	
Mistletoe	<i>Scurrula atropurpurea</i> (Blume) Danser
Barnyard grass	<i>Echinochloa crus-galli</i> (L.) Beauv. ssp. <i>hispidula</i> (Retz.) Honda
Balloon plant	<i>Cardiospermum halicacabum</i> L.
Carabao grass	<i>Paspalum conjugatum</i> Berg.
Chinese burr	<i>Triumfetta bartramia</i> L.
Chocolate weed	<i>Melochia concatenata</i> L.
Cogon grass	<i>Imperata cylindrica</i> (L.) Beauv.
Common wireweed	<i>Sida acuta</i> Burm. f.
Devil weed	<i>Chromolaena odorata</i> (L.) R.M. King & M. Robinson
Fimbristylis	<i>Fimbristylis miliacea</i> (L.) Vahl
Goose grass	<i>Eleusine indica</i> (L.) Gaertn.
Gooseweed	<i>Sphenocleazeylanica</i> Gaertn.
Java grass	<i>Cyperus kyllingia</i> Endl.
Jungle rice	<i>Echinochloa colona</i> (L.) Link.
Knotgrass	<i>Paspalum distichum</i> L.
Lilac tasselflower	<i>Emilia sonchifolia</i> (L.) DC. ex Wight
Mallow	<i>Malvastrum coromandelianum</i> (L.) Garcke
Small-flower umbrella plant	<i>Cyperus difformis</i> L.
Rice flatsedge	<i>Cyperus iria</i> L.
Pickerel weed	<i>Monochoria vaginalis</i> (Burm. f.) Presl
Purple nutsedge	<i>Cyperus rotundus</i> L.
Ragleaf	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore
Tropic ageratum	<i>Ageratum conyzoides</i> L.
Slender amaranth	<i>Amaranthus viridis</i> L.
Spiny amaranth	<i>Amaranthus spinosus</i> L.
Water lettuce	<i>Pistia stratiotes</i> L.
Insects	
Rice black bug	<i>Scotinophara</i> spp.
Rice stem borer	<i>Scirpophaga</i> spp.
Whiteflies	<i>Bemisia tabaci</i> (Gennadeus) <i>Trialeurodes vaporariorum</i> (Westwood)
Fruitworm	<i>Helicoverpa armigera</i> (Hubner)
Fruitfly	<i>Bactrocera philippinensis</i> (Drew & Hancock) <i>B. occipitalis</i> (Bezzi)
Mites	<i>Polyphagotarsonemus latus</i> (Banks)
Spider mites	<i>Tetranychus</i> spp.
Thrips	<i>Thrips palmi</i> Karny
Bean Aphids	<i>Aphis craccivora</i> Koch
Melon Aphids	<i>A. gossypii</i> Glover

PEST DYNAMICS AND CROP PRODUCTIVITY

Bean pod borer	<i>Maruca testulalis</i> (Geyer)
Diamond-back moth	<i>Plutella maculipennis</i> (L.)
Leafminer	<i>Liriomyza</i> spp.
Cutworm	<i>Spodoptera litura</i> (Fabr.)
Rigid coconut scale insect	<i>Aspidiotus rigidus</i> Reyn.
Lanzones mussel scale insect	<i>Unaspis mabilis</i> Lit & Barbecho
Green leafhoppers	<i>Nephotettix virescens</i> (Distant) <i>N. nigropictus</i> (Stal)
Mollusc	
Golden apple snail	<i>Pomacea canaliculata</i> (Lamarck) <i>P. maculata</i> Perry
Vertebrates	
Common rice field rat	<i>Rattus norvegicus</i> Temminck
Asian field rat	<i>R. argentiventer</i> (Robinson and Kloss)
Fruit bats	<i>Otopterus carillon</i> Kock
Crow	<i>Corvus senegalensis</i> (Horsfield)
Diseases	
Rice tungro virus	combination of two viruses
Bacterial leaf blight	<i>Xanthomonas oryzae</i> (Ishiyama) Dowson pv. <i>oryzae</i> (Ishiyama) Swings et al.
Rice blast	<i>Pyricularia oryzae</i> Cav.
Rice sheath blight	<i>Rhizoctonia solani</i> Kühn
Bacterial wilt	<i>Ralstonia solanacearum</i> (Smith) Yabuuchi et al.
Leaf mold	<i>Cercospora fuligena</i> (Roldan) Deighton
Leaf spot	<i>Alternaria</i> spp.; <i>Cercospora</i> spp.
Blossom-end rot	Mineral deficiency (Calcium)

CHAPTER 6

EFFECTS OF CLIMATE CHANGE ON FOOD SECURITY THROUGH LIVESTOCK AND POULTRY PRODUCTION

RENATO SA. VEGA, PAULINE R. CAJANO AND RAEM DOMINIC S. BRION

This chapter discusses the structure of livestock and poultry industries in the Sta. Cruz Watershed as well as the direct and indirect effects of climate change on their existing production, including Cadmium contamination assessment as threats to food security. Only 36 out of 160 respondents were livestock and poultry farmers, and all were backyard raisers. Swine was found to be the top income earner among the livestock and poultry animals and considered the most vulnerable to heat stress, the most apparent effect of climate change. Cd contamination was determined in the samples of feeds, liver, manure and meat using AAS-Flame. Traces of Cd were found in the samples with values beyond the tolerable limit.

Keywords: livestock, climate change, Cadmium, heat stress

INTRODUCTION

The livestock and poultry industries provide the best protein sources with meat, milk, eggs and other essential nutrients (FAO 2011) vital for the development and growth of the body (Smith et al. 2013). These industries are also a significant source of income for more than one billion people globally and serve as a form of damage reduction caused by natural hazards for families in vulnerable areas (Herrero et al. 2009). As of January 2015, there were almost 12 million livestock and poultry heads reported in the country, with 65 percent produced by backyard farmers (BAS 2014). In the contrary case, reports regarding economic loss from livestock raisers are evident globally due to risks brought by climate's unpredictability.

Though studies claim that climate change effects will not manifest until after a few decades, it is certain to have negative impacts on income generation as it slowly causes biophysical changes where most of our agricultural production takes place (Schmidhuber and Tubiello 2007). As it continues to threaten the agricultural sector, demands for animal-source foods are predicted to be doubled with the coming years (Nelson et al. 2009) due to the growing appreciation for their nutritional benefits as well as the constant increase in population. These demands are further magnified by economic growth, urbanization and globalization, which are considered to be the driving forces for global shifts in diets that require higher protein intakes (Pingali 2007). This demand inflation calls for a more intensified agricultural production, which could put a great risk on food security.

Defined by FAO in 1996, food security has four key dimensions: (a) food availability, (b) access to food, (c) stability of food supply, and (d) utilization of safe and nutritious food (as cited by FAO 2011). This study will examine climate change effects on food security, more specifically on its first and fourth dimensions, through livestock and poultry productions in the Sta. Cruz Watershed. Food availability will be based on the actual livestock and poultry productions existing on the site, while the utilization of safe and nutritious food will be initially assessed for heavy metal contamination of swine, specifically Cadmium (symbol: Cd), as guided by the study in ducks entitled "Low Levels of Organochlorine Residues in Combination with Cadmium in Feed at Peripubertal Stage of Domestic Mallard (*Anas platyrhynchos* Linn.)" (Vega et al. 2011).

This chapter aims to determine the effects of climate change on food security through livestock and poultry productions, of six barangays in Sta. Cruz Watershed. Specifically, it aims to:

1. Describe the structure of livestock and poultry production in the Sta. Cruz Watershed;
2. Identify the direct and indirect effects of climate change on livestock and poultry productions as experienced by the livestock and poultry raisers; and
3. Analyze Cd contamination on the feeds and the pork.

STRUCTURE OF LIVESTOCK AND POULTRY PRODUCTION

Out of 160 respondents, only 36 (22.5 percent) were livestock and poultry raisers covered by the watershed. The distribution according to the species of livestock and poultry raised are shown in figure 6.1. All of the respondents were small scale or backyard farmers. The concentration of livestock and poultry farmers was in the low elevation where 9.4 percent of the total respondents were located; this was followed by

6.91 percent and 6.25 percent in the medium and high elevations, respectively. Possible reasons include (a) the nearness and accessibility to the market; (b) a wider rice-land area (1,400 ha) as the source of pasture, forage grasses and rice-by products; and (c) a higher meat demand due to the population's higher purchasing capability.

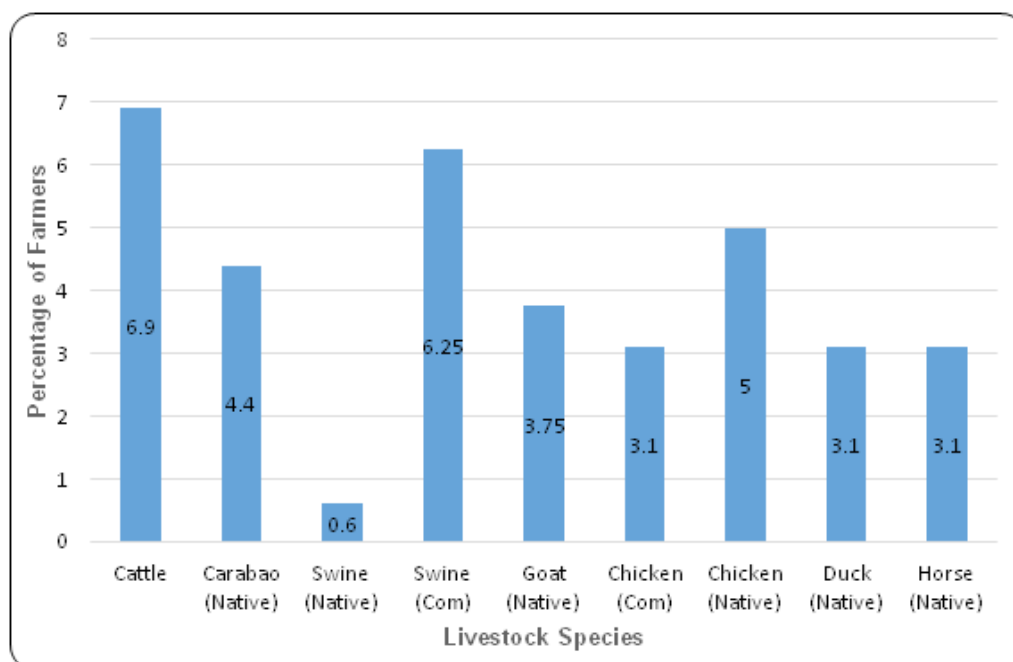


Figure 6.1. Percentage of farmers raising livestock and poultry (using sampled data)

Figure 6.2 shows the breakdown of farmers per elevation based on each livestock and poultry species raised. The disparity of the animals raised across elevation could reflect the farmer's needs arising from the nature of their location. For instance, horses were only found in the high elevation areas where a means of transport for crop-produce was a necessity. Likewise, carabaos, which are raised for plowing rice fields, were predominant in the low elevation areas where rice fields are commonly found. Aside from the needs of the raisers, predominance of animals raised also revealed the location's access to certain feed resources. In the case of ducks in the low elevation, its rice field availability was a good source of feeds. Farmers access feeds from rice land after harvest until the next transplanting through a duck-ranging system. It is the best alternative for costly commercial feeds since some of the farmers keep livestock and poultry for household consumption.

The mean number of heads (per animal) raised by each farmer is presented in figure 6.3. Since all of the respondents were backyard raisers, mean values obtained were relatively small. Animals that were raised with the most number of heads in low elevation areas were exotic chickens, ducks and native chickens. For the medium elevation, animals raised were exotic chickens, swine and native chickens. For the high elevation, these were swine, native chickens and horses. Overall, chicken (exotic and native) and swine had the highest mean number of heads. The values obtained from cattle raisers can be considered inconsistent compared to the rest of the animals; while figures 6.1 and 6.2 show that there were many cattle raisers across the elevations, data from figure 6.3 (number of heads) showed a much lower value. This suggests that cattle-

raising households have just a few cattle, with most having only one. An important factor to consider based on the results is the seasonality of markets. For cattle owners, keeping one is a good source for emergency funds; the animal is usually sold only when unexpected problems in the household are encountered. On the other hand, the consistency of data for swine and chickens could indicate that these two are sold regularly in the market. Swine is commonly sold upon weaning while chickens are sold upon reaching maturity or after 45 days for the commercial breeds.

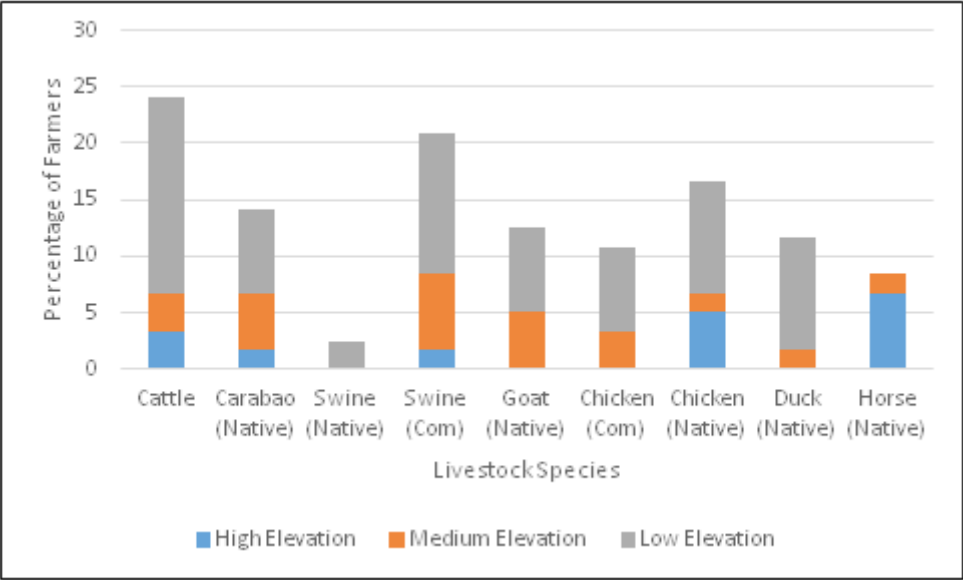


Figure 6.2. Breakdown of livestock and poultry raisers from each elevation

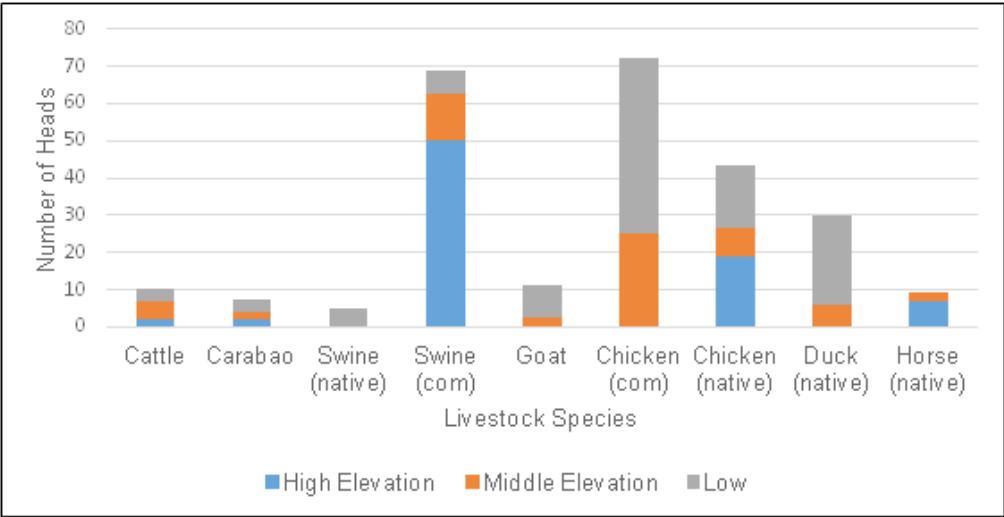


Figure 6.3. Mean number of heads of raised by livestock and poultry farmers in Sta Cruz Watershed

Table 6.1 tabulates the types and breeds of animals with the number of farmers that raise them and cross-tabulates that data to show the number of farms per combination

of animals. Figures show that fifty-eight per cent of the farmers were raising a single animal, 28 percent were raising two, while 14 percent were raising more than two. The results show that the majority of the farmers specialized in one animal, commonly the commercial breed of swine. On the other hand, the usual animals that were raised with others or in combination were cattle, carabao and goat. These were the grazers or the livestock animals that only depend on native pasture for feeds.

Table 6.1. Combination of livestock/poultry raised by the farmers in Sta. Cruz Watershed

Animal		Swine ¹		Chicken ¹		Native Cattle	Native Carabao	Native Goat	Native Horse	Native Duck
		N	C	N						
Swine	Commercial	10	0	2	1	1	1	1	1	2
	Native		1	0	0	0	0	0	0	0
Chicken	Commercial			5	2	2	2	4	0	2
	Native				8	4	2	2	0	2
Cattle (native)						11	4	4	0	2
Carabao (native)							7	3	1	2
Goat (native)								6	0	3
Horse (native)									5	0
Duck (native)										5

¹C – commercial; N – native

Most of the farmers depend on locally available feeds so that they could keep costs to a minimum. The non-cost animals are those that can feed on grass, such as goats, carabaos, horses and cattle; chickens and ducks are raised at a low cost. Swine has the highest production cost. Almost all the swine in the study sites are commercial breeds that rely greatly on expensive commercial feeds and, because the swine are commonly raised for generating income, veterinary and drug expenses are also part of production costs as profits greatly depend on the swine's health.

Data for prices sold were determined from those participating in the market. Based on the price per head, cattle have the most expensive market value, which commonly ranges from PHP 14,000 to 17,000 aging three to five years old. For swine, a weanling costs around PHP 1,300 to 1,800 and chickens are sold for PHP 150 to 180 per head. Given that there is an average litter size of 6-12 piglets and the price of weanlings per head, it can be concluded that swine is the top income earner among the livestock and poultry raised annually. Though cattle relatively costs much higher, its seasonality of market lasts for three to five years compared to swine, which generates more than two parities (number of birthings) a year.

EFFECTS OF CLIMATE CHANGE ON LIVESTOCK AND POULTRY PRODUCTION

This section will discuss the direct and indirect effects of climate change as experienced by livestock and poultry farmers in the Sta. Cruz watershed. As stated by Smit, McNabb, and Smithers (1996), climate change affects animal production through the alteration of feed-grain sources and availability, including the weather and extreme events affect animal performance and health via the spread of diseases and pests.

Direct Effects of Climate Change

The direct effects of climate change on animal production are the risks in the health, growth and performance of the animal brought about by heat-related stresses and diseases (Thornton et al. 2009). Farmer data on these effects should be considered in order to assess climate change impact on livestock and poultry animals. Fifty-eight percent of the total farmers “strongly agree” while 22.2 percent “agree” that climate change caused a reduction in their animal production (table 6.2). Majority (63.8 percent) of the respondents who recognized climate change effects and agreed with the statement came from the low and medium elevation areas while majority (30 percent) of those who disagreed came from the high elevation.

Table 6.2. Perception on the reduction of livestock production due to climate change (heat stress and cold night) by the backyard livestock raisers

Perception	High Elevation	Mid Elevation	Low Elevation	Mean
Strongly disagree	-	-	-	-
Disagree	3 (30%)	1 (9.1%)	1 (6.7%)	5 (13.9%)
Don't know	1 (10%)	-	1 (6.7%)	2 (5.6%)
Agree	1 (10%)	4 (36.4%)	3 (20%)	8 (22.2%)
Strongly agree	5 (50%)	6 (54.5%)	10 (66.6%)	21 (58.3%)
Total	10	11	15	-

When asked about climate change effects, farmers considered extreme heat, typhoons and floods as the major climate change impacts they have experienced and believe to be happening more frequently over time. Among these, they considered extreme heat brought about by global warming as the most common and the worst problem they face when it comes to their animals' productivity.

Abnormalities, diseases or disorders listed by the farmers were all observed in swine/pigs (table 6.3). Pneumonia and watery feces were the most common ailments across elevations; meanwhile, disorders observed mainly in the low and mid elevations were heat-stress related, such as heat stroke, skin rashes and vomiting. Pigs have a low heat capacity due to the absence of sweat glands, preventing them from releasing heat from their bodies (Nardone et al. 2010). A gestating sow's thermo neutral zone ranges from 12 to 20°C (Botto et al. 2013) but the usual temperature in the Philippines during summer ranges from 30°C to 35°C. The sequential response of pigs to extending heat stress are normally: (a) faster respiration rate (>40 beats/minute); (b) increased water intake, displacing the capacity of the stomach for feed; (c) frequent urination and watery feces; (d) lethargy and anorexia; and finally, because of negative energy balance and insufficient nutrition the animal (e) becomes predisposed to illness or disease in the presence of pathogenic microorganisms (Mount 1979 as cited in Thuy 2005; Vega et al. 2010). Other diseases include the Foot and Mouth Disease (FMD), which was observed in the site way back in 2005, before our country was declared FMD free in June 2011 (Lapus 2014). Also, according to the respondents, respiratory and gastrointestinal disorders are more intense relative to 20 years before.

Table 6.3. Recent disorders or diseases of pigs observed by backyard farmers at the Sta. Cruz watershed

Organs/ Systems with Disorder	High Elevation	Mid Elevation	Low Elevation
Gastro-Intestinal	Watery feces	Watery feces	Watery feces, Vomiting
Lungs	Pneumonia, Cough	-	Pneumonia, Colds
Cardiovascular	-	Heat Stroke	Heat Stroke
Reproductive	Difficulty conceiving	-	No Milk Release
Viral Disease	-	-	Foot & Mouth Disease
Parasites	Worms (endoparasite)	Skin Rashes	

Indirect Effects of Climate Change

The indirect effect of climate change involves the alteration of food source availability that lead to changes in the quality and quantity of animal food (Thornton et al. 2009). Farmers were asked about the availability of commercial feeds, local feeds and native pasture. Results showed no seasonal variability among the kinds of feeds but these vary across elevations. For instance, most farmers who answered that native pasture is very abundantly available throughout the year came from the low elevation site where more rice fields are found. Local feeds availability is least abundant across elevations while commercial feeds were the most abundantly available source of feeds across elevations. Unfortunately, the survey results could not provide any conclusions because the data gathered were mostly affected by various factors that vary across elevation, like accessibility and awareness to locally abundant feed resources.

Cd Contamination. Heavy metal contamination has always been a great threat to human health. The backyard piggery farms have almost similar management styles in raising the pigs under confinement, utilizing 100 percent commercial feeds that are mostly available in the market. These formulated rations are sold in the market by several feed mill companies operating within CALABARZON; the names of the companies will not be disclosed as this is just an exploratory/ preliminary assessment.

The heavy metal Cd was assayed by means of AAS-FLAME (Atomic Absorption Spectrophotometry – FLAME) by the Central Analytical Service Laboratory of UPLB with ISO/IEC 17025-2005. The estimated method detection limit (EMDL) of the assay is 0.050 ppb. The results of several samples of commercial feeds, manure, liver and meat (100g each) that were gathered from Barangays San Francisco and Bucal, Nagcarlan are presented in table 6.4. Out of four feed companies, two participated by providing 200g sample feed ingredients for Cd analysis and these are presented in table 6.4. Only limited samples were gathered due to the expensive cost of Cd analysis; thus, this assessment will only serve as basis for further studies.

When the formulated diets of pigs' were found to have more than 0.025 ppm of Cd, the companies were notified through email that their formulated ration obtained Cd beyond the tolerable daily limits imposed by Health Canada (2011) and 0.070 ppm by the European Food Safety Authority (2012). Results in table 6.4 show high levels of Cd contamination in most feed and meat samples. This could be a health concern for consumers because during extreme climate events, farmers may shift to the use of commercial feeds due to convenience.

Table 6.4. Concentration of Cd $\pm$ SEM¹ (ppm or mg/kg) of formulated rations², manure and edible parts/ tissues taken from farmers (February to September 2014)

Classification	Sample	N	Mean $\pm$ Sem³ (ppm or mg/kg)
Formulated Ration	Pre-Starter	2	1.33 $\pm$ 0.27
	Starter	2	1.12 $\pm$ 0.03
	Grower	2	1.18 $\pm$ 0.06
	Breeder	4	1.35 $\pm$ 0.12
	Finisher	1	1.4275
Organic Fertilizer	Manure	8	0.46 $\pm$ 0.125
Edible Parts	Liver	6	0.849 $\pm$ 0.22
	Blood	4	0.104 $\pm$ 0.07
	Meat	6	0.069 $\pm$ 0.03
Feed Ingredients	Rice Bran	2	0.635 $\pm$ 0.13
	US Soya	2	0.68 $\pm$ 0.01
	Ground Corn	2	0.19 $\pm$ 0.21
	Cassava Meal	1	0.39
	Mono Ca-P	1	2.71
	Biofos	1	12.03
	Zeolite	1	3.74
	Antioxidant	2	4.475 $\pm$ 2.55
	Mineral Premix	2	5.315 $\pm$ 1.72
	Vitamin Premix	1	1.62
	Salt	2	7.1 $\pm$ 0.07
	DL – Methionine	1	ND
	Choline Chloride	1	0.04
	L- Threonine	1	ND
	L - Lysine	1	ND
	Limestone	2	8.22 $\pm$ 0.07

¹ Heavy metal Cd was analysed using AAS-Flame method at the Central Analytical Service Laboratory of the National Institute of Molecular Biology and Biotechnology, UP Los Baños;

³ ND= Non-detectable; Provisional Tolerable Monthly Intake (TDI) is less than 0.025ppm (25ug/kg b.w.) as imposed by EFSA 2009

SUMMARY AND CONCLUSION

Thirty-six backyard livestock and poultry raisers were identified out of 160 respondents. Majority of the farmers came from the low elevation site because its location has easier access to food resources and the market; the site also has higher meat demands. The farmers' selection of which animals to raise depended on their needs and the convenience as influenced by their elevation. Animals were raised for labour, income generation, household consumption, or all three. Most of the farmers raised multiple animals. Popular choices among them are the grass-eating animals,

which were identified as non-cost animals because they graze on free land. Other non-cost animals were raised for household consumption while those with a high-cost of production were for income generation. Based on its market seasonality and dominance across elevations, swine is considered as the top income livestock earner in the Sta. Cruz watershed.

The livestock and poultry farmers have perceived a reduction in animal production, which they believe is caused by climate change (intense daytime heat and cold nighttime temperature, flooding and high humidity). The direct effect of climate change was more pronounced in swine farms; pig raisers have observed more respiratory, reproductive, cardiovascular, gastrointestinal, viral and parasitic diseases. Diseases and disorders manifested in the low and mid elevation areas were heat-stress related. It can be concluded that swine is the most susceptible to the effects of warming temperatures due to their lack of sweat glands, hence, inability to release body heat, resulting in stress.

Generalizations for the indirect effects of climate change as experienced by the farmers could not yet be provided because several factors must first be considered.

Threats on food security/safety include Cd contamination of feed for swine production. Cd analysis results show traces of Cd on samples of meat, liver, manure and feeds with values that are beyond the tolerable amount of 0.025 ppm.

POLICY RECOMMENDATIONS

It will be more strategic to not only consider the productivity traits of the animal breeds but its over-all capability to adapt and cope with heat related stress and diseases as well (Nardone et al. 2010). With this in mind, crossbreeding animals to select traits best suited for the evolving environment is one possible solution for mitigating the effects of climate change on the livestock and poultry industry. Hybrid crosses of pigs and chickens developed by crossbreeding exotic breeds with commercial breeds will offer a more sustainable solution in that a commercial breed's productivity and a native breed's adaptability to heat stress might create a more stable atmosphere for livestock and poultry production. Moreover, it could also reduce the feed cost for native breeds that depend on locally available feeds and forages. This approach may indirectly reduce the importation of commercial feed ingredients contaminated with Cd and other heavy metals, which are apparently higher than locally available materials. Accordingly, municipal or Local Government Units should provide access to pure native boars that will provide sperms to impregnate exotic breeds of sows, which are predominantly available in the village.

Another recommendation is for the enhancement and improvement of the certification and feed regulatory processes by issuing process checking and unwanted residue detection. Cadmium poses a serious threat to human health when consumed. According to studies, damage to the kidney and bones may occur at lower Cd exposure levels than anticipated (Jarup 2003). It is recommended that cadmium contamination effects on mammals should be studied further.

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CHAPTER 7

FOOD MARKET ADAPTATION STRATEGIES TO CLIMATE CHANGE

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The study aimed to determine the adaptation strategies of traders of rice, vegetables, root crops, fish, poultry, and livestock for food security under conditions of climate change. To achieve the objectives of the study, key informant interviews of barangay officials and 32 agricultural traders in the high elevation barangays of Nagcarlan, medium elevation barangays of Liliw, and low elevation barangays of Sta. Cruz, as well as major public markets of Nagcarlan and Sta. Cruz, all in the province of Laguna, was done in 2014.

The key barangay officials and agricultural traders considered strong typhoons and floods as extreme events. Unforgettable extreme events were Typhoons Ondoy in September 2009, Santi in October 2009, Milenyo in September 2006 and the habagat (southwest monsoon) in July 2012, as well as the floods in some Sta. Cruz barangays caused by Ondoy, Santi and the habagat, which lasted from less than a month to six months.

Extreme events do not seem to have an effect on the buying and selling prices of rice, chicken and pork. The sale of fish and shellfish, however, are hampered during these extreme events. Market prices of vegetables, root crops, and fruits are generally much higher during severe weather; although the volume sold is much less, the profit per kilogram of these agricultural commodities is much higher during extreme events. The effects of extreme events on the food trade do not vary much across elevations; one distinct difference, though, is in the vegetable sales of the barangays that are prone to flooding; when their fields are inundated with floodwaters, crops are destroyed and they have nothing to sell.

Notable problems encountered by traders include limited capital, delayed payment of buyers, high prices and price fluctuations, and spoilage of agricultural commodities, especially during the rainy season. Adaptation strategies of traders during extreme events include resting for two to three days, decreasing or increasing the volume handled of commodities, refraining from slaughtering pigs, and mixing frozen cuts of chicken with fresh ones.

Since market prices are generally higher during extreme events, it is recommended that these prices be monitored at the barangay level. Establishing a market information network and setting price ceilings for some commodities could help. It is also important that food security be ensured at all times. Some traders pointed out that there is a need for a bagsakan or trading center for agricultural commodities in the barangay; some hope to have their own stall in the market; others want loans with low interest rates to increase their capital.

Keywords: agricultural traders, food market, extreme events, adaptation strategies

INTRODUCTION

Background of the Study

Typhoons, flooding, heat stress, and drought can result in significant declines in crop yields and fish, poultry and livestock production, posing risks to food security and the environment. The emerging trends in climate change and its increasing negative impacts on food security and the environment need urgent attention by the government and the entire citizenry. It is imperative that food adaptation strategies to climate change, corresponding coping mechanisms, and necessary structural adjustments be carried out to sustain or improve food availability, accessibility, and utilization, especially in vulnerable areas.

An understanding of the agricultural traders' risk profiles, together with an analysis of the marketing system for food (including rice, vegetables, root crops, fruits, fish, poultry and livestock) and the roles of the various stakeholders in the food market industry, including the local government units (LGUs) responses to climate change and interactions with the people in the community, is crucial in formulating policies that would facilitate or improve adaptation strategies and coping mechanisms. It is therefore important that the flow of information, incentives, and the enabling environment be in place toward this end. Hence, the results of this study on food market adaptation strategies to climate change could be useful to the food market industry stakeholders in improving responses to climate change and in charting directions of policies and programs on food security, especially during extreme events.

This study aims to determine the adaptation strategies of traders of rice, vegetables, root crops, fruits, fish, poultry, and livestock under conditions of climate change as they relate to food security. Specifically, the objectives of this study are to:

1. describe the socio-economic characteristics of farmers and traders living in the vulnerable and non-vulnerable areas covered by the Sta. Cruz Subwatershed;
2. determine the knowledge, attitude and perception of these traders about climate change and climate variability;
3. determine the adaptive strategies of these traders to manage and minimize the effects of climate change and variability on their food security and the factors affecting their adoption of such strategies; and,
4. recommend policy measures to improve food market adaptation strategies to climate change.

REVIEW OF LITERATURE

Food security has been exacerbated by the effects of climate change. Hence, adaptation strategies are necessary to cope with these changes. Potential damages of climate change and climate variability, according to Leary (2007), are dependent on the responses or adaptations to changes in the environment that people make. Furthermore, Howden et al. (2007) contended that achieving increased adaptation action will necessitate integration of climate change-related issues with other risk factors, such as climate variability and market risk, and with other policy domains, such as sustainable development. The vulnerability of people would tend to influence the means of adaptation or their response to change in the environment due to climate change.

Meanwhile, the vulnerability of people or the potential for loss (Barnett and Adger 2007), depends on the “extent to which they are dependent on resources and ecosystem services,

the extent to which the resources and services they rely on are sensitive to climate change, and their capacity to adapt to changes in these resources and services.” Thus, according to Barnett and Adger, “the more people are dependent on climate sensitive forms of natural capital, and the less they rely on economic or social forms of capital, the more at risk they are from climate change” (2007). Handmer, Dovers, and Downing (1999) cited that vulnerability is an “aggregate measure of human welfare that integrates environmental, social, economic and political exposure to a range of harmful perturbations.”

Parry et al. 2001 (in Fischer et al. 2005), stated that a consensus has emerged that developing countries are more vulnerable to climate change due to the following: predominance of agriculture in their economies, the scarcity of capital for adaptation measures, their warmer baseline climates, and their heightened exposure to extreme events. On the other hand, “institutions in the wealthy industrialized countries are robust and their societies appear to be relatively well insulated against the impact of climate variability, economic problems and so on” (Handmer et al. 1999).

METHODOLOGY

Secondary data were gathered from the provincial LGU of Laguna and the municipal LGUs of six selected towns, namely, Liliw, Magdalena, Sta. Cruz, Majayjay, Rizal and Nagcarlan, during the period of September to October 2013.

Secondary data consisted of the provincial data on agricultural production, recent typhoons, ecological profile, investment programs, and development plans (i.e., Provincial Development and Physical Framework Plan 2010-2017 and Provincial Development Plan), which were acquired from the provincial government offices of Laguna, such as the Provincial Agriculture Extension Services (PAES), the Provincial Planning and Development Office (PPDO), and the Provincial Disaster Risk Reduction and Management (PDRRM). Similarly, municipal level data related to climate change and food security, typhoons and other natural disasters for the six municipalities under the study were gathered from the Municipal Agriculture Offices (MAOs), Municipal Planning and Development Offices (MPDOs), Municipal Disaster Risk Reduction and Management Offices (MDRRMOs), and Municipal Social Welfare and Development Offices (MSWDOs).

Primary information were likewise elicited from key informants consisting of barangay officials and agricultural traders in the identified six study barangays to draw some general information on current climate change issues as well as on traders’ adaptive strategies to the impacts of climate change on their marketing activities. A total of 32 agricultural traders (22 from the six barangays and 10 from the major public markets of Nagcarlan and Sta. Cruz) and six barangay officials were interviewed (table 7.1).

RESULTS AND DISCUSSIONS

Socio-demographic and Economic Profile of Agricultural Traders

Age of traders interviewed ranged from 21 to 72 (table 7.2). All were female except for one male. All were married except for one single and two widows. Most respondents finished secondary to college level of education. Their main sources of income were mostly related to trade and business. The amount of operating capital needed in the trading of agricultural commodities ranges from PHP 1,000 to PHP 20,000.

Table 7.1. Number of Key Informants Interviewed by Study Site, Laguna, 2014

Agricultural Traders	Number
High Elevation	
San Francisco, Nagcarlan	3
Bukal, Nagcarlan	5
Medium Elevation	
Calumpang, Liliw	4
Bongkol, Liliw	3
Low Elevation	
Patimbao, Sta. Cruz	5
San Pablo Sur, Sta. Cruz	2
Major Public Markets	
Sta. Cruz	4
Nagcarlan	6
Barangay Officials	
High Elevation	
San Francisco, Nagcarlan	1
Bukal, Nagcarlan	1
Medium Elevation	
Calumpang, Liliw	1
Bongkol, Liliw	1
Low Elevation	
Patimbao, Sta. Cruz	1
San Pablo Sur, Sta. Cruz	1

Table 7.2. Socio-demographic and Economic Profile of Traders, Laguna, 2014

Characteristic	High Elevation	Medium Elevation	Low Elevation
Age	31-70	21-50	21-72
Sex	All female	6 female; 1 male	All female
Civil Status	6 married; 1 single; 1 widower	All married	5 married; 2 widower
Education	2 elementary, 5 secondary, 1 college	1 elementary; 3 secondary; 3 college	2 elementary; 2 secondary; 3 college
Main Source of Income	7 trade/business; 1 farming	6 trade/business; 1 service	All trade/business
Other Sources of Income	1 trade/business; 3 farming/fishing	1 trade/business	1 farming/fishing; 1 service

Perception of Climate Change

The key informants define climate change as having too much heat or drought during the dry season or too much rain during the rainy season, and experiencing dry spells during the rainy season, and heavy rains during the dry season. For them, extreme events are strong typhoons, floods, typhoon and flood, and typhoon and drought.

Majority of the key informants have claimed that they fully understand the concept of climate change and concede the following:

- Climate change is man-made and not caused by God
- Extreme events are caused by climate change
- Extreme events are becoming more severe now
- Extreme events are becoming more frequent now
- Extreme events area problem

Asked whether or not negative impacts of extreme events can be prevented or reduced, 52 percent of the key informants disagreed while 45 percent agreed somewhat. Asked if there was an early warning system for extreme events in their municipality, 39 percent said there was, 26 percent said there was not, and 35 percent did not know. Sixty-four percent of the respondents said they were adequately prepared to handle extreme events while the rest said they were not.

Recent and Unforgettable Extreme Events

According to the respondents in the high elevation site, recent extreme events experienced were Typhoon Yolanda in November 2013, Ondoy in September 2009, and Milenyo in September 2006; for respondents in the medium elevation areas, they were Typhoons Ondoy, Santi (in October 2009), and Milenyo; for those in the low elevation site, they were Typhoons Yolanda, Ondoy, Santi, Milenyo and the habagat (in July 2012). All of the above mentioned events, except Yolanda, were said to be unforgettable (table 7.3).

Table 7.3. Recent and Unforgettable Extreme Events, Laguna, 2014

Study Site	Recent	Unforgettable
High Elevation		
Bukal	Yolanda, Ondoy, Milenyo	Ondoy
San Francisco	Milenyo	
Medium Elevation		
Calumpang	Ondoy, Santi, Milenyo	Ondoy
Bongkol		Ondoy, Santi
Low Elevation		
Patimbao	Ondoy, Santi, Habagat, Milenyo	Ondoy, Santi, Milenyo
San Pablo Sur	Ondoy, Santi, Habagat, Milenyo, Yolanda	Ondoy, Santi

Current Situation

High Elevation

San Francisco, Nagcarlan

The unforgettable extreme event experienced in the barangay was Typhoon Milenyo on 28-29 September 2006. Typhoon Milenyo had strong winds and heavy rains. Forty percent of the households in the barangay had their roofs blown away, 30 percent of the banana trees and 10 percent of the coconut trees fell down, and there was no electricity for one week. Fortunately though, there was no flood. No relief goods nor any assistance whatsoever were extended to the residents. Sources of income are rice and vegetable farming, and employment in four candy factories.

Palay produced is sold in the barangay and satisfies 70 percent of the needs of residents. The other 30 percent is bought from the public market of Nagcarlan. It is interesting to note

that all 30 sari-sari stores operating in the barangay sell rice even though the barangay is only one to two kilometers away from the Nagcarlan public market.

Vegetables grown are radish, tomato, cucumber, cabbage, bitter melon, baguio beans, eggplants and chayote. Vegetables produced are more than enough for the needs of the barangay. Hence, about 20 to 30 vegetable growers are also vegetable traders (assembler-wholesalers); they buy the produce of other farming households in the barangay and the other barangays of Nagcarlan, and some barangays of Liliw then bring these vegetables to the trading center in Tanauan, Batangas. There are two vegetable retailers who have their stall in the barangay.

Root crops grown are sweet potato, cassava, and gabi. Root crops produced, just like vegetables, are more than enough for the needs of the barangay residents. There is only one trader who buys the marketable surplus in the barangay and other barangays of Nagcarlan and Liliw; 20 percent more are bought from Nueva Ecija then sold in the trading center of Tanauan, Batangas.

Fruit trees are lanzones, mango, and banana. The marketable surplus of banana and lanzones is sold in the barangay (40 percent), delivered to the trading center of Tanauan, Batangas (30 percent), and picked up by traders from Divisoria in Metro Manila (30 percent). The mango produced is for local consumption; 30 percent more are bought from the Nagcarlan Public Market. In the barangay, there is one mobile (tricycle) vendor who sells mango, and one sari-sari store vendor who sells mangoes and bananas. Other needs for fruits like watermelon, apple, orange, and grapes are all bought from the Nagcarlan Public Market.

There are no fisherman-residents. Most residents buy fish from either the Nagcarlan Public Market, three mobile vendors from the municipality of Rizal in Laguna, Barangay Taytay, and another barangay in Nagcarlan, or from a barangay resident who sells fish bought from the Nagcarlan Public Market. Fish bought by residents are mostly tilapia, bangus, galunggong, hiwas, dalagang bukid and tulingan.

There is one commercial poultry farm in the barangay. The produce is sold only in the barangay. There is also a resident who has a grocery store that sells chicken. Twenty percent of the local consumption of chicken comes from the public market of Nagcarlan.

Ten percent of the households raise pigs in their backyard and supply about 50 percent of the needs of the barangay. The other 50 percent are sourced from the Nagcarlan Public Market. All beef and carabeef needs are obtained from the Nagcarlan Public Market.

Bukal, Nagcarlan

Temperatures since 2008 have been observed to be warmer in the summer and colder in December. When the temperature is very low, the production of vegetables (e.g. cabbage, beans, tomato, pechay, and chayote) usually declines by 50 percent or more. Rice is not planted in the barangay.

It has also been observed that, unlike before, rains come almost everyday during the rainy season. Also, if the forecast is signal number 1 in the barangay, the weather experienced in the area is like that of signal number 2.

Destructive typhoons in Southern Luzon that residents remember include Dading in 1970, Rosing in 1995, and Ondoy in 2009. But while these typhoons were destructive in most of the affected areas, there was little to no damage reported in Barangay Bukal.

An initiative from the DENR's agroforestry program encouraged tree planting in the barangay; millions of trees have been planted since the program started some 35 years ago. The survival rate for the trees is estimated to be more than 50 percent. At the start of the program, budget was allocated for caretakers but this only lasted for 12 years.

Although there is currently no more budget for it, the people in the barangay have been taking good care of the watershed by planting trees; there is also an ordinance that bans the cutting of trees.

Of the 250 families residing in the barangay, 98 percent farm vegetables; some households also plant root crops. Vegetable and rootcrop farmers bring their vegetables daily to the buying stations (a total of 15-20) in the barangay using horses for transport. Vegetables that arrive in the buying stations are also sourced from farmers that reside in the municipalities of Rizal and Liliw in Laguna.

All buying stations are said to share the same pricing scheme for the commodities sold. Buyer-traders pick up the vegetables from the buying stations and bring them to San Pablo, Pasay, Cavite, Pangasinan, Bico, and Tanauan, Batangas. In some buying stations, 20 percent are sold to traders from Divisoria and Cavite who pick up the vegetables while 80 percent are delivered to the Tanauan trading center. Buyers in Tanauan are wholesalers from Alabang, Pasig, Cavite, and Bicutan. During an extreme event, almost all vegetables handled are brought to Tanauan. Buyer-traders from other areas do not come to Bukal during a calamity.

Farm prices usually range from PHP 1 to 10/kg. Only tomatoes are brought to Pangasinan. Farmers are given a 50 percent down payment upon the delivery of vegetables. The other 50 percent is paid the next day. Traders who buy and pick up the vegetables at the buying station give their payment the following day.

With a typhoon or no typhoon, the price of vegetables depends on the interaction of supply and demand forces. While Barangay Bukal is not that much affected by extreme events, the volume handled of agricultural commodities, especially vegetables, is lower, thus commanding higher market prices. Spoilage is likewise higher during extreme events. During the last typhoon (in 2013), however, the price of vegetables was low due to high supply—even if there were not much vegetables coming from the barangay and the adjacent municipalities, there were many vegetables coming from other places like Majayjay and Baguio.

There are four types of weather in the barangay: rainy; too much rain (in September to November or until December); warm; and hot (or too warm, observed in March and April). According to traders, this has been observed for the past 10 years. This climate change has negative effects on vegetable production. About a 50 percent reduction in the production of all vegetables grown in the area was noted. When the weather is too warm, vegetables like chayote and leafy vegetables dry up easily. During strong typhoons, affected vegetables in Bukal are cucumber, Baguio beans, chayote, and radish. While cucumber is harvested in the months of August to September (the months when strong typhoons usually occur in Laguna), the other vegetables mentioned are continuously produced and always available in the barangay. As observed from buying stations, there is around a 67-89 percent reduction in the volume traded for these vegetables during dry times. When there is continuous rain or heavy rain, the quality of the cucumber, chayote, and radish easily deteriorates because too much water dissolves a portion of these vegetables, particularly when not sold immediately.

Tomatoes are usually high in supply in Bukal during the months of March to May and in October; cabbage in January to February; pechay Baguio in January to February; bitter melon in April to May; and sweet potato in June and October.

A total of 200 kg to three tons daily are handled and sold (except for some spoilage) by the buying stations. Of the vegetables grown and traded in the barangay, tomato, chayote, and cucumber have the greatest volume. Marketing losses were estimated at about 200 kg out of one ton of vegetables traded, two to three times a year. Marketing losses of below 200 kg due to continuous rains or heavy rains happen for about seven

days in a year. It was pointed out, however, that even though such losses are experienced by traders, recovery is easy in the vegetable business.

There are no commercial poultry and livestock farms in the barangay but there are backyard raisers of native chicken. There are also up to 10 households that raise anywhere from one to 10 pigs; when the pigs are about four months old, they are sold to livestock buyers in Nagcarlan and San Pablo City. Seven households raise two to three cattle per household. Some households slaughter their cattle and sell the meat to meat retailers in the Nagcarlan Public Market. When there is typhoon, the people in the barangay usually eat sardines with vegetables because there is usually no other fish and meat available in the barangay for up to five days. Normally, there are two to three vendors of fish, chicken meat and pork (no beef) in the barangay. Six stores sell rice delivered to them from San Pablo City. Sari-sari stores sell eggs and canned goods like sardines and corned beef; these stores occasionally sell fruits like banana, mango, and coconuts, which are produced in the barangay. For other food needs, residents go to the Nagcarlan Public Market.

Medium Elevation

Calumpang, Liliw

Extreme events identified were strong typhoons like Santi and Milenyo. During Typhoon Santi, 10 percent of the houses in the barangay had roofs blown away by strong winds; the irrigation dam and foot bridge were damaged; a husband and his wife died in the flood. The flood lasted for 24 hours, knee high on the road, and chest to neck-high in the lower parts of the barangay.

During Typhoon Milenyo, floods were similar to the floods brought by Typhoon Santi, but Typhoon Milenyo was stronger than Typhoon Santi in terms of wind and rains. Twenty percent of the coconut trees, 15 percent, of lanzones trees, and 70 percent, of the banana trees fell down. Fifteen percent of the houses had roofs blown away; the foot bridge and irrigation dam were likewise damaged.

No casualties were reported during Typhoon Santi but the barangay did not have electricity for a week. Typhoon Milenyo, meanwhile, caused a power outage that lasted two weeks. There was also no water in the water pipes for one week because of these typhoons. The barangay suffered other typhoons but damages were not as serious. For the most part, the barangay gets a protective shield from mountains such as Mt. Banahaw and Sierra Madre; another advantage is that the place is relatively elevated compared to Sta. Cruz and other municipalities of Laguna.

The barangay received relief goods (rice and canned goods) from the municipal local government unit (MLGU) for Typhoons Santi, Milenyo and Yolanda. The barangay LGU, meanwhile, used their calamity funds to distribute rice, noodles, coffee, and sugar to residents.

Other typhoons that hit the barangay were Typhoon Rosing in 1995 and Typhoons Welming and Dading. There were no floods during these events. Flooding, however, has become a present-day problem because of logging and quarrying (since the 1990s).

The barangay residents' sources of income include rice and vegetable farming, construction work, hired labor, trading of banana, santol and coconut, and the operating/driving of public utility jeepneys. There are about 30 rice farmers and 15 vegetable farmers in the barangay.

Marketable surplus of palay is sold to 10 viajeros coming from other areas of Laguna. Residents buy rice from the public markets of Nagcarlan and Sta. Cruz as well as from the 20 sari-sari stores selling rice in the barangay. One rice retailer sells National Food Authority (NFA) rice brought from Alaminos and/or San Pablo, Laguna.

Vegetables grown are pechay, bitter gourd, cabbage, eggplant, kangkong and okra. Of these vegetables, only the kangkong has a yield abundant enough to fill the needs of the residents and create a surplus that is sold to a viajero who brings the vegetable to Pasay, Metro Manila. Residents buy the other vegetables either in the public markets of Nagcarlan and Sta. Cruz or from five vendors in the talipapa, who buy their vegetables from assembler-wholesalers in the Sta. Cruz Public Market.

Fruit trees grown are papaya, lanzones, rambutan, santol, jackfruit, and mango. Santol and lanzones are mostly sold and delivered to traders in Quezon City (Nepa Q-mart), Divisoria, Pasay, and Sampaloc, which are all in Metro Manila. Bananas are delivered to banana chips factories in Nagcarlan and to Sta. Cruz wholesalers and wholesaler-retailers; the fruit is also sold by a resident who is a retailer in the Sta. Cruz Public Market. Coconuts are sold to a copra processing plant in the barangay and to other traders who offer a higher price. Mango is delivered to Divisoria, Nagcarlan, and Sta. Cruz. All the other fruits produced are for home consumption.

Five percent of the households grow root crops (such as sweet potato, cassava, and gabi) in their backyard. When produce is more than enough for home consumption, a portion of it is sold to traders with stalls in the Sta. Cruz and Nagcarlan public markets.

Five percent of the households raise chickens in their backyard while two persons are engaged in commercial poultry production. With regard to swine, 30 percent of the households raise pigs in the backyard whereas one individual is engaged in commercial swine production. Chicken retailers, on the other hand, source their chickens from Calumpang, Nagcarlan and Sta. Cruz. Pork is also sold daily by retailers who pick up the product from Nagcarlan.

Beef is not sold regularly; only when a cow gets injured heavily will the cattle-raiser consider selling it as meat. Carabeef is sold every Saturday by one meat retailer who buys the meat from Liliw.

There are three mobile fish vendors and four talipapa stall owners who sell fish sourced from the public markets of Sta. Cruz and Nagcarlan.

The barangay is lucky to have a talipapa with 24 stalls; four for fish, five for vegetables, seven for pork, one for carabeef, five for chickens and eight for snacks. There are also three bakeries and five other eateries. The other needs of the residents are obtained from the Nagcarlan Public Market (9 km away) and the Sta. Cruz Public Market (12 km away). Both public markets can be reached by riding a jeepney.

Bungkol, Liliw

The most unforgettable extreme event was Typhoon Milenyo on 28-29 September 2006; while the storm brought strong winds and a lot of rains, not much flooding was experienced. Another extreme event was Typhoon Santi in October 2009; Milenyo had stronger winds but Santi produced one casualty in the barangay—a resident who was overcome by waters while crossing the river.

About 80 to 90 percent of households engage in rice farming; that is the same proportion for vegetable farming, which can lead to the conclusion that most households engage in both rice and vegetable production.

With Typhoon Milenyo, 50 percent of the palay production was damaged. During both typhoons, almost all the vegetables were damaged. Of the fruit trees, 40-50 percent of the bananas, 10 percent of the lanzones, 10 percent of the coconuts, and 5 percent of the other trees either fell down or were damaged during both extreme events.

After Typhoon Milenyo, the MLGU of Liliw went house to house to determine the extent of damages. It gave relief goods composed of canned goods, rice and noodles; money for repair was given to residents with heavily damaged houses. The barangay

LGU, meanwhile, helped in the cleaning of the streets, especially the roads obstructed by fallen trees; it also distributed one set of relief goods (containing rice, noodles, and canned goods) per household.

Immediately after Typhoon Santi, the MLGU distributed relief goods through the barangay LGU.

Other typhoons that passed through the country did not affect Liliw that much; the barangay's relatively high elevations spare it from flood problems.

Sources of income of residents are mostly from planting rice and vegetables, and from harvesting coconuts.

After deducting an allocation for home consumption, 95 percent of the palay is sold to five assembler-wholesalers from other Liliw barangays, Pagsanjan, and San Pablo City, who in turn sell the palay to rice millers; the remaining 5 percent is sold to the rice miller in the barangay. About 50 percent of the residents buy rice from the town proper of Liliw and Nagcarlan. The other 50 percent either source their rice from the 15 sari-sari stores that sell rice bought from the barangay's rice mill or buy palay directly from farmers and have it milled at the rice mill.

Vegetables grown are tomato, bitter melon, string beans, cabbage, pechay, mustard, radish, camote, chayote, beans and cucumber. Almost all vegetables produced are sold: 25 percent in the public markets of Liliw and Nagcarlan; 25 percent in the public market of Sta. Cruz; and 50 percent delivered to Metro Manila markets, most particularly to Divisoria. Some residents also buy from the public markets of Liliw and Nagcarlan, and from two mobile vendors from barangays Suba, Magdalena, and Majayjay.

Fruit trees grown are banana, lanzones, coconut, mango and papaya. Marketable surplus is delivered to the town proper of Liliw for banana; to Divisoria (80 percent) and Bulacan (20 percent) for lanzones; to the coconut oil processing plant in San Pablo for coconut; and to Divisoria (80 percent) and Liliw (20 percent) for unripe papaya and ripe papaya. Mangoes are for household consumption.

Residents usually buy fish from the public markets of Liliw and Nagcarlan but they can also buy from three mobile fish vendors who each use a tricycle to go about their daily rounds, that start at 6 or 8 in the morning. Fish sold are tilapia, galunggong, and bangus (milkfish). One vendor is from Majayjay who gets fish from fish wholesalers in the Nagcarlan public market; another vendor sells fish that come from a fisherman-wholesaler in Lucena; and the other vendor gets fish from a fish wholesaler in the Sta. Cruz Public Market.

Households usually plant root crops such as cassava, sweet potato, and gabi for home consumption. Only one household has a marketable surplus, which is sold in the public market of Liliw.

Only 5 percent of the households raise native chickens in their backyards and only two households raise backyard pigs. Chickens, other poultry products, and pork are bought from Liliw and Nagcarlan and from two mobile vendors (one from Barangay Suba, Magdalena; the other one from Majayjay) who also sell vegetables.

Beef and carabeef are not sold in the barangay. Residents seldom buy beef and opt more for carabeef, which they purchase at the public markets of Liliw and Nagcarlan.

Prices in Nagcarlan are said to be lower than in Liliw. For instance, a kilogram of fish worth PHP 100 in Liliw costs only PHP 80 in Nagcarlan.

Low Elevation

Patimbao, Sta. Cruz

Unforgettable extreme events in the barangay were Typhoons Santi, Ondoy, Milenyo and Rosing. The barangay, however, experienced the worst extreme event

during Typhoon Santi in October 2009, which lasted for two days. It was during this time that they first experienced flooding; there was a sudden rise in the water level but this immediately subsided. It took one week, however, for the community to clean the surroundings because there were many fallen trees, damaged pathways and mud. The irrigation dam was likewise damaged. All the rice fields were submerged and destroyed; none of the palay or the vegetables were fit to harvest. Reports claimed that the flood was caused by the combined overflow of the Magdalena and Sta. Cruz rivers. The flood was thigh-high for about two hours. It was estimated that about 15 riverside houses, and all their contents, were swept away by the current. Fortunately, there were no casualties. About 5 percent of the fishermen could not go fishing. It was estimated that 10 percent of the fruit trees, such as banana, mango, santol, lanzones and coconut, was damaged. There was no electricity for one week, tap water flow was not normal, and 5 percent of the artesian wells were damaged.

Prior to Santi, there was Typhoon Ondoy in September 2009, which lasted for two days. The wind was quite strong, blowing away the roofs of 20 houses. The flood was knee high in Sitio 7. The residents could not work. All the fishermen could not go out to fish for the duration of the storm and a few days after that. Ten percent of the fishing boats were either damaged or blown away. Farmers were not able to work in the fields. Construction workers were hampered from working as well. Damage to rice fields (specifically, to the palay that was ready for harvest) was estimated at 30 percent, 100 percent of all vegetables planted were damaged; 5 percent for banana trees; and 7 percent for other fruit trees. There was no electricity for a week and only very little water was flowing inside the houses' water pipes.

During Typhoon Milenyo in September 2006, there was no electricity for three days. The damage to the barangay was similar to the damage that Ondoy brought, except that there were no floods during Milenyo.

Typhoon Rosing, which was classified as signal number 4, came in the last week of 1995 and lasted for about four days; the damage was similar to the damage brought by Typhoons Milenyo and Ondoy, and a leg-deep flood was recorded in Sitio 7.

Sources of income of residents are fishing, farming, construction, planting and the selling of sampaguita.

There is one big rice mill in the barangay where almost all rice farming households sell their marketable surplus. Fifty percent of these households have a credit-marketing tie-up with the rice mill while the other 50 percent have more straightforward sales with the mill. After milling, the owner of the rice mill delivers rice to wholesaler retailers in San Pablo City; the rice mill owner also has a stall in the Sta. Cruz public market where rice is sold directly to consumers. Residents of the barangay buy rice either from the barangay sari-sari stores (50 percent), directly from the rice mill (30 percent), or from retailers at the Sta. Cruz public market (20 percent). Almost all the 35 sari-sari stores in the barangay sell rice.

Vegetables grown are pechay, mustard, patola, eggplant, upo, okra, bitter gourd, string beans, and radish. Three assembler-wholesalers buy and pickup the marketed surpluses of the vegetable growers and deliver the vegetables to Metro Manila markets. Two of the traders deliver to wholesaler-retailers in Divisoria while the other one delivers to a wholesaler-retailer in Pasay. Barangay residents get their vegetable either from their own farms or from merchants; residents can buy vegetables from sari-sari stores, five mobile vendors selling out of a basket or bilao, three mobile-tricycle vendors who travel from other barangays of Sta. Cruz, and from vegetable retailers in the Sta. Cruz Public Market. Fifteen of the 35 sari-sari stores in the barangay sell vegetables.

There are about 30 fishing households in the barangay; almost all of them have their own

banca. The fish is for home consumption and any marketed surplus is sold; 25 fishermen sell to fish retailers in the Sta. Cruz Public Market while the other five are mobile vendors that sell directly to consumers in the barangay.

There are no commercial poultry raisers as it is not allowed in the barangay. Some five households raise backyard chickens but majority of the residents buy their chicken needs from the Sta. Cruz Public Market. Households can also order from one enterprising resident who delivers chicken to them; the chicken meat comes from another barangay. Those with catering services have dressed chicken delivered to them weekly by a resident who works in the Magnolia chicken farm in Cabuyao, Laguna.

There are three households in the barangay who slaughter hogs weekly and supply about 30 percent of the barangay's pork needs. Pork is also purchased in the Sta. Cruz public market.

All the beef and carabeef needs of the barangay are bought from the Sta. Cruz public market.

Fruits grown with marketed surplus are rambutan, santol, avocado, sampaloc, banana, and lanzones. There are three resident-traders who buy fruits from the growers and bring these to Divisoria. There are a few mango trees and coconut trees, mostly for home consumption.

About 10 percent of the households grow root crops like cassava, sweet potato, and gabi in their backyard; the marketed surplus of which are delivered and sold to wholesaler-retailers in the Sta. Cruz Public Market. Another 10 households produce root crops as lessees in the two other barangays of Sta. Cruz; their produce is picked up by three traders from other barangays and delivered to wholesaler-retailers in Divisoria.

When a typhoon causes floods, residents use a banca for transport. Floods in Sta. Cruz can last for six months before it finally subsides; during this time, residents buy their food from sari-sari stores and the public market. The stores continue to operate even during flood events and residents claim that there is generally no problem with sourcing food. The barangay also has 10 eateries and two bakeries.

San Pablo Sur, Sta. Cruz

Sta. Cruz is considered a catch basin. A regular downpour that goes on for even just four hours can cause floods in several sites of San Pablo Sur and San Pablo Norte.

The most unforgettable extreme events in San Pablo Sur were Santi in October 2009, bringing strong winds and heavy rains, Ondoy in September 2009, bringing heavy rains, and the habagat in July 2012; all these events caused major flooding. With Typhoon Ondoy, floods lasted from September to December 2009; with Santi, October to December 2009. Affected areas were Sitio Bongavilla, with floods knee-deep, and Sitio Sampaguita, with floods waist-high. There was also a flash flood during Typhoon Santi and the bridge was damaged. During Ondoy, fallen trees added to the obstruction of waterways causing water to rise. The habagat, on the other hand, caused the most flooding of all. Floods in Sitio Sampaguita lasted from July to December 2012; Sitio Bongavilla and Sitio Camia was flooded for almost three months; and Sitio Ilang-ilang was flooded for less than a month. The impact of Typhoon Milenyo in 2006 was less devastating compared to those of other typhoons.

Nowadays, typhoons and flooding are more frequent. The water level of Laguna de Bay has likewise been observed to be rising; the dirt and garbage that floods sweep up from the barangays flow into the lake. Climate change has been observed since 2009. Respondents have experienced rains in dry season and warm and hot weather during the rainy season.

Sources of income for residents are farming and the operation of public utility tricycles.

The total land area is 97.45 ha. Total agricultural area is 15-20 ha, most of which are planted with rice. Vegetables are planted along the sides of the ricefields.

There are about 11 rice farmers and five vegetable farmers in San Pablo Sur. Vegetables planted are patola, okra, pechay, mustasa, sili, eggplant, upo, and malunggay.

Floods can sometimes destroy crops and wipe out harvest.

Palay production cost is PHP 25,000/ha. Rice farmers are mostly tenants, with the tenant and the landlord sharing in the production cost and in the harvest, or they can be lessees, giving a fixed amount per harvest to the landlord for the use of the land. Some farmers use mortgaged lands.

Of the palay harvest, up to 10 cavans (50 kg/cavan) are used for home consumption and seeds; all that are left are sold to suki viajero-traders from other areas who pick up the palay from their farms.

For their rice consumption, people in San Pablo Sur buy rice from the local public market and the Sta. Cruz public market retailers and wholesaler-retailers. One sari-sari store in the barangay sells rice.

Vegetables produced locally are sold in the local public market or by vegetable vendors who move around the barangay. Vegetable production, however, does not meet the needs of the entire barangay. Vegetables produced and sold in the barangay by two vendors (one mobile with a cart, the other with a stall in the market) supply only 10 percent of the needs of the barangay; hence, residents buy most of their vegetables from the Sta. Cruz Public Market. Vegetables sold by the two vendors, however, are priced lower than the vegetables sold in the Sta. Cruz Public Market.

Sweet potato and cassava are also planted in the barangay. There are few fruit trees, like mango and guava. Less than 5 percent of the households produce bananas for home consumption. Other needs for fruits and root crops are bought from the Sta. Cruz Public Market.

There is one mobile fish vendor who makes rounds in the barangay. Other needs for fish, chicken, pork, beef, and carabeef are obtained from the Sta. Cruz Public Market.

Poultry and livestock are not raised commercially in the barangay because it is prohibited; hence, residents buy these in the public market. About five households raise poultry for home consumption and for special occasions, like a fiesta.

Before selling to traders, farmers first negotiate prices for their produce. For palay, it is usually PHP 15.50/kg; the price increases to PHP 16/kg when the barangay experiences floods.

Less than 5 percent of residents are OFWs and less than that are government employees. Most households are poor, with income coming from construction work or operating a public utility tricycle; these types of jobs cease during a calamity, income is likewise affected. During both Santi and Ondoy, around 700 families were affected with most of them losing their sources for income. To augment income, some go fishing, others became dependent on the local government officials. The barangay LGU sometimes gives “cash for work.”

Because tricycles are nonoperational during floods, bancas are used to transport people; fees are PHP 10/person.

When there was a flood in the Sta. Cruz during the second half of 2013, the public market had to transfer temporarily to an area near the city hall, about 200 m away. When the flood subsided, the market moved back to the former public market area.

The barangay has not yet made any ordinance on climate change and food security. This is unfortunate because food becomes scarce during extreme events; case in point, during floods, vegetables are either not available or available in small quantities only; likewise for fish, which comes in just enough for personal consumption.

Effects of Extreme Events on Food Markets

Rice

The volume of rice traded and the market price of rice do not change with extreme events unless there is really a shortage in the supply of rice nationwide (table 7.4). Buying prices of rice range from PHP 30 to 44/kg while selling prices are from PHP 33 to 47/kg, with a markup of PHP 2-7/kg.

Table 7.4. Volume traded and market price of rice during normal times and extreme events (2013-2014)

Item	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Calumpang	Bungkol	Patimbao	San Pablo Sur
Volume of Rice Handled (PHP/kg): same for normal/extreme events	50/week	25-50/week	375/week	25/week-85/month	15/day-250/week	25/week
Buying Price (PHP/kg)						
- Normal	36	34-44	36	38-41	30-40	36
- Extreme Events	36	34-44	36	38-41	30-40	36
Selling Price (PHP/kg)						
- Normal	39	37-47	43	40-43	33-43	38
- Extreme Events	39	37-47	43	40-43	33-43	38

Vegetables

During extreme events, the volume of vegetables traded is reduced by 33-93 percent in high elevation barangays; 50 percent in Calumpang (medium elevation) and 50-75 percent in Patimbao (low elevation) (tables 7.5a and 7.5b). There are no vegetables sold in San Pablo Sur (low elevation) because of the floods, and almost no vegetables are sold in Bungkol (medium elevation) because crops are heavily damaged. Buying prices during extreme events are generally higher than normal buying price by PHP 1-20/kg, except in Bungkol and San Pablo Sur where mark-up per kilogram of vegetables by traders is PHP 1-30 during normal times and PHP 3-40/kg during extreme events. In Bungkol, only onions and garlic are sold during extreme events and their markup is the same with or without extreme events. In San Pablo Sur, the mark-up for vegetables is PHP 8-50/kg during normal days.

Root crops

Among the study sites, the high elevation barangays have the most volume of root crops, with a range of 700 kg/month (about 23 kg/day) each of sweet potato and cassava in San Francisco; and 30-500 kg/day of sweet potato in Bukal (table 7.6). Calumpang, in the medium elevation area, and Patimbao, in the low elevation area, also sell sweet potatoes and gabi, but in small quantities, about 1-2.5 kg daily in the former and 1.5 kg daily in the latter for each kind of rootcrop. During extreme events, the volume of root crops traded is much lower in the barangays mentioned (by 33-71 percent in San Francisco; 60-100 percent in Bukal; 50 percent in Calumpang) except in Patimbao, where the traded volume of sweet potato and gabi increased by 100 percent. Mark-up by traders during extreme events (PHP 5-10/kg) is either the same or a little bit higher than the mark-up during normal times. Buying prices range from PHP 7-40/kg during normal days and PHP 10-50/kg during extreme events.

Table 7.5a. Vegetables during normal times and during extreme events (2013-2014)

Time Period	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Calumpang	Bungkol	Patimbao	San Pablo Sur
Normal	Chayote, tomato, cabbage, eggplant, kangkong, sitao, okra, potato, carrot, squash, sili, onion, garlic, pechay, pechay baguio, baguio beans, mustasa, bittergourd, radish	Chayote, tomato, cabbage, eggplant, pechay baguio, cucumber, baguio beans, ampalaya, radish	Chayote, tomato, cabbage, eggplant, kangkong, sitao, okra, potato, carrot, squash, sili, onion, garlic, pechay, patola, cucumber, baguio beans, mustasa and ampalaya	Chayote, tomato, cabbage, eggplant, sili, onion, garlic	Chayote, tomato, cabbage, eggplant, kangkong, sitao, okra, potato, carrot, squash, onion, garlic, baguio beans, ampalaya, radish, camote tops	Tomato, eggplant, kangkong, okra, squash, sili, patola, ampalaya
Extreme Events	Chayote, tomato, cabbage, eggplant, kangkong, sitao, okra, potato, carrot, squash, sili, pechay, baguio beans, mustasa, ampalaya, radish	Cucumber, baguio beans, chayote, radish, tomato	Chayote, tomato, cabbage, eggplant, squash, onion, garlic, pechay, mustasa, ampalaya	Onion, garlic	Chayote, tomato, cabbage, eggplant, kangkong, sitao, okra, potato, carrot, squash, onion, garlic, baguio beans, ampalaya, radish	None

Table 7.5b. Volume handled and selling price of vegetables during normal times and during extreme events (2013-2014)

Time Period	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Calumpang	Bungkol	Patimbao	San Pablo Sur
Volume Handled (kg/day) - Normal	Tomato: 1-300; Cabbage, radish: 200-300; Pechay baguio, baguio beans, ampalaya: 29-43; Squash: 0.75-71; Chayote, okra, kangkong, eggplant: 0.5-29; Others: < 1	Eggplant: 4; Ampalaya: 300 Cabbage: 7-214; Others: 80-2500	Baguio beans: 1-1000 Others: 0.25-5	All: 0.03-1	Eggplant: 20 Others: 0.07-3	Kangkong, eggplant, ampalaya: 5-15 Others: 0.14-1

Volume handled (kg/day) - Extreme Events	Same volume traded for eggplants 33-93% reduction in other vegetables	67-89% reduction in volume traded	50% less	Almost no traders and almost no vegetables being sold	Same volume traded for garlic and chayote 50-75% reduction in other vegetables	No vegetables traded
Buying Price - Normal - Extreme Events	4-140 5-150	2-30 10-45	8-100 30-150	15-100 50-100	10-120 30-140	7-80 No trade
Selling Price - Normal - Extreme Events	5-170 8-190	4-40 15-65	10-110 35-120	25-150 60-150	15-130 45-160	15-130 No trade
Usual Mark-up - Normal - Extreme Events	1-30 3-40	3-10 5-20	2-10 5-20	10-50 10-50	5-10 15-20	8-50 No trade

Table 7.6. Volume traded and market prices of root crops during normal times and during extreme events, by study site, 2013-2014

Time Period	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Calumpang	Bungkol	Patimbao	San Pablo Sur
Volume Handled - Normal	Sweet potato: 300/week; Gabi: 700/mo; Cassava: 300/wk	Sweet potato: 30-500/day	Sweet potato, gabi: 1/day-5/ every other day	None	Sweet potato, gabi: 1.5/day	None
Volume handled - Extreme Events	Sweet potato: 200/wk; Gabi: 200/mo; Cassava: 200/wk	Sweet potato: 0-200/day	Sweet potato, gabi: 0.5/day-1.25/every other day	None	Sweet potato, gabi: 3/day	None
Buying Price - Normal	Sweet potato: 8-30; Gabi: 8-25; Cassava: 7-20	Sweet potato: 12-20	Sweet potato: 20-40; Gabi: 15-30	None	Sweet potato: 25-35; Gabi: 30-40	None
- Extreme Events	Sweet Potato: 10 Gabi: 15 Cassava: 15	Sweet potato: 40	Sweet potato: 50 Gabi: 50		Sweet potato: 50; Gabi: 50	
Selling Price - Normal	Sweet potato: 10-40; Gabi: 15-30; Cassava: 12-30	Sweet potato: 14-25	Sweet potato: 25-50; Gabi: 20-40	None	Sweet potato: 35-45; Gabi: 40-50	None
- Extreme Events	Sweet potato: 15; Gabi: 20; Cassava: 25	Sweet potato: 45	Sweet potato: 60; Gabi: 60		Sweet potato: 60; Gabi: 60	

Fruits

Among fruits, bananas and guyabano are the ones normally available for sale in San Francisco (high elevation) (table 7.7). Reduction in the volume of bananas traded ranges from 30 percent in saba to 83 percent in tundan. Guyabano, with 10 kg/week traded during normal days is not seen in the market during extreme events. Buying prices per kilogram of banana are lowest for saba at PHP 5-12.50 during normal days and PHP 10-25 with extreme events, and highest for lakatan at PHP 20-40 for normal days and PHP 40 with extreme events. Usual markups per kilogram between buying and selling prices are PHP 2-12.50 during normal times and PHP 5-20 during extreme events. In the low elevation barangays of Patimbao and San Pablo Sur, only saba is normally sold. Buying prices of saba are from PHP 5-20/kg; the usual markup by vendors is PHP 5-10/kg. Bananas are most likely available for sale in the other study sites, however, these were not seen at the time of the interview.

Table 7.7. Volume traded and market prices of fruits during normal times and during extreme events (2013-2014)

Item	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Calumpang	Bungkol	Patimbao	San Pablo Sur
Normal Saba Tundan Lakatan Guyabano	500/wk 300/wk 80/wk 10/wk				2/wk	10 every other day
Extreme Events Saba Tundan Lakatan Guyabano	350/wk 50/wk 50/wk 0					
Buying Price Normal Saba Tundan Lakatan Guyabano	5-12.50 10-25 20-35 10-40					
Extreme Events Saba Tundan Lakatan Guyabano	10-20 30 40				5-15	8-20
Selling Price Normal Saba Tundan Lakatan Guyabano	7-20 15-35 30-45 20-60				10-25	20-30
Extreme Event Saba Tundan Lakatan Guyabano	25 40 60					

Fish/shellfish

Fish/shellfish vendors available for interview were in San Francisco (high elevation) and Calumpang (medium elevation) (table 7.8). During normal days, buying prices per kilogram range from PHP 30-120 for fish and PHP 100-500 for shellfish in San Francisco; and PHP 70-150 for fish in Calumpang. Mark-up is PHP 20-60/kg of fish and PHP 20-100/kg of shellfish. During extreme events, seafoods are not available in the study sites.

Table 7.8. Volume traded and market prices of fish/shellfish during normal times and during extreme events (2013-2014)

Item	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Calumpang	Bungkol	Patimbao	San Pablo Sur
Normal Milkfish Tilapia Tulignan Galunggong Blue Marlin Yellow fin Shrimp Alimasag Alimango Alamang	80/wk 50/wk 70/wk 10/wk 50/wk 10/wk 200/mo		10/day 25/day 5/day 10/day 3/day		2/wk	10 every other day
Extreme Events	0					
Buying Price Normal Milkfish Tilapia Tulignan Galunggong Blue Marlin Yellow fin Shrimp Alimasag Alimango Alamang Extreme Events Saba Tundan Lakatan Guyabano	30-60 30-120 40-100 100-250 100-200 250-500 15-50 No fish traded		120-150 95-100 70-90 80-95			
Selling Price Normal Milkfish Tilapia Tulignan Galunggong Blue Marlin Yellow fin Shrimp Alimasag Alimango Alamang Extreme Events	50-120 50-140 60-130 150-300 120-250 300-600 30-70 No fish traded		140-170 120 90-110 100-115			

Meat

Meat vendors interviewed were selling chicken and pork in San Francisco (high elevation) and Patimbao (low elevation), and chicken in Calumpang (medium elevation) (table 7.9). In San Francisco and Patimbao, chicken and pork are still sold during extreme events. In San Francisco, the volume of meat handled during extreme events is even larger by 33 percent in chicken and 25 percent in pork. In Patimbao, there is no change in the volume sold with or without extreme events. The vendor in Calumpang does not sell meat during extreme events. It is interesting to note that buying price and selling price of chicken and pork do not change with or without extreme events.

Table 7.9. Volume traded and market prices of meat during normal times and during extreme events (2013-2014)

Item	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Calumpang	Bungkol	Patimbao	San Pablo Sur
Normal Chicken Pork	2/day 8/day		20-25		2/wk 2/wk	
Extreme Events Chicken Pork	3/day 10/day		None		2/wk 2/wk	
Buying Price Normal Chicken Pork	110 170		120		125 180	
Extreme Events Chicken Pork	110 170				125 180	
Selling Price Normal Chicken Pork	130 190		140		150 200	
Extreme Events Chicken Pork	130 190				150 200	

Estimated Profit of Agricultural Traders

In rice, volume handled by traders, buying prices, and selling prices are the same during normal days and during extreme events (table 7.10). Volume sold, however, declines by more than 50 percent when there is a strong typhoon or flood. Hence, although profit per kilogram is the same with or without an extreme event, total profit per day decreases during an extreme event due to the lower number of kilograms bought by consumers.

In vegetables, marketing cost is either the same or higher during an extreme event than during normal days. But marketing losses are generally higher during extreme events, particularly during bad weather. Likewise, buying price, selling price and profit per kilogram of vegetables are much higher. It should be pointed though that the

volume of vegetables handled by traders is much less when there is an extreme event. The number of vegetable traders is also reduced.

During extreme events, root crops, fruits, chicken and pork are available only in some barangays. Traders of root crops and fruits realized higher profits per kilogram but with lower volume traded during extreme events. On the other hand, since the buying and selling price of chicken and pork do not change with or without extreme events, meat retailers got more or less the same profit per kilogram. The change in the volume traded of chicken and pork varies. In San Francisco (high elevation), the traded volume of chicken and pork increase by 33 percent and 25 percent, respectively, during extreme events. The volume traded is the same in Patimbao (low elevation). In Calumpang (medium elevation), the meat vendor sells only chicken; she does not sell meat during extreme events. Seafoods for sale are not available in the barangays during extreme events.

Table 7.10. Estimated Marketing losses, marketing cost and marketing profit (per kilogram) during normal and extreme event (2013-2014)

Item	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bukal	Bungkol	Calumpang	Patimbao	San Pablo Sur
Rice						
(Normal/ Extreme Event)						
Losses	0	0	0	0	0	0
Cost	0.40	0.88	1.00	1.25	0.65	1.41
Profit	2.60	3.60	2.25	1.75	2.35	3.50
Vegetables						
Normal						
Losses	0-3	0-1	0	0-3	0-1	0
Cost	0.50-2	1-1.50	3	1-2	1-2	0.44
Profit	0.50-25	1-8.50	7.47	1-8	4-8	10
Extreme Event						
Losses	1-3	0-2	0	0-3.50	0-1.50	-
Cost	0.50-2	1-1.50	3	2-4	2-4	-
Profit	1.50-35	4-16.50	7-47	3-16	13-15	-
Root crops						
Normal						
Losses	0	0	-	0	0	-
Cost	0.5	0.35	-	0.50	0.65	-
Profit	6.08	4.15	-	7	9.35	-
Extreme Event						
Losses	0	0	-	0	0	-
Cost	1	0.35	-	0.75	0.32	-
Profit	6.78	4.65	-	9.25	9.68	-
Fruits						
Normal						
Losses	0	-	-	-	0	-

FOOD MARKET ADAPTATION STRATEGIES

Cost	1	-	-	-	5	-
Profit	2	-	-	-	10	-
Extreme Event						
Losses	0	-	-	-	-	-
Cost	2	-	-	-	-	-
Profit	3	-	-	-	-	-
Chicken/ Pork						
Normal						
Losses	1	-	-	0	0	-
Cost	3.2	-	-	5	5	-
Profit	15.80	-	-	15	17.50	-
Extreme Event						
Losses	1	-	-	-	0	-
Cost	3.2	-	-	-	5	-
Profit	15.80	-	-	-	17.50	-
Fish/ Shellfish						
Normal						
Losses	2	-	-	0	-	-
Cost	5	-	-	5	-	-
Profit	13	-	-	15	-	-

Major Public Markets

The Nagcarlan and Sta. Cruz public markets are the major public markets nearest the study sites; these are where residents source their food needs when supply in the barangays is not enough for the residents.

Nagcarlan

Rice

In 2014, retail prices of NFA rice per kilogram in Nagcarlan were PHP 27 and PHP 32; these were said to be PHP 25 and PHP 30, respectively, in 2013. There are two NFA rice retailers in the Nagcarlan Public Market.

According to the bigger rice retailer interviewed, she sold NFA rice ranging from two sacks to 14.29 sacks/day depending on the availability of NFA rice for sale in NFA, San Pablo City. She adds just PHP 2/kg to the buying price. After deducting the cost of marketing rice [e.g., trucking, underweight (less than 50 kg sack of rice), market fees], she gets a net profit of PHP 1/kg. In 2013, she procured a varying number of 14 to 100 sacks per week, depending on the supply of NFA rice for that week; she was able to sell the same quantity in one week. A customer who brought his own bag or container for the rice he wanted to buy was allowed to purchase 3-5 kg/day only; it was rationed so that many other customers could be served. Even during a typhoon or calamity, the selling price of NFA rice is the same. Customers still go to the public market when they need rice during extreme events.

Fish

The top four most popular fish sold in Nagcarlan Public Market are galunggong, tilapia, tulingan, and bangus. Of these kinds of fish, the supply of galunggong and tulingan decrease by about half during extreme events (table 7.11). The supply of tilapia is still the same as tilapia just comes from the place. The supply of milkfish increases by 50 percent during extreme events as bangus fishponds tend to overflow during a typhoon.

Table 7.11. Quantity of fish sold daily during normal times and extreme events in Nagcarlan, 2013

Fish	Quantity sold daily (kg.)		Selling price (PHP/kg)	
	Normal	Extreme events	Normal	Extreme events
Galunggong	15	5-10	100	120
Tilapia	10	10	120-big 70-small	120-big 70-small
Tulingan	10	5	100	140
Bangus (milkfish)	5	10	120	100

Because of the decline in the supply of galunggong and tulingan during extreme events, the prices of galunggong and tulingan increase by 20 percent and 40 percent respectively. On the other hand, the retail price of bangus goes down by 20 percent because of the increase in its supply. The price of tilapia remains the same.

The milkfish being sold in Nagcarlan comes from Lucena City in Quezon Province (5 percent), Bulacan (5 percent), and Dagupan in the province of Pangasinan (90 percent). During extreme events, the supply of bangus comes from Dagupan (80 percent) and Bulacan (20 percent). There are also five fish dealers coming from San Pablo City (Lucena City suppliers deliver the fish to these dealers in San Pablo City) who supply the fish retailers in the Nagcarlan public market. During extreme events, if the supply of fish is low, the fish dealers deliver only small quantities to the fish vendors in the market.

It is interesting to note that the fish retailers did not report any marketing losses nor any marketing problems. They asserted that the fresh fish that were not sold during the day will be cooked and sold the following day. They added that they get more profit during an extreme event; normal profit is PHP 10-20/kg compared to PHP 10-40/kg during an extreme event. Marketing cost includes market fees, plastic bags, and the depreciation of weighing scale.

Meat

Dressed chickens sold in the public market of Nagcarlan come from Lucena and Calumpang, Liliw. Extreme events were said to have no effect on the price of chicken. Changes in the retail price of chicken still depend on the interaction of supply and demand forces.

The dressed chicken retailer interviewed handles 50 kg of dressed chicken daily with or without extreme events. She has not experienced spoilage. Sometimes, 3 kg is left after the day in the public market but this is placed in the freezer and sold together with the fresh ones, meaning some frozen cuts are mixed with the fresh cuts of chicken.

In 2013, buying price was PHP 137/kg. Selling price or retail price was PHP 150/kg. After deducting the marketing costs (PHP 150 for electric consumption, monthly rental for the space in the public market, annual business permit, plastic bags, and

depreciation of weighing scale) estimated at PHP 3/kg, retailers usually get a PHP 10/kg net income from selling dressed chicken.

Slaughtered pigs usually come from backyard farms in Nagcarlan. In 2013, volume handled by retailers was about 50kg daily sold at PHP 170/kg. Prices are based on the prevailing market price. For a 70-kg pig live weight (equivalent to 43kg carcass weight), it was estimated that a retailer will get PHP 500 profit. During extreme events, they refrain from slaughtering pigs. They reasoned that since there is no electricity, the pork would easily get spoiled if not sold immediately after the pig was slaughtered. However, in some cases where they have some pork for sale during a typhoon, the price is still the same as during normal days. During normal days, 0-20 kg of pork may not be sold and hence, placed in the freezer for sale the following day. Normally, one pig is slaughtered daily. In the Nagcarlan Public Market, the number of pork retailers is 30. There are 10 chicken retailers, about 120 fish retailers, and 100 vegetables retailers. There are five stalls selling carabeef daily. There is only one beef retailer who sells beef during Saturdays and Sundays only. According to key informants, carabaos and cows for slaughter are bought from the Padre Garcia, Batangas livestock auction market. Just like pork, carabeef and beef are not usually sold in the market during extreme events.

Sta. Cruz

Rice

Just like in Nagcarlan and other Laguna areas, marketing of rice is not that affected by extreme events. Since it is a necessity and there are government price controls, particularly for NFA rice, prices of rice remain the same even if there is a strong typhoon. People still go to the market to buy rice whenever possible.

Chicken

It was reported by chicken retailers that the situation is almost the same with or without extreme events. Buying price of dressed chicken is PHP 100/kg while selling price is PHP 120/kg. Sources of dressed chickens are Nagcarlan, Lucena City, and other nearby Laguna areas. After deducting the marketing costs, which include market fees, plastic bags, the depreciation of weighing scale and business permits, net income of retailers range from PHP 10-15/kg. Those handled by the retailer range from 30 to 35 kg daily. There are about 30 stalls for chicken retailers in the Sta. Cruz public market.

Pork

Pork was sold at PHP 180-190/kg by pork retailers in 2013. Volume handled is normally 5-12 heads (about 83 kg in live weight per head equivalent to 58kg carcass weight per head) daily bought at PHP 110/kg liveweight. They pick up the hogs daily from the piggery farm in Siniloan, Laguna, spending about PHP 600 in gasoline. Other marketing costs include PHP100/head for slaughtering the animal, market fees, license fees/permits, and the depreciation of weighing scale. Buyers come from as far as Kalayaan and Victoria, Laguna,

Gross income is estimated at PHP 500/head while net income is about PHP 300/head. Pork not sold daily ranges from 0-5 kg and the pork left is usually made into tocino. Hence, there are no marketing losses.

During an extreme event, only five heads of hogs are slaughtered as the number of buyers of pork decreases. Their eight “suki” restaurants likewise buy less than the 20-30 kg supplied daily. It was asserted that the price of pork does not change during extreme events as there is competition from other pork retailers. There are 40 stalls selling pork in the Sta. Cruz public market. Some retailers have been selling pork in this market

for 36 years already. Retailers and consumers alike were momentarily inconvenienced during the flood in Sta. Cruz caused by the habagat; the public market was overcome by floodwaters and had to be transferred temporarily to an area near the city hall, about 1.5 to 2 km away from its original location.

Problems of Agricultural Traders

Problems encountered by traders consisted of limited capital, delayed payment of buyers, high prices and price fluctuations, and spoilage of agricultural commodities, especially during the rainy season. With or without extreme events, these problems are being experienced. In addition to these, flooding occurrences is worsening, especially in low-lying areas, affecting the marketing activities of traders.

Adaptation Strategies by Traders

High Elevation

San Francisco

Residents claim that there is no food problems in the barangay during extreme events and that businesses operate as usual. (It must be noted, however, that seafood is not available during these events.)

Bukal

Some traders lower the volume of agricultural commodities traded. Some traders go to the Tanauan trading center to sell vegetables. Other traders opt to rest for two to three days.

Medium Elevation

Calumpang and Bungkol

There are almost no vendors of agricultural commodities during extreme events. These vendors just wait for the weather to normalize. If ever there would be traders, these traders reduce the volume of their traded commodities.

Low Elevation

Patimbao

There are almost no traders in the barangay. A trader doubles volumes handled during extreme events as residents refrain from going to the city public market.

San Pablo Sur

There are almost no vendors of agricultural commodities in the barangays because of flood. Vendors present lower the volume of their handled agricultural commodities. The banca is used to transport commodities.

Nagcarlan Public Market

There is usually a lower number of traders in the public market. In general, traders lower the volume of goods traded during extreme events to avoid spoilage. Some of the vegetables are even peddled house to house in nearby areas. Chicken retailers mix frozen cuts of chicken with fresh ones. Pigs are not slaughtered during extreme events. Likewise, beef and carabeef are not available for sale. The volume of fish handled is

lower by 33-67 percent for galunggong; 50 percent for tulingan; higher by 100 percent for milkfish; and no change for tilapia.

Sta. Cruz Public Market

There is a lower number of vendors in the public market. The volume of vegetables handled by traders is reduced. Hogs slaughtered are also reduced by 41 percent. Pork that is not sold is made into tocino, which is also for sale. When the public market is flooded, the vendors install themselves in drier places near the city hall.

CONCLUSIONS AND RECOMMENDATIONS

Strong typhoons and floods are considered extreme events by the key barangay officials and agricultural traders. There is a high reduction in the volume and kind of vegetables traded during extreme events. In some low elevation areas where flooding is experienced, there are even no vegetables for sale. Buying price, selling prices and profit per kilogram of vegetable sold are likewise much higher during extreme events than during normal days.

Volume of rice handled, buying prices and selling prices, and profit per kilogram of rice sold are the same with or without extreme events. The number of kilograms sold of rice, however, is reduced.

Root crops, fruits, chicken and pork are sold only in some barangays during extreme events. While traders of root crops and fruits obtain higher profits per kilogram, traders of chicken and pork have more or less the same profit per kilogram as buying and selling price of these meat products do not change with or without extreme events. Fish and shellfish are not available for sale in all the study sites during extreme events.

Problems met by traders consisted of limited capital, delayed payment of buyers, high prices and price fluctuations, and spoilage of agricultural commodities, especially during the rainy season. Moreover, traders' activities are adversely affected by worsening flooding. Adaptation strategies of traders during extreme events include resting for two to three days, decreasing or increasing the volume handled of commodities, refraining from slaughtering pigs, and mixing frozen cuts of chicken with fresh ones.

Since prices of vegetables, root crops, fruits, and some fish in the study sites have much higher prices during extreme events, there should be a monitoring of prices for these commodities during extreme events. The imposition and enforcement of price ceilings at the barangay level, ensuring at the same time the adequacy, accessibility, affordability, and safety in consuming the agricultural products, should be given utmost consideration by the country's government planners and policy-makers. Some traders noted that a bagsakan or trading center for agricultural commodities is a necessity in the barangay; some hope to have their own stall in the market. With regard to flooding, the government should do something to alleviate the problem by improving drainage facilities.

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Appendix Table 7.1. Volume traded and frequency of procurement of agricultural commodities and fish products during normal times, July 2013-June 2014, Laguna

Commodity	Volume Traded and Frequency of Procurement							
	High Elevation		Medium Elevation		Low Elevation			
	Bucal	San Francisco	Bungkol	Calumpang	Patimbao	Pablo Sur	Sta. Cruz	Nagcarlan
Rice (kg/day)	0	50/wk (1)	25/wk – 85/mo.	375/wk (1)	15/day – 250/wk (2)	25/wk (1)	-	-
Vegetables								
Chayote (kg/day)	80 - 2,500 (4)	10 - 29 (1)	1/mo.	3 (2)	2 – 3 (1)	0	50 EOD (1)	3 – 50 EOD (3)
Tomato (kg)	200 - 600/day (4)	1-300 (2)	2 EOD – 2/wk (2)	5 EOD – 5/day (2)	3 (1)	2 - 3/wk (1)	25	10 – 20/wk (2)
Cabbage	50 - 1,500/wk (4)	300 (1)	1 EOD (1)	5/day – 10 EOD (2)	2 (2)	0	30	20/wk
Eggplant	30/wk (1)	20 (1)	1 EOD (1)	2/day – 5 EOD (3)	20 (1)	10 (1)	0	0
Kangkong (tali)	0	100 (1)	0	20 EOD – 20/day (2)	10 (1)	150 (1)	0	10 – 25/day (2)
Sitao	0	1 (1)	0	1 (1)	1 (1)	0	0	0
Okra	0	0.5 - 10 (2)	0	1 (1)	1 (1)	2 (1)	0	2/wk
Potato	0	1 (1)	0	3/day – 5/wk (2)	1 (1)	0	0	25 EOD – 20/wk (2)
Carrot	0	0.5 (1)	0	1/day	5/day – 1/wk (2)	0	10 (1)	0
Squash	0	0.75/day – 500/wk (2)	0	2/day – 5 EOD (2)	2 (1)	9/wk (1)	0	5/wk (1)
Sili	0	0.25 (1)	1/wk (1)	0.25 (1)	0	1/wk (1)	15 twice/wk (1)	0
Calamansi	0	0.5 (1)	0	0	0	0	10 (1)	0
Onion	0	1 (1)	2/wk – 1/m	2/day – 5 EOD (2)	2 EOD (1)	0	50 EOD	20/wk
Garlic	0	0.25 (1)	2/wk – 1/m	1 EOD – 1/day (2)	0.5/wk (1)	0	14 (1)	0.5 – 7/wk (2)
Ginger	0	0	0	1 (1)	0	0	0	0
Pechay	0	1/wk (1)	0	2 EOD – 2/day (2)	0	0	0	10/wk
Pechay Baguio	500 – 1,000 (1)	200/wk (1)	0	0	0	0	10 (1)	0

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Commodity	Volume Traded and Frequency of Procurement							
	High Elevation		Medium Elevation		Low Elevation			
	Bucal	San Francisco	Bungkol	Calumpang	Patimbao	Pablo Sur	Sta. Cruz	Nagcarlan
Patola	0	0	0	2 (1)	0	5 twice/ wk (1)	0	0
Cucumber	1,5000 - 2,000 (1)	0	0	2 (1)	0	0	0	0
Baguio beans	300 - 1,000 (2)	200/wk	0	1 - 1,000 (2)	1 (1)	0	10 EOD	0
Mustasa	0	10 (1)	0	2 EOD (1)	0	0	0	0
Ampalaya	300 (1)	300/wk (1)	0	2 EOD (1)	1 (1)	5 (1)	0	1/day - 10/wk
Radish	100 - 1,000 (1)	200 (1)	0	0	1 (1)	0	0	0
Camote tops (tali)	0	0	0	0	50 (1)	0	0	0
Bell pepper	0	0	0	0	0	0	3 (1)	0
Root crops								
Sweet potato	30 - 500 (3)	350/wk (1)	0	1/day - 5 EOD (2)	1.5 (1)	0	0	0
Gabi	0	700/mo. (1)	0	1/day - 5 EOD (2)	1.5 (1)	0	0	0
Cassava	0	300/wk (1)	0	0	0	0	0	0
Fruits								
Saba	0	500/wk (1)	0	0	2/wk (1)	10 EOD (1)	0	0
Tordan	0	300/wk (1)	0	0	0	0	0	0
Lakatan	0	80/wk (1)	0	0	0	0	0	0
Guyabano	0	10/wk (1)	0	0	0	0	0	0
Meat								
Chicken	0	0	0	20 - 25 (1)	2/wk (1)	0	0	0
Pork	0	0	0	0	2/wk (1)	0	0	0
Fish and shellfish								
Bangus (milkfish)	0	0	0	10 (1)	0	0	130 (1)	0
Tilapia	0	0	0	25 (1)	0	0	155 (1)	0
Tulingan	0	0	0	5 (1)	0	0	100 (1)	0
Galunggong	0	50/wk (1)	0	10 (1)	0	0	100 (1)	0
Blue marlin	0	0	0	3 (1)	0	0	0	0

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Posit	0	0	0	3 (1)	0	0	0	0
Yellow fin tuna	0	70/wk (1)	0	0	0	0	0	0
Commodity	Volume Traded and Frequency of Procurement							
	High Elevation		Medium Elevation		Low Elevation			
	Bucal	San Francisco	Bungkol	Calumpang	Patimbao	Pablo Sur	Sta. Cruz	Nagcarlan
Shrimp	0	10/wk (1)	0	2 (1)	0	0	0	0
Crabs	0	60/wk (1)	0	0	0	0	0	0
Alamang	0	200/mo. (1)	0	0	0	0	0	0

Note: EOD = every other day

*Figures in parenthesis are the number of respondents reporting

Appendix Table 7.2. Buying and selling price of agricultural commodities

Vegetables	High Elevation		Medium Elevation		Low Elevation	
	San Francisco	Bucal	Bungkol	Calumpang	Patimbao	San Pablo Sur
Chayote						
Buying price						
Normal	10-20	4-30	25	8-40	15-60	-
Extreme Events	16-40	10-40	-	40	60	-
Selling Price						
Normal	15-30	7-32	40	10-50	25-70	-
Extreme Events	22-50	15-50	-	50	80	-
Tomato						
Buying price						
Normal	5-50	2-20	15-40	5-50	10-60	7-50
Extreme Events	7-60	15-30	-	30	100	-
Selling Price						
Normal	7-60	4-22	25-50	8-60	15-90	15-100
Extreme Events	10-100	20-35	-	35	120	-
Cabbage						
Buying price						
Normal	15-50	6-30	50	25-50	25-120	-
Extreme Events	36-50	15	-	70	120	-
Selling Price						
Normal	20-90	8-35	60	30-60	40-130	-
Extreme Events	40-55	25	-	100	150	-

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Eggplant						
Buying price						
Normal	10-55	-	50	15-20	15-80	7-18
Extreme Events	26	-	-	50	60	-
Selling Price						
Normal	15-70	-	60	20-50	25-100	20-60
Extreme Events	40	-	-	60	80	-
Sitao						
Buying price						
Normal	10-35	-	-	15-20	20-60	12
Extreme Events	13-60	-	-	-	50	-
Selling Price						
Normal	15-50	-	-	20-30	30-70	20
Extreme Events	23-80	-	-	-	60	-
Okra						
Buying price						
Normal	15-80	-	-	20-34	20-60	-
Extreme Events	20-130	-	-	-	60	-
Selling Price						
Normal	17-100	-	-	25-40	30-80	-
Extreme Events	35-150	-	-	-	80	-
Potato						
Buying price						
Normal	30-50	-	-	40-60	40-70	-
Extreme Events	60	-	-	80	70	-
Selling Price						
Normal	40-60	-	-	50-70	50-80	-
Extreme Events	70	-	-	100	100	-
Carrot						
Buying price						
Normal	40-60	-	-	50-75	40-60	-
Extreme Events	70	-	-	-	60	-
Selling Price						
Normal	50-80	-	-	60-85	50-80	-
Extreme Events	80	-	-	-	80	-

FOOD MARKET ADAPTATION STRATEGIES

Squash						
Buying price						
Normal	8-20	-	-	8-30	20-50	7-25
Extreme Events	10-30	-	-	40	55	-
Selling Price						
Normal	10-25	-	-	10-40	30-60	10-35
Extreme Events	15-40	-	-	50	70	-
Sili						
Buying price						
Normal	25-60	-	15-50	20-30	-	30-80
Extreme Events	100	-	-		-	-
Selling Price						
Normal	35-80	-	20-60	25-40	-	60-80
Extreme Events	120	-	-		-	-
Onion						
Buying price						
Normal	50-70	-	50-90	30-50	40-100	-
Extreme Events	80	-	50-90	80	50	-
Selling Price						
Normal	60-80	-	60-150	40-60	60-125	-
Extreme Events	100	-	60-150	100	60	-
Garlic						
Buying price						
Normal	80-120	-	50-100	40-100	50	
Extreme Events	150	-	50-100	100	50	
Selling Price						
Normal	100-170	-	60-150	50-120	60	
Extreme Events	180	-	60-150	120	60	
Ginger						
Buying price						
Normal		-	-	50		
Extreme Events		-	-			
Selling Price				60		
Normal		-	-			
Extreme Events		-	-			

ENVIRONMENT AND FOOD SECURITY INTERACTIONS AMID CLIMATE CHANGE

Sili						
Buying price						
Normal	30-60	-	-			-
Extreme Events	40	-	-			-
Selling Price						
Normal	50-80	-	-			-
Extreme Events	55-65	-	-			-
Pechay						
Buying price						
Normal	10-50	-	-	10-50		-
Extreme Events	20	-	-	60		-
Selling Price						
Normal	15-30	-	-	15-60		-
Extreme Events	22-50	-	-	80		-
Patola						
Buying price						
Normal				15-20		-
Extreme Events						-
Selling Price						
Normal				20-25		-
Extreme Events						-
Cucumber						
Buying price						
Normal		4-10		20-35		-
Extreme Events		10				-
Selling Price				25-40		
Normal		6-13				-
Extreme Events		15				-
Baguio Beans						
Buying price						
Normal	15-50	5-40		15-30	20-80	-
Extreme Events	35	20			100	-
Selling Price						
Normal	20-80	7-45		30-50	35-100	-
Extreme Events	40-55	25			120	-

FOOD MARKET ADAPTATION STRATEGIES

Mustasa						
Buying price						
Normal	10-60			30-50		-
Extreme Events	13			60		-
Selling Price						
Normal	12-80			40-60		-
Extreme Events	30			80		-
Ampalaya						
Buying price						
Normal	25-80	10-35		15-50	25-80	-
Extreme Events	33			60	100	-
Selling Price						
Normal	35-100	13-40		30-60	35-90	-
Extreme Events	40-55			80	140	-
Radish						
Buying price						
Normal	8-35	5-30			30-50	-
Extreme Events	11				60	-
Selling Price						
Normal	10-45	8-35			40-60	-
Extreme Events	20-25				80	-
Pechay Baguio						
Buying price						
Normal	8-55	12-35				
Extreme Events	22					
Selling Price						
Normal	10-75	15-40				
Extreme Events	27-33					
Kangkong						
Buying price						
Normal	4-5			2-4	2-5	
Extreme Events	5-7			5	6	
Selling Price						
Normal	5-6			3-6	3-6	
Extreme Events	8			6	7	

CHAPTER 8

COMMUNITY-LEVEL ADAPTATION TO EXTREME CLIMATE EVENTS

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The study sought to determine community adaptation to climate change-related events in the Sta. Cruz subwatershed located in three municipalities of Laguna representing three elevation levels: Sta. Cruz for low elevation, Liliw for medium elevation and Nagcarlan for high elevation. The data of the study were taken from focus group discussion conducted among community officials and representatives of farmers' associations. Results show that there is a growing awareness on the irregularities in weather patterns which they attribute to climate change. Extreme climate events have adversely affected the agricultural sector but the food security was not severely affected because of the adaptation strategies employed. The strength of all the study sites in their adaptive capacity was on the institutions and governance component, specifically on frameworks and structures and human resource capability. The weaknesses identified are on the following: absence of land use policies, early warning system, limited food and livelihood security programs, community information, education and communication program. Policy and program directions must be able to address these concerns to improve community adaptation to climate change over the long term.

Keywords: community adaptation, adaptive capacity, watershed

INTRODUCTION

Climate change is a domestic and international concern. In its 2007 synthesis report, the Intergovernmental Panel on Climate Change (Pachauri, Reisinger, and the Core Writing Team 2007) observed a nearly doubled rise in global surface temperature from data between 1906-2005 and 1856-2005, a span of just 50 years. The same publication reported a global sea level rise averaging from 1.8 mm between 1961 and 2003 and about 3.1 mm between 1993 and 2003. Intensified weather conditions, such as more frequent and stronger typhoons, and hot days and nights, are anticipated mainly because of the anthropogenic emissions of greenhouse gases.

Seventy percent of the world's rural population experience food shortage (IFAD 2010). Table 8.1 shows that the Philippines ranked third among all countries in the World Risk Index and ranked ninth in terms of vulnerability to climate change. This suggests that the Philippines, a country highly dependent on agriculture, will suffer food production losses due to changing weather patterns. With climate events highly hydro-meteorological in nature—manifested as typhoons, flooding, and droughts, there will also be impacts on the water supply and water quality of the country. All these will have implications for food security.

Table 8.1. Top 10 country ranking in the World Risk and Climate Change Vulnerability Indices

World Risk Index, 2012 ¹			Climate Change Vulnerability Index, 2014 ²	
Rank	Country	Risk (%)	Rank	Country
1	Vanuatu	36.31	1	Bangladesh
2	Tonga	28.62	2	Guinea-Bissau
3	Philippines	27.98	3	Sierra Leone
4	Guatemala	20.75	4	Haiti
5	Bangladesh	20.22	5	South Sudan
6	Solomon Islands	18.15	6	Nigeria
7	Costa Rica	17.38	7	DR Congo
8	Cambodia	17.17	8	Cambodia
9	Timor-Leste	17.13	9	Philippines
10	El Salvador	16.89	10	Ethiopia

¹Source: Brodbeck and Jeschonnek 2012

²Source: Verisk Maplecroft 2013

Food security consists of four dimensions: “physical availability of food, economic and physical access to food, food utilization, and the stability of the other three dimensions over time” (FAO 2008, 1). With the expected effects of climate change to all dimensions of food security, the community needs to strengthen its adaptation, as well as its adaptive capacity. This study views community adaptation within the context of adaptive capacity. McCarthy et al. (2001) defines adaptive capacity as “the ability of a system [human or natural] to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.” The study interrelates these two concepts as adaptation practices will indicate the need to enhance adaptive capacity and, in turn, adaptive capacity will enable the delivery of effective adaptation practices.

The study aims to determine the adaptation strategies to extreme climate events (typhoons, droughts, dry spells) practiced at the community level. Specifically, it seeks to answer the following questions:

1. What are the socio-demographic and agricultural characteristics of the watershed communities?
2. What are their knowledge and understanding of climate change?
3. What are the impacts of extreme climate events on various sectors and on food security of the communities?
4. What are the adaptation strategies related to food security employed before, during, and after the climate events?
5. What is the adaptive capacity of the communities? What are the strengths and weaknesses of the communities in adaptation related to food security, and what recommendations should be made to address these weaknesses?

REVIEW OF LITERATURE

According to a United Nations Task Team on Social Dimension of Climate Change discussion paper (2011), people play two roles in the climate change issue—as a victim and as an agent of change. Climate change brings about extreme events and, since humans have the highest degree of vulnerability, adverse impacts such as loss of lives and properties happen. On the other hand, climate change transforms the role of humans to that of a change agent for they are capable of preparing and responding to it.

Vulnerability differs among households, communities and countries (Ahmed, Dalal, and Forusz 2009). However, those that heavily rely on the natural resources around them and are, at the same time, exposed to many risks, are usually the most vulnerable. Climate change continues to affect the natural resources base of these groups, usually in the agriculture, fisheries, water, and forestry sectors, which deliver the basic need of humans, which is food. There have been reports of agriculture losses year after year, a decline in fish production, and the degradation of forests for other human needs (such as energy). These emphasize the central issue of food security in the wide climate change scenario.

The social dimensions of climate change compel discussion and analysis of both the conditions within and among human systems that make them vulnerable, and the actions undertaken to respond to the complexities of climate change and food security issues.

Mitigation and Adaptation to Climate Change

There are two ways of how impacts of climate change can be addressed—mitigation and adaptation (McCarthy et al. 2001). Mitigation is a response mechanism that deals with “reducing sources of or enhancing sinks of greenhouse gas (GHG),” such as the use of renewable energy sources to replace traditional fossil and coal-fueled power plants known to emit GHG or through afforestation and reforestation activities. On the other hand, adaptation is a response mechanism that deals more with “adjusting the natural and human systems in response to actual or expected climatic stimuli.” In the Philippines, the focus of climate change efforts is more on adaptation rather than on mitigation because of the geophysical and socio-economic characteristics of the Philippines. As a developing country, the Philippines is exposed to a number of climate-related hazards, and there are limitations in resources (technological and economic) to adapt to climate change.

Adaptation involves a wide range of stakeholders and actions across different levels—individual, household, community, national and international. Adaptation is “a dynamic social process and the ability of societies to adapt is determined, in part, by the

ability to act collectively” (Adger 2003). The way the society at large collectively acts to confront hazards and reduce risks is one of the determinants of vulnerability (Adger et al. 2004). This suggests that to combat the negative impacts brought about by climate change, it is necessary to encourage households to take part in collective action. The community level best reflects the arena for this collective action, which involves other sectors aside from the households, such as members of the local government and council, peoples’ organizations, civil society groups and non-governmental organizations.

A review of the adaptation practices in the Pacific emphasizes the importance of an “open, transparent and highly-participatory process” in climate change adaptation efforts (PACE-SD 2011). The process suggests that the community must participate in deliberating options and solutions to climate change. Furthermore, there is a need to enhance people’s skills and capacity to deal with climate change impacts. Pandey and Okazaki (2005) also adds that community participation is critical in making sustainable disaster management practices, which entails “partnership, participation, empowerment and ownership by local people”.

The significance of adaptation activities enacted at the community level is that it provides a strong foundation for collaboration at the national and international policy levels (Huq and Ayers 2009). Strong community engagement on their design, implementation and monitoring ensures the effectiveness of adaptation activities (Ebi 2009). Furthermore, adaptation activities implemented at the individual or household level often brings out insignificant effects compared to when they are collectively acted upon together to face the challenges posed by climate change.

A number of research studies have discussed community-based efforts related to climate change adaptation. One of them is the community-based adaptation framework developed by CARE (Dazé, Ambrose, and Ehrhard 2009), which analyzed the roles of local government and the different institutions on climate change adaptation at the community level. It has reiterated the need to conduct institutional mapping which is a tool used to examine institutions that are most important to people, employing questions on the nature of organizations, their interactions with the population and with other local organizations, their strengths and weaknesses, gaps in their capacity and level of influence over adaptation planning and implementation (Dazé, Ambrose, and Ehrhard 2009).

A study on adaptation strategies to food security and climate variability issues in Nigeria focused on the coping strategies driven by social networks formed within the community (Mamouda 2011). The strategies include: cooperation of the extended family, village, or focus group level to strive for better harvests; search and purchase of food from intercommunity cereal banks and the cereal banks of other districts or countries; temporary and permanent migration for work opportunities; food banks (pertaining to community-based organizations managing food stocks); and water resource management. The study revealed that community organizations and institutions help address food security issues in their area. These organizations and institutions each play a role in the process, from capacity building to planning to fund generation to implementation.

Case studies in Mali and Ethiopia in Africa (Naess et al. 2010) documented adaptation efforts within the village level. These include providing essential health care for infants and mothers, education and school feeding, and establishment of cooperatives and cereal banks. On the other hand, interventions from outside institutions include livelihood diversification programs, school feeding, micro-finance, motor pumps (for irrigation), dikes, dune fixation, construction and technical improvement of wells and reforestation, and afforestation. This study highlighted the key role of local institutions

(social and institutional structures) in the coping and adaptation efforts of households, which include facilitating access to resources and decision-making power, thus affecting the households' adaptive capacity.

These studies show that the decision-making at the community level affects both the individual-to-household level and the macro-level (national). Adaptation, when done collectively and collaboratively, is more effective than when done individually. The collaboration between local institutions and outside networks is an asset to adaptation.

Community Adaptation and Adaptive Capacity in the Philippines

In its framework strategy on climate change, the Climate Change Commission (2010) sets the ultimate goal of the Philippines towards climate change adaptation: “to build adaptive capacity of communities and increase the resilience of natural ecosystems to climate change and optimize mitigation opportunities towards sustainable development.” In the same framework, four principles guide adaptation strategies: equity and social justice, the precautionary principle, the principle of subsidiarity, and sustainable development.

These guiding principles emphasize the role of the decision-makers when it comes to climate change issues. The principle of subsidiarity puts the community at the center of decision-making, in which approaches to addressing climate change issues are participatory and collaborative among and across sectors. Community in the Philippine context pertains to the barangay, the municipality, and on up to the level of the province. There are many adaptation efforts already in place at the community level in the Philippines.

Predo (2010) documented the actual experiences and adaptation plans to flooding brought by extreme climatic events of communities and selected municipalities in Ormoc, Leyte and those along Cabalian Bay in Southern Leyte. Adaptation measures include relocation, evacuation, restructuring of house unit, building stone breakwaters, improving the dike system and canals, change in land use, change in livelihoods and early preparation of household needs. The study revealed that respondents implemented adaptation strategies that only involved households (evacuation measures and reconstruction of houses) rather than those that required community cooperation (usually engineering works, like construction of dikes and canals). This is mainly due to the “lack of confidence to rely on cooperative solutions or to depend on the local government units for defensive strategies and actions”.

Perras et al. (2008) discussed the various adaptation practices employed by farmers in the Pantabangan-Carranglan watershed area to reduce the impacts of climate variability. Similar to the results in the study of Predo (2010), only about three adaptation practices were on a community-wide perspective (i.e., community kinship/ties especially in availing of loans, and NGO and government assistance). Other adaptation practices were on an individual basis. The study suggested that further research should elaborate on the limitations and challenges to adaptation at the household and societal levels. It also highlighted the importance of bottom-up assessment and planning and participatory processes in research.

Adaptation strategies in the Philippine setting are still on the verge of recognizing the role of the community (collective action, etc.) as its driver. The prevalent issues (usually political) hindering adaptation at the community level suggest that there is a need to look into the dynamic processes and interactions in a community.

Adaptive Capacity

The different characteristics of a system adapting to climate change is what is being referred to as “adaptive capacity.” According to Smit and Wandel (2006), adaptive capacity is “context-specific.” The determinants of adaptive capacity vary across countries and regions—on its value and its nature. Parry et al. (2007) used the term “differential adaptive capacity,” which means that “adaptive capacity is unequal across and within societies.” The main reason for this differentiation is the “multiple processes” that affect vulnerability (Parry et al. 2007). Though faced with differential adaptive capacity per region or locality, the literature presents a commonality among the determinants (or indicators) of adaptive capacity.

Indicators of Adaptive Capacity

A broad classification of adaptive capacity indicators includes: (a) economic resources or financial resources; (b) technology, or ability to develop technology; (c) information and skills, or the knowledge, understanding, and grasp of the issues; (d) infrastructure; (e) institutions, and support systems; and; (f) equitable distribution of and access to resources across stakeholders (Pachauri, Reisinger, and the Core Writing Team 2007).

Mendis-Millard and Reed (2007) identified a general set of resource capitals of community that includes ecological, social and cultural, human, and economic and built capital. Ecological assets refer to natural resource endowments and ecosystem services, while social and cultural assets are networks, norms and the existence of trust that facilitate citizen participation. Human assets include skills, education, experiences, and general abilities of the individual while economic and built capital refers to financial resources as well as infrastructure.

Marrero (2010) presented a more specific list of adaptive capacity indicators. These include: (a) access to material and technological resources through economic resources (or income); (b) social resources (pertaining to community organization and collective action); (c) social memory not only of those affected by the hazards but also of those who were slightly or were not at all affected; (d) cognitive and motivational factors (pertaining to perceptions of risk, of effectiveness of past interventions, and reliance on public hazard protection); (e) education or community awareness of a more complex view of the hazard; and (f) reduction of psychological reliance on structural adjustments.

In the Africa Climate Change Resilience Alliance (ACCRA) Local Adaptive Capacity (LAC) Framework, Jones et al. (cited in Reid, Faulkner and Weiser 2013) has also identified five characteristics of adaptive capacity, which includes asset base, institutions and entitlements, knowledge and information, innovation, and flexible forward-looking decision-making and governance. Asset base is the availability of assets that allows the system to respond, while institutions and entitlements mean the existence of an appropriate and evolving institutional environment allowing fair access and entitlement. Knowledge and information refer to the ability to collect, analyze and disseminate knowledge and information about adaptation efforts. Innovation refers to an enabling environment to foster innovation, experimentation, and exploration of solutions and new opportunities. Flexible, forward-looking decision-making and governance refers to the ability to anticipate, incorporate and respond to changes in governance structures and planning.

The common indicators of adaptive capacity include technological, economic or financial, physical or infrastructural, natural, social, and political or institutional resources.

A study on adaptive capacity adopted five indicators of adaptive capacity in their study of community adaptation—institutions and governance, risk assessment, monitoring and warning, knowledge, education and information, climate change adaptation technology and infrastructure, and underlying risk factors. Furthermore, community organizations indicators include human resources, economic or financial resources, institutions and networks, knowledge and skills, and technology and infrastructure (Penalba and Elazegui (2011).

METHODS AND DATA

The Sta. Cruz watershed area consists of the municipalities of Liliw, Magdalena, Sta. Cruz, Majayjay, Rizal, and Nagcarlan. Three municipalities represent the low, medium, and high elevation levels. The study focused on two communities in each municipality, thus, covering a total of six communities. Table 8.2 describes the study sites relative to the susceptibility to climate change hazards.

Table 8.2. Study areas by elevation and type of hazards frequently experienced

Elevation	Municipality/Barangay					
	Sta. Cruz		Liliw		Nagcarlan	
Low (10-20 masl)	San Pablo Sur Flooding (more vulnerable)	Patimbao Flooding (less vulnerable)				
Medium (20-470 masl)			Calumpang Flooding (more vulnerable)	Bungkol Flooding (less vulnerable)		
High (above 480 masl)					Bukal Landslide (more vulnerable)	San Francisco Landslide (less vulnerable)

Secondary data collected in the municipalities were as follows: socio-economic profiles, comprehensive land use plans (CLUPs), disaster risk reduction management (DRRM) plans, municipal ordinances, and programs on agriculture and environment. Secondary data collected in the communities were as follows: barangay integrated development plans (BIDPs), DRRM plans, profiles and barangay ordinances. Focus groups (FGs) in the six barangays generated information on perceptions and knowledge on climate change, recollection of the worst extreme events experienced in the areas, impact of these extreme events on the different sectors (agriculture, water, infrastructure, health, livelihood, and food security), adaptation strategies (practiced and planned), and available resources within the barangays to execute adaptation to extreme events. The participants included barangay captains, barangay councilors and health workers, peacekeepers or bantay-bayan, and representatives of farmers associations.

Thematic analysis was done to identify the community's common experiences with extreme events, adaptation strategies, and adaptive strategy.

RESULTS AND DISCUSSION

Community Profile of the Study Sites

A brief barangay profile of each of the study sites captured the general situation (socio-demographic and agriculture) of each barangay (table 8.3).

Socio-demographic Characteristics

Table 8.3. Socio-demographic characteristics of the study sites

	Elevation Characteristics					
	High		Medium		Low	
	San Francisco	Bukal	Calumpang	Bungkol	San Pablo Sur	Patimbao
Classification of Barangay	rural, agricultural	rural, agricultural	rural, agricultural	rural, agricultural	urban	urban, lowland
Population size	2,602	779	3,754	759	2,573	7,910
No. of households	615	220	748	172	600	2,500
Population density	17 persons/hectare	12 persons/hectare	24 persons per hectare	9 persons/hectare	26 persons/hectare	34 persons/hectare
Average family size	4	3	5	4	4	3
Sources of income						
Farming/ Fishing Agriculture and Forestry sector	12.01%	68.43%	32.98%	1.67%	-	-
Employee/ Service Workers	-	-	51.39%	14.07%;	-	-
Business	-	-	7.13%	4.66%	-	-
Laborers/ Skilled Workers	30.52%	6.51%	-	-	-	-
Service workers and shop and market sales workers	18.78%	-	-	-	-	-
Plant and machine operators and assemblers	11.73%	6.02%	-	-	-	-
Source of domestic water	-	-	8.50%	16.31%	-	-
Percent of Households with Access to Potable Water Supply/ Barangay Water System	Barangay water system	Barangay water system; Springs	Liliw Waterworks Association (LIWA)	Liliw Water District	3 rd level water supply	2 nd -3 rd level water supply

Sources: Barangay Management Information System (BMIS of Bukal, Nagcarlan). 2002; Barangay Disaster Risk Reduction Management Plan (BDRMP of Calumpang, Liliw, San Pablo Sur, Sta. Cruz). 2013 and 2014; Barangay Governance Performance Management System (BGPMS of Calumpang, Liliw and Patimbao, Sta. Cruz). 2011 and 2014.

Among the six barangays, those in low elevation (Patimbao and San Pablo Sur) had the highest population size (7,910 and 2,573, respectively) and density (24 and 26 persons per hectare, respectively) compared to the barangays at the medium and high levels. Bungkol had the lowest population (759), followed by Bukal (779). Both also recorded the lowest population density among all the communities (nine and 12 persons per hectare, respectively).

The more vulnerable sites tended to have higher population and greater density than those less vulnerable, except for the communities at the high elevation where the lesser vulnerable barangay (San Francisco) had more people and density than the more vulnerable one (Bukal).

The average family size is four for all the barangays regardless of elevation. Calumpang had the highest average family size of five, while Bukal had the lowest, with three members.

The sex ratio of all the communities was close to 1:1. San Pablo Sur and Calumpang (both identified as more vulnerable) had a lesser male population, while the other four barangays had more females than males.

Educational attainment data, obtained for the medium and high elevation barangays, indicated that only a small percentage (less than 0.05%) had no formal schooling.

Average monthly income data were available only in barangays in high elevation. The less vulnerable barangay (San Francisco) had a higher average monthly income of PHP 10,095 than the Barangay Bukal which only averaged PHP 7,851.

The sources of income common to all the barangays were farming, fishing, and other agriculture-related work; skilled work (laborers); service work (company or government employees) and businesses. Service work as the main source of income was prevalent for residents in barangays at medium elevation. For the high elevation areas, skilled work comprised a high percent as the main source of income, followed by farming, service work, and plant and machine operation and assembly. No significant differences among the less and more vulnerable barangays could be observed in relation to the main sources of income.

All of the barangays had access to water supply. In the barangays with low elevation, a second to third level water supply¹ was available to households. The domestic water supply in the barangays at medium elevation was provided by water companies such as the Liliw Water District and the Liliw Waterworks Association. In the barangays at high elevation, a large percentage of people already had access to the barangay water system. A portion of households in Bukal got their water supply from springs.

Land Use and Agricultural Profile

In terms of land use, agriculture is the major type, except for Patimbao where residential areas comprise the major land use. More than half of the total land area of these barangays is agricultural lands (Table 8.4).

Rice is the most commonly grown crop in low elevation barangays, particularly in San Pablo Sur. In Patimbao, other crops include fruit trees such as lanzones, banana, rambutan, and mango. In the barangays at medium elevation, crops grown include rice, coconut, and fruit trees such as lanzones and bananas. Vegetables are also common in Barangay Bungkol. The upland barangays, on the other hand, do not plant rice. Their main agricultural produce are coconuts, fruit trees (such as lanzones and banana), vegetables (tomato, cucumber, beans, etc.) and root crops (taro, sweet potato, cassava).

¹Second level water supply refers to public water faucets while third level refers to water faucets in individual households.

Table 8.4. Land use and agricultural profile of the study sites

	Elevation Characteristics					
	High		Medium		Low	
	San Francisco	Bukal	Calumpang	Bungkol	San Pablo Sur	Patimbao
Land area	150 ha	63 ha	159.8505 ha	81.2485 ha	97.45 ha	235.85 ha
Agricultural	-	-	123.34 ha (77.16%)	70.67 ha (87%)	53 ha (54%)	75 ha (32%)
Residential	-	-	31.62 ha (19.78%)	5.25 ha (6.46%)	32.48 ha (33%)	157.23 ha (67%)
Commercial	-	-	2.17 ha (1.36%)	2.75 ha (3.38%)	-	-
Agro-livestock	-	-	1.7 ha (1.06%)	-	-	-
Institutional	-	-	1.02 ha (0.64%)	-	-	-
Agricultural crops	Banana, Bitter gourd (ampalaya), Cabbage, Cassava, Chayote, Coconut, Cucumber, Taro (Gabi), Green beans (Habitsuelas), Lanzones, Pechay, Radish, Sweet Potato (Camote), Tobacco, Tomato	Chayote, Coconut, Green beans (Habitsuelas), Lanzones, Banana, Cabbage, Calamansi, Sweet Potato (Camote), Taro (Gabi), Rice (Palay), Squash, Tomato	Rice (Palay), Lanzones, Coconut, Banana	Rice (Palay), Lanzones, Banana, Papaya, String beans, Ampalaya	Rice (Palay)	Rice (Palay), Lanzones, Banana, Mango, Rambutan,
Source of irrigation						
Irrigated	-	-	100%	100%	100%	100%
Rainfed	97.31%	99.56%	-	-	-	-

Sources: Barangay Management Information System (BMIS of Bukal, Nagcarlan). 2002; Barangay Disaster Risk Reduction Management Plan (BDRMP of Calumpang, Liliw, San Pablo Sur, Sta. Cruz). 2013 and 2014; Barangay Governance Performance Management System (BGPMS of Calumpang, Liliw and Patimbao, Sta. Cruz).

2011 and 2014.

All the agricultural land in the low and medium elevation barangays are irrigated. The farms in the upland barangays are rainfed, with frequent rains reported throughout the year.

Knowledge and Understanding of Climate Change and Extreme Events

The participants in the FGDs noted that the usual dry and wet seasons are no longer distinct. Typhoons are more frequently occurring. Barangays in the low elevation areas experience sudden intense heat and untimely heavy rains because of climate change. They said that sometimes the weather is hot or cold. It is intensely hot particularly

when there is severe drought. Likewise, flooding occurs after heavy rains. The elderly and younger people are getting sick, and animals as well.

The folks of Calumpang, Liliw (medium elevation and more vulnerable) focused on the cause and effects of climate change on their crops. They noted the seemingly longer dry season and that the heat of the sun seems to be more irritating on their skin. They also observed instances of flooding in their areas and there is flowing water in the river. However, because of climate change, the river seems to be drying up, in their view.

The participants from the Barangay Bungkol, Liliw (medium elevation and less vulnerable) think climate is changing as the dry and wet seasons are no longer distinguishable. Cold temperatures can no longer be felt.

The participants from Bukal, Nagcarlan (high elevation and more vulnerable) observed stronger typhoons because of climate change. On the other hand, participants from San Francisco, Nagcarlan (high elevation and less vulnerable) noted the less than distinct dry and wet season have made the cropping calendar hard to follow. Dry seasons are longer and rains are more continuous.

A growing awareness on the effects of climate change was observed in all barangays. They identified weather irregularities (unusual extreme heat or rains; prolonged duration of heat or rains resulting in indistinct dry and wet seasons; both rain and shine experienced within the day), stronger and more frequent typhoons, flooding, more sickness among the elderly, children and even the animals, and a decreased yield in crops, fruit trees, and vegetables as related to the changing climate. There were also differences in climate change knowledge among the barangays in each elevation level. The residents of barangays at low elevation linked climate change to flooding in their areas and increasing illnesses among the elderly, children, and even animals. The barangay residents in the medium elevation areas also attributed unusual instances of flooding during typhoons to climate change. They also thought that climate change has affected their crops, particularly lanzones trees, which have taken three years before they started to bear fruits again. The barangays in the high elevation sites linked climate change to observed stronger typhoons and to changes in the normal cropping calendar.

Extreme Events and Various Effects in the Agricultural Sector

Participants from all barangays, except those from Bukal, Nagcarlan, cite Typhoon Milenyo in 2006 as the most unforgettable extreme event in 2006. Milenyo brought strong winds and heavy rains that caused flooding, eventually damaging agriculture.

Residents, except those of San Francisco, also recalled the wrath of Typhoons Santi and Ondoy in 2009. In these barangays, heavy rains and flooding occurred, causing a number of casualties from the storms. The people of San Pablo Sur had anticipated flooding in their barangay because of their location. Aside from the fact that they are in a low-lying area, their barangay is a catchment for the water from the surrounding mountains. It is in their area where the waters from the mountains and the lake meet.

Only the residents of Patimbao, Sta. Cruz experienced drought in 2005. They remembered not being able to harvest crops for two seasons. The barangays of Calumpang and Bungkol in Liliw, and Bukal and San Francisco in Nagcarlan, have recently observed droughts, which affect their crops and fruit trees.

In the barangays at low elevation, fruit trees (lanzones, banana, mango and rambutan) were damaged. Rice areas were flooded while fruit trees were blown down by strong winds. Patimbao suffered flooding in 30 percent of their rice areas, while in San Pablo Sur it was 50 percent. About 83-90 cavans/ha were lost, translating to a value of PHP 1

million to 1.5 million in damages. Damages to fruit trees were estimated at around PHP 1.6 million worth of damage (table 8.5).

Table 8.5. Damage to agriculture due to typhoon

	Elevation Characteristics					
	Low		Medium		High	
	San Pablo Sur, Sta. Cruz	Patimbao, Sta. Cruz	Calumpang, Liliw	Bungkol, Liliw	San Francisco, Nagcarlan	Bukal, Nagcarlan
Typhoon	Ondoy	Santi	Ondoy/Santi	Santi	Milenyo	Ondoy
Crop/Area in hectares (ha)/no. of trees damaged	Rice: 26.5 ha	Rice: 37.5 Fruit trees: 4,200 trees	Rice: 2.8 Coconut: 6,000 trees Fruit trees: 10,000 trees	Rice: 25ha Vegetables: 16 ha Fruit trees: 40ha lanzones; 1000 banana	Vegetables: 102ha	Vegetables: 2.25 ha
Value of damage (PHP)	Rice: 1,550,250	Rice: 1,053,270 Fruit trees: 1,610,000	Rice: 229,320 Coconut: 240,000 Fruit trees: 159,000	Rice: 450,000 Vegetables: 220,000 Fruit trees: 2,505,000	Vegetables: 5,100,000	Vegetables: 850,000
Total value of damage (PHP)	1,550,250	2,663,270	628,320	3,175,000	5,100,000	850,000

In the medium elevation communities, rice, fruit trees and some vegetables were affected by strong winds and by flooding brought by heavy rains. Calumpang experiences a yield of 130 cavans/ha because only 10 percent of the rice area was damaged by the typhoon. Around seven percent of lanzones trees were also affected. In Bungkol, 25 ha of rice lands were damaged and the yield was lower at 40 cavans/ha. Rice fields that were partially damaged had already been harvested by farmers before the typhoon came. Banana trees were totally destroyed by the typhoon.

The crops of high elevation barangays are mainly vegetables such as tomato, cucumber and Baguio beans. Total value of damages ranged from PHP 850,000 to PHP 5.1 million. In Bungkol, an expected yield of 30,000 kg of Baguio beans was lost to damages by Typhoon Ondoy.

Foregone income due to fallow farms and work suspensions was the major effect of the typhoons on the livelihood of the barangay residents.

Irrigation system

The typhoons also damaged the irrigation facilities including the main dam and irrigation canals thus disrupting the supply of water to the farms. This prevented farmers from planting for the next one to three cropping seasons. In Barangay Patimbao, Sta. Cruz, (at low elevation), the repair of the dam suspended the operation of the irrigation system and the farmers were not able to plant rice the next three seasons. Foregone income amounted to around PHP 10.5 million. Funds amounting to around PHP 40,000 for the repair of the irrigation canals were taken from the barangay internal revenue allotment (IRA). In the lowland Barangay San Pablo Sur, floodwaters brought by typhoon Santi took one month to subside.

In Calumpang, Liliw, the Sta. Cruz dam was first heavily damaged during Typhoon

Milenyo, and was again damaged during Typhoons Ondoy and Santi. Damage to the national irrigation system was worth PHP 2 million but NIA repaired the system. The barangay also missed three rice cropping seasons worth PHP 2.3 million. The damaged NIA dam affected many municipalities in Laguna, including Sta. Cruz, Pila, Liliw, Victoria, Calauan, and Bay and around 4,000 farmers. Meanwhile, in Barangay Bungkol the rice fields were damaged due to inundation.

In the two upland barangays which have no irrigation system, rain was the problem. Continuous rain in September, October, November and January damaged many vegetable farms.

Domestic water supply

The water supply for domestic consumption was also affected by the typhoons. The common causes for these water interruptions were broken waterlines and pipes washed away by the rivers. In Calumpang (medium elevation), the Liliw Waterworks Association (LIWA) and the municipal government funded the repair of the waterlines for drinking. In Bungkol, there was a two-week water interruption. The cost of buying water was PHP 100 per week per household, an additional burden on household expenses.

Barangay Bukal (high elevation) suffered water interruption for one day due to Typhoon Santi, but an estimated PHP 12,000 was spent to replace damaged water pipes and lines for domestic water supply. In San Francisco, the waterlines were fixed through the bayanihan system spearheaded by the barangay council.

Power supply

All of the barangays suffered power interruptions during typhoons. Patimbao had a three-day power interruption, while Bungkol had a month-long power interruption during Typhoons Ondoy and Santi. Each household spent an average of PHP150-200 in one month for gas, candles, and fuel. The power supply in Bukal was interrupted even before the typhoon came but was immediately restored days after. Damages to the power lines were minimal. Under Typhoon Milenyo, Barangay San Francisco, experienced a one-week power outage.

Impacts of Extreme Climate Events on Community Food Security and their Adaptation Strategies

Damage to the agriculture sector poses a challenge to the food supply dimension during extreme events, especially because agricultural lands comprise 30-50 percent of the total land area in low elevation barangays and over 70 percent in the higher elevation communities. Flooded rice fields in barangays at low and medium elevations were either left with only half of their usual yield or had nothing to harvest. Damaged irrigation systems suspended rice planting resulting in loss of income and rice stock for household consumption. This may translate to food insecurity, especially because rice is a staple food.

Even if adversely affected by typhoons, barangays in the high and medium elevation perceived no problems in their food supply. Community members have their own way of coping with food supply issues during extreme events. They have easy access to alternative food sources near their farms. They also have stock farm produce (aside from the marketed produce), which is for household consumption. Residents of high elevation areas buy their rice from markets because they do not plant their own rice.

“There is no problem because almost all of us plant. We have our own harvests. We can eat.”

“We, in this area, have no problems in terms of food because we are contented with just having salt, and we have many vegetables here. We have stock sardines (canned goods) in our houses, just add vegetables in it. So, even if there are no fish vendors for a week, we can live. Even if we just have salt, oil and vegetables, we already have food on our tables.”

“We are in an agricultural area that is why we never lose root crops like taro and sweet potato. Those are our alternative sources of food if, let’s say, our farms will be totally washed out. We boil taro and dip it in sugar (like suman, a native delicacy composed of rice, which is dipped in sugar). We are very far from hunger.”

“Usually, we buy rice outside, in half-cavans. At times, even if we do not consume all our stock, we will already buy another. And often, we program rice stock for a month.”

The barangays in the high and medium elevations have not yet experienced food shortage pressing enough to warrant the delivery of relief goods and outside assistance.

“We still have not experienced asking food from other places. If our supply is not enough, we have families. We help each other.”

“We have not yet depended for help because in our place, we have our own farms. We do not depend on the government. We have rice stock. We have not yet asked help from DSWD to give us enough food. This is really a blessing of God to us.”

“It is enough. We have not yet experienced no rice, no food. We have not yet experienced it here in our barangay.”

“We are in our farms. We harvest vegetables. It is unusual...those who are not getting enough food are those who are, maybe, really lazy.”

On the other hand, both barangays in the low elevation area and one in the medium elevation area depend on markets nearby for their food supply. Some households were provided with relief goods distributed by different organizations (government, non-governmental, and private) during extreme events, including food. Only a small portion of their population own rice lands.

“While there is flooding, we are given assistance by the municipal, provincial government, but it is not always the case. Ration, relief goods, rice, canned goods, noodles.”

“They gave people food. Mr. Swerte gave food to those affected. They were given rice and already cooked food.”

The proximity of markets affects the barangay’s physical access to food. This is not a problem for the barangays in the low and medium elevation because these barangays are near commercial areas where the public markets are located. In contrast, barangays in the high elevation areas are very far from the public markets. To address this disadvantage, mobile markets visit these areas in the morning. The existence of roads makes access to the main public market in the poblacion easy.

“In our place, as early as 5 o’ clock in the morning, there are already fish vendors. There are many of them who sell fish. But in my estimation, only 10% (of the households) go down and buy food in the public market.”

“Sometimes, they come to our place, carrying meat and fish products. They rent places in our houses. There are about three of them, sometimes two.”

During typhoons, no mobile vendors are present, but the study participants did not perceive this as a problem.

The rise in food prices during extreme events is a problem for food access, as pointed out by those in the less vulnerable barangays at low elevation and the more vulnerable in the medium elevation. The problem is aggravated by the temporary loss of sources of income among the farmers and fisherfolk; when this happens, affected families look for other sources of income such as working as laborers, construction workers or tricycle drivers. The solution of one low elevation barangay vulnerable to this problem was “cash-for-work,” where the local government hires residents in clean-up and reconstruction activities after the typhoon and compensates them for their service. This little income enabled households to meet their food needs. The farmers in the high elevation barangays received financial loans from the provincial government program (Kaunlaransa Laguna). Fifty farmers were granted loans, but only half of them were able to repay, forcing the barangay council to pay the outstanding balance. In the medium elevation barangay, there was no mention of any adaptation strategy employed.

The problem of food in the aftermath of extreme events was addressed collectively through the so-called bayanihan spirit. Social networks made up of neighbors and relatives provided assistance, with local governments and charitable organizations also contributing relief goods.

Other adaptation strategies related to food security that are proactively put in place include seminars, trainings and awareness campaigns, and livelihood programs and programs on agriculture, including the distribution of seeds and other farm inputs and livestock dispersal. However, these are insufficient and are not given much importance. Livelihood programs have also suffered from a lack of continuity, difficulty in applying knowledge acquired, and lack of capital and lack of market tie-up.

Indirectly-related adaptation strategies include water management (operation and management of irrigation systems), watershed management (flood control measures through tree planting) and financial loans for farmers.

Overall, though, food security does not seem to be a major concern of the barangays.

Adaptive Capacity Rating on Various Areas

The adaptive capacity of a barangay gives an indication of their ability to cope with climate-related events and reduce the impacts, particularly on agriculture, their primary source of livelihood. An analysis of the different capacity indicators reveals the areas addressed by the barangays and the needs to protect agriculture and food security.

Institutions and Governance

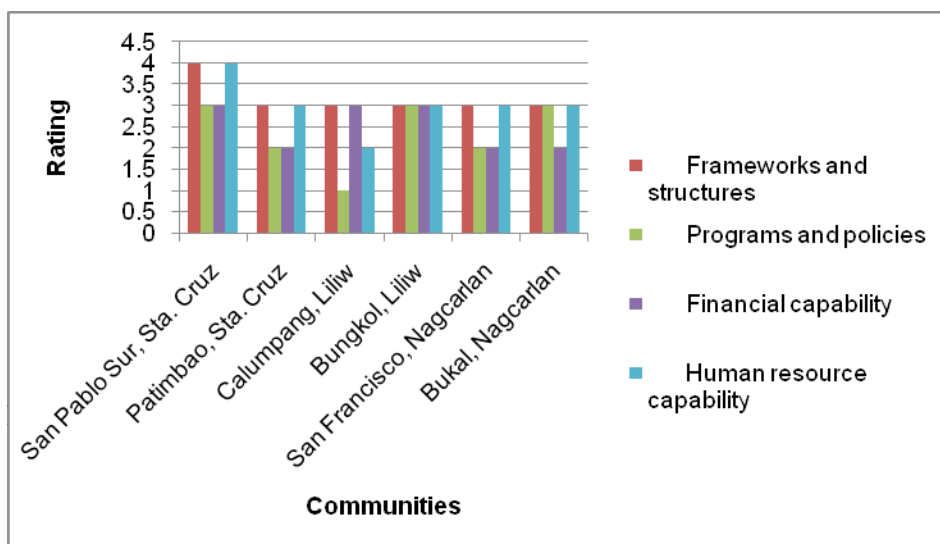


Figure 8.1. Adaptive Capacity ratings of the study areas on institutions and governance component

Frameworks and Structures

All of the barangays rated their adaptive capacity high, within a range of 3 to 4 (figure 8.1). This is mainly because all the barangays had already established their DRRM councils and were already in the process of drafting their DRRM plans in accordance with the DRRM law. The common constraints in this area are insufficient funds and the lack of some equipment necessary in dealing with extreme events. The DRRM framework of the barangays focuses on rescue and relief operations.

Programs and Policies

The common agricultural program implemented in all the barangays is seedling distribution. Other programs target the specific agriculture needs of the barangay. San Pablo Sur acquired post-harvest facilities. Patimbao conducted trainings and seminars regarding farming and livelihood programs, and also initiated the construction of irrigation canals. Barangay Bungkol has a livestock dispersal program. Agricultural programs in San Francisco and Bukal include fertilizer application, financial assistance, trainings and seminars, and free vaccination of livestock. Programs to construct farm-to-market roads and irrigation canals are also in place in Bukal. The communities at high elevation areas have more agricultural programs than areas in the low and medium elevation barangays because of the many agricultural concerns in their areas.

No barangay gave a perfect score for this category as ratings ranged from 1 to 3. The presence of disaster-related programs, projects and activities in the said barangays, such as solid waste management and participation in the National Greening Program (NGP) was the reason for the high rating in this category. The common concern was the insufficiency of funds to organize and implement policies, programs and activities (PPAs). The lack of citizens' participation due to political reasons is another concern specified by San Pablo Sur residents. The lowest score given was 1, by the Barangay Calumpang. No resolutions had been passed to implement disaster-related PPAs in the barangay.

Financial Capability

All the barangays depended on their internal revenue allocations (IRA) to implement adaptation measures to climate-related hazards. According to the implementing rules and regulations of the DRRM law (Rule 18, Section 1-2), a minimum of five (5) percent of the revenue from regular sources may be allotted to the local disaster risk reduction and management fund (LDRRMF), formerly known as the calamity fund. This LDRRMF may finance activities for disaster prevention and mitigation, disaster preparedness, disaster response, and recovery and rehabilitation. Out of the LDRRMF, 30 percent is allocated as a “quick response fund or stand-by fund for relief and recovery programs.”

With their IRAs as the only source of funds, almost all of the barangays lamented the insufficiency of their calamity fund for their DRRM programs. The LDRRM fund ranged from as low as PHP 42,000 for the upland Barangay Bukal to PHP 187,000 in the lowland barangay of Patimbao. The six barangays usually allocated their LDRRMF to disaster preparedness and quick response programs. Disaster preparedness expenditures include the acquisition of supplies and equipment like megaphones, handheld or two-way radios, other materials for rescue operations, medicines and relief goods. For the agriculture sector, the LGUs provide the seeds for the rehabilitation of damaged farms.

Human Resource Capability

The participants gave their barangays a high rating for this category. San Pablo Sur rated 4 while the other barangays, except Calumpang, rated 3. Calumpang residents rated themselves a 2.

All the barangays have had to participate in several trainings and seminars on climate change, DRRM and rescue operations, which was conducted by government agencies, such as Department of Interior and Local Government (DILG) and Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), and academic institutions, such as UP Los Baños. Most of the participants of these trainings and seminars were the barangay personnel—usually the barangay officials themselves and the members of Bantay Bayan, the committee on peace and order. Information dissemination and knowledge transfer of the trainees to local stakeholders, however, is perceived to be a problem.

In rating efforts on barangay training, only one barangay (San Pablo Sur) rated their initiatives perfect, while the other four barangays scored 1. San Pablo Sur community members reported that barangay personnel are able to impart their knowledge to the residents of area; training and seminars are usually organized by Technical Education and Skills Development Authority (TESDA) and focus on livelihood programs such as meat processing and candle-making. Aside from San Pablo Sur, Bungkol has also conducted trainings that dealt with agriculture, though these were very limited.

A good part of the knowledge gained in trainings and seminars by barangay personnel have yet to be relayed to the rest of members and residents of the barangay. In the case of Patimbao, only the head of the farmers’ association attends trainings, but not much has been done to relay the information to other farmers.

The lack of perceivable results from trainings and seminars in the poorly-rated communities has been attributed to the lack of cooperation among barangay residents. The reasons for this lack of cooperation may be a lack of interest, lack of time or lack of capital to apply the new knowledge. Misguided incentives may also be the cause for the indifference towards trainings and seminars. Instead of seeing new learning as a way to improve their lives, constituents will just consider what tokens and giveaways are handed out during the seminar.

The schools in the low elevation barangays have initiated information and education

campaigns tailored to the students. These are usually about solid waste management practices and tree planting. In the medium and high elevation barangays, however, not much has been done in terms of public education regarding climate change. For Barangays Calumpang and San Francisco, no evidence of an education campaign was seen; Barangay Bungkol had information, education, and education (IEC) materials, which were mainly posters about landslides and other hazards and directions for dealing with emergency situations. A public education initiative in Bukal was limited to teaching about waste segregation. Overall, there is a need to strengthen the awareness of the teachers/educators by inviting them to attend seminars on climate change. Respondents from Bungkol suggested house-to-house announcements as a public education initiative.

An essential aspect of adaptive capacity is the creation of community organizations. Organizations that were seen across all elevations were the senior citizens' associations, women and youth organizations, farmers' association, as well as religious organizations and transport groups (tricycle and jeepney drivers).

In the low elevation barangays, sitio neighborhood organizations were established in compliance with the directive of the municipal LGU of Sta. Cruz requiring each sitio to have one. The organization's main activity is the construction of bahay kubo, which encourages backyard gardening.

In San Pablo Sur and Calumpang, people were organized in line with the government's 4Ps (Pantawid Pamilyang Pilipino Program) program. In Patimbao, there was the Samahan ng mga Magsasampaguita, a livelihood generation group.

Nagkakaisang mga Anak ng Calumpang, a cultural organization, organizes the annual Santones Festival. In the high elevation barangays, there are various work-related associations comprised of barangay officials and staff such as barangay secretaries, health workers and nutrition scholars; there are also organizations for volunteers, a group called Samahang Kalalakihan, micro-credit institutions, and academic organizations.

Risk Assessment, Monitoring and Warning

Hazard Map

The barangays in the low and medium elevations have already generated their own hazard maps. High elevation barangays, on the other hand, are currently undergoing seminars on geographic information system (GIS) mapping to update their hazard maps.

Lowland barangays, however, have identified some points that still need to be added to their generated hazard maps. San Pablo Sur sees the need to map out evacuation sites while Patimbao sees the need to identify river control structures along their riverbanks. Respondents from Bukal have also suggested that copies of the hazard map be made more accessible to the public.

Early Warning Device

The early warning devices common to all the communities were megaphones, bells and sirens (kalentong or kalemangin Tagalog). These instruments are used to warn residents of impending weather events, however, the devices proved to be of no service to most of the barangays during the past typhoons. Instead, these instruments were used to announce the start of curfew hours, emergency situations, church activities, community activities, seminars and waste collection. No early warning devices were reported in Bukal; warnings were delivered to them by a radio announcer referred to as Bravosix.

Monitoring System

Almost all of the communities depended on television and radio for news about

weather events; some respondents mentioned text messaging and the internet as other sources. Still, other communities relied on municipal or provincial advisories fed on their handheld radio units.

The upland barangays have a centralized monitoring system. A radio announcer by the name of Bravosix delivered daily weather forecasts, gave details on typhoons approaching (location, intensity, track), and announced any class or work suspension. The coverage of Bravosix's monitoring stretches to the neighboring municipality of Liliw. According to the FG in Calumpang, Bravosix was based in Nagcarlan.

Technology and Infrastructure

Concerns about technology and infrastructure focus more on facilities for emergency operations, evacuation facilities, and relocation sites.

Weather Instruments and Communication Facilities

No weather instruments are installed in any of the communities at present. The usually flooded barangay of San Pablo Sur plans to set up a color-coding system to update and warn the residents about the flood level situation in the barangay during a typhoon.

The ratings of the barangays in the low and medium elevations ranged from two to four. All the barangays had similar communication facilities, which included megaphones, cellphones, and handheld radios. Television was also mentioned by some barangays as a means of communication. Only two out of six barangays gave themselves a perfect score for this category. They perceived the existing communication facilities to be sufficient to satisfy their needs for communication. On the other hand, the communities that were rated between 2 and 3 admitted that they were still in need of communication devices (handheld radios and sirens).

Underlying Risk Factors

The underlying factors that could affect a barangay's vulnerability to climate change-related risks include: the barangay's programs and policies on land use, environmental resource management, food security and livelihood programs, and overall planning. These factors are contributory measures to ensure that barangays are highly anticipative and prepared for the potential impacts. Figure 8.2 shows the ratings given by the barangays communities for the different underlying factors specified.

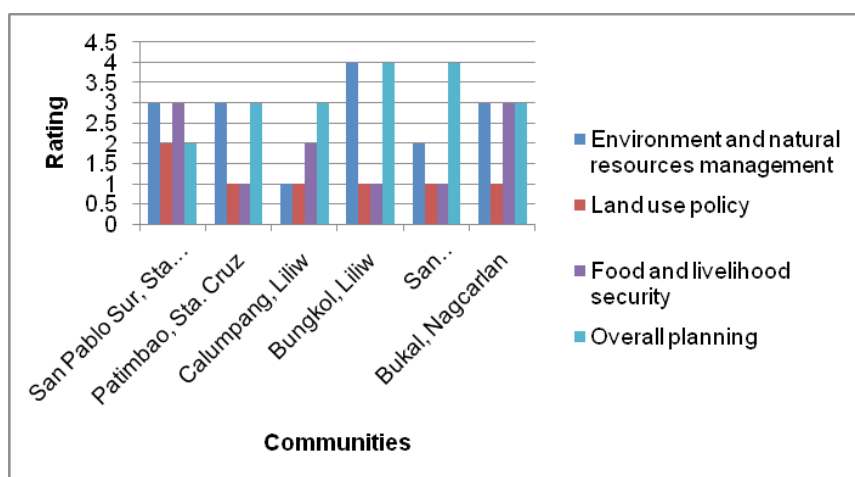


Figure 8.2.
Adaptive capacity ratings of the study areas on underlying risk factors component

Environment and Natural Resources Management

Barangays in the low, medium and high elevation levels have implemented tree planting activities and waste segregation to help the environment. Bukal participates in the national greening program. Environmental protection is reflected in their cooperation in the management of Mt. Banahaw, a protected area. Fourteen DENR-deputized bantay-gubat volunteers monitor Mt. Banahaw monthly and regularly report findings (new species, damaged trees, illegal logging activities) to DENR. Calumpang has not yet implemented any programs for the environment. The strict observance of adopted policies, such as waste segregation, cigarette smoking, and burning of wastes by other local constituents, is a major constraint.

Other adaptation strategies considered by barangay leaders include the protection of the environment through tree planting and improving the awareness of constituents. Farmers in the Barangay Bungkol, Liliw, for instance, pump water from the river during dry spells.

Environmental projects to abate the effects of flooding include tree planting activities; the LGU's bantay-gubat is mobilized for this activity. LGUs also seek partnerships with schools, the private sector and national government agencies to do so. In Patimbao, materials for tree planting come from the municipal agriculture office, and provincial environment and natural resources office (PENRO). Environmental projects in Bukal are supported by private organizations, such as the Foundation for the Philippine Environment, Haribon and Syngenta. The Department of Agriculture is also tapped for seminars on the proper use of fertilizers.

Food and Livelihood Security

All barangays have livelihood programs but one common problem is the lack of funds for implementing or practicing techniques learned. Program attendees lack capital to start and maintain their desired enterprise. Barangay Bukal identified the lack of marketing for their products as a major constraint.

Community efforts related to food security are also in place. San Pablo Sur has allotted a budget for agricultural programs like the distribution of seeds, insecticides and medicines to farmers. In Calumpang, there are programs for pig dispersal, a provision for fertilizers and seeds (rambutan, vegetables), and lessons on compost-making. Bungkol disperses livestock animals to farmers. Bukal established a farmers' association that encourages organic farming and livestock monitoring. Patimbao is currently the only barangay that lacks a program related to food security.

Land Use Policy

Only one of the barangays (San Pablo Sur) confirmed an existing land use policy for their area. Views on whether a land use policy was needed at the barangay level differ in each of the communities. Patimbao, Bungkol, and Bukal did not see the need for it and asserted that there are other more densely populated areas (such as the poblacion) in the municipality that needed land use policies. On the other hand, Calumpang saw the need to implement such a policy as they currently have problems with delineating and differentiating the areas of piggeries and residential areas.

Overall Planning

The communities of Bungkol and San Francisco rated their overall planning as perfect. Patimbao, Calumpang and Bukal gave themselves threes for overall planning while San Pablo Sur was at two. Bungkol and San Francisco based their ratings on the existence of climate change and DRRM. The three barangays that rated themselves 3

blamed the lack of finance as a major factor that constrained their planning. The most common identified solution to this constraint was to seek assistance from government offices, congressmen, and local chief executives (the mayor and governor).

The various areas of adaptive capacity examined in this study reveal that the focus of efforts is geared towards the disaster risk reduction response, such as relief and rescue operations. This is evident on the items that their LDRRM funds are spent, which are rescue equipment, and communication facilities such as two-way radios. Though there are initiatives on food security, which are usually coursed through agricultural programs, it is not the main focus of their communities' climate change efforts. This may be attributed to the insignificant effects of extreme events on the food security situation of the barangays, as previously discussed.

CONCLUSION AND RECOMMENDATIONS

Barangays in the Sta. Cruz Watershed located in three types of elevations were affected in various ways by extreme events. Typhoons Milenyo (2006), Ondoy (2009) and Santi (2009) were associated with extreme events. The communities were aware of the irregularities in weather patterns.

The impacts of extreme events on sectors related to food security were enumerated. Because of their large dependence on agriculture, the barangays in all the study sites are susceptible to the risks associated with food security issues. However, amidst these risks that come with damages brought about by typhoons, communities in the high elevation areas did not perceive any significant changes in their food security situation; this has been attributed to the following adaptation strategies: (a) securing stock farm produce for household consumption; (b) accessing alternative food sources near their farms; (c) availing of loans granted to farmers to finance the repairs for damages to their farms; and (d) sharing food through social networks (neighbors, relatives).

For both communities in the low elevation and one in the medium elevation, food supply did not become a problem during extreme events because: (a) markets and commercial centers were located nearby; (b) they received relief goods and food from the LGUs and other organizations; and (c) they joined cash-for-work programs to support the basic needs of those who lost their livelihood during the extreme events. However, there is a perceived problem with food rationing in the more vulnerable lowland area, such as San Pablo Sur. It can then be said food security in these areas is not yet a main concern.

The barangays in the study sites had both strengths and weaknesses in their capacity for adaptation to extreme climate events. High ratings were given for frameworks and structures, and human resource capability. On the other hand, weaknesses were identified in: (a) the underlying risk factors which include initiatives on land use policy, and food and livelihood security; (b) the knowledge, education and information systems; (c) technology and infrastructure, including weather instruments and early warning systems, and relocation sites; and (d) financial capability.

The adaptive capacity of the barangay indicates their ability to cope with climate-change related events. The study has revealed that there is a need to improve the existing capacity of the barangays involved. The first step is to identify the weakest area in terms of their capacity to adapt to climate change-related events. One of the primary constraints in the implementation of adaptation strategies is the availability of calamity funds. Although they can implement technological, institutional and economic strategies, respondents kept on mentioning the need for a sufficient budget that can fund these activities. Coordination with the stakeholders is also impeded

because of an insufficient budget. There is a need to enhance the financial capability of the communities by enhancing the utilization of technologies to reduce damage to agriculture during extreme events. Lessons learned from the experience of typhoons that hit the barangays indicate that the value of damages always substantially exceeds the budgetary allocation to respond to the extreme event. Heavily dependent on their internal revenue allocation, the barangays need to build their capacity to generate resources from external sources.

The DRRM framework has been operating in the barangays but it has failed to strengthen resilience-building as they ignore the lessons learned from past typhoon experiences.

The potentially damaging effect of climate change is still low in priority compared to the issues of poverty, health, and local politics. The knowledge, education, and information systems have been identified to help strengthen the adaptive capacity of communities. Raising awareness about extreme events and increasing understanding on climate change are two necessary requirements for capacity building.

Institutions and governance, particularly on frameworks and structures, and human resource capability, were identified to be the strength of all the barangays. Planning and coordination should include strong linkages and communication with both public and private sectors. The participation of local constituents, on the other hand, is imperative to fill the gaps that often create ineffective adaptation. Building social capital and seeking partnerships, not only with the business community but also with the scientific community, would enable the communities to harness resources (e.g., financial, technological) to build their adaptive capacity and build back their communities better.

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CHAPTER 9

FOOD VULNERABILITY OF HOUSEHOLDS AND THEIR COPING STRATEGIES DURING EXTREME WEATHER EVENTS

KAREN P. QUILLOY, ZENAIDA M. SUMALDE AND ARMAND CHRISTOPHER C. ROLA

This chapter discusses the food security status of selected households from vulnerable areas of Sta. Cruz Subwatershed, Laguna, the impacts of extreme weather events on their food security, their food vulnerability during extreme weather events, and the factors affecting them. A dynamic and forward-looking approach and binary logit analysis were used in the analyses. Key findings reveal that the household respondents are generally still in the tolerable state of food insecurity. However, when faced with climatic stress like extreme weather event, households perceive themselves as more likely to become vulnerable to food insecurity. Among the significant factors that affect their propensity to become food insecure are the elevation of their barangay, dependency on market for their staple food, and their engagement in farming as a source of livelihood. Based on these findings, the study recommended the following strategic actions: (i) strengthening of public distribution systems that offer a wide variety of cheaper food substitutes like secondary crops; (ii) improvement of existing food assistance programs; (iii) promotion of sustainable home gardening of food plants like fruits and vegetables and indigenous crops, coupled with technical trainings on agricultural practices; (iv) household agricultural production diversification; (v) improving early warning system in the barangay and municipality; and (vi) continuing education on the effective coping strategies to manage the impacts of disasters. In putting into action these recommendations, special attention should be given to the households in high elevation barangays as they are found to be less food secure and more vulnerable to food insecurity when hit by extreme events like typhoons.

Keywords: household food security, coping strategies, food vulnerability, extreme events

INTRODUCTION

The fourth assessment report of the Intergovernmental Panel on Climate Change has identified the increase in frequency and intensity of extreme weather events as one of the most adverse impacts of climate change that the human population has to deal with at present and in the immediate future (Pachauri, Reisinger, and the Core Writing Team 2007). In the Philippines, this is even of greater concern as it is one of the countries most affected by extreme weather events. For the period of 1994–2013, the Philippines ranked as the fifth most affected country based on the Germanwatch Global Climate Risk Index (Kreft et al. 2014). The increasing frequency and intensity of typhoons in the country, together with other climate change-induced weather events such as heat waves, heavy precipitation events, and the increase in the intensity of floods and droughts, have been posing serious threats to the food security of Filipinos, particularly of the poor and vulnerable, due to their extensive damages to food production, food distribution infrastructure, assets and livelihood, and human life.

Broadly defined, food security exists “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs, and food preferences for an active and healthy life” (World Food Programme 1996). It can be viewed at different levels of human organization—global, regional, national or subnational, household, and individual. Food security at the global or national level does not guarantee that all households will be able to secure their food needs, especially if they are vulnerable to shocks and risks. At this aggregate level, food security deals with the wider food system involving its four dimensions of food availability, food access, food utilization, and food stability. On the other hand, food security at the household level mainly focuses on the dimension of food access, which is where food poverty and food deprivation problems often originate.

The operational definition of household food security states that “a household is food secure when it has access to the food needed for a healthy life for all its members (adequate in terms of quality, quantity and it being culturally acceptable), and when it is not at undue risk of losing such access” (SCN 1991). The state of food insecurity of a household could be transitory or chronic. Transitory food insecurity is a short-term inability to access adequate food to maintain an active and healthy life. It leads to a cyclical or temporary decline in a household’s food intake which is often triggered by shocks and fluctuations in food production and availability, food prices, household income, as well as climate hazards such as drought and floods (Kennes 1990; Abele, Twine, and Legg 2007; FAO 2008). Depending on the extent of vulnerability and coping capacity of households to these shocks, their state of food insecurity may worsen into a chronic condition. Chronic food insecurity is a long-term or persistent inability to acquire enough food for a healthy and active life due to inadequate access to productive or financial resources or due to extended periods of poverty (Kennes 1990; FAO 2008).

Given the chronic and transitory distinctions of household food insecurity, the interaction between food security and extreme weather events cannot be understated. Exposure to risks and shocks and the ability to cope with them are important factors that can affect food security. Maharjan and Khatri-Chhetri (2006) argued that a high level of exposure to risks of natural disasters and an inability or lack of capacity to cope with it has a significant impact on the status of food security of households. People who are already vulnerable and suffering from food insecurity are likely to be the first affected by the impacts of climate change (FAO 2008). Poor people with limited risk absorption capacity are unlikely to cope with the variability and uncertainties in food system performance. In many developing countries like the Philippines, rural households

who mostly depend on agriculture for their livelihoods tend to be more exposed and vulnerable to risks and shocks that disrupt their food access and are thereby prone to food insecurity. The food security of the urban poor, who depend on non-agricultural sources of living and do not produce their own food, can likewise be strained if their means of acquiring food are put at risk.

In view of the increasing frequency and intensity of extreme weather events brought about by climate change and its threats and impacts to household food security, it is important to understand how these tensions can affect the food security status of households in the country. Will households become more vulnerable to food insecurity when faced with climate hazards? What factors can further push the already vulnerable and food insecure households to a worse state of food insecurity in times of extreme weather events?

This chapter discusses the interactions between extreme weather events and food security at the micro level using the case of households from one of the vulnerable areas in the Philippines—the Sta. Cruz Subwatershed in the province of Laguna. It provides an understanding of the food security status of households exposed to the risks and threats of extreme weather events and the factors that could place them in danger of food insecurity. It also analyzes the factors affecting a households' adoption of coping strategies for food shortage, which have implications to the severity of the food security problems of the vulnerable households.

MATERIALS AND METHODS

Study Site and Data Description

The main interest of the study is the vulnerable households or those exposed to extreme weather events in the vulnerable areas by the Sta. Cruz Subwatershed. A two-stage stratified approach with quota sampling was used in the selection of the study sites. Within the subwatershed, three municipalities were selected to represent households from high, medium, and low elevation areas. For each study site, two barangays or villages were selected to further represent the “vulnerable” and the “less vulnerable” areas of the subwatershed, with vulnerability being determined in terms of susceptibility to in the low and medium elevation areas and to landslide in the high elevation areas (table 9.1).

For each barangay, 31 randomly selected household heads or a total of 186 respondents participated in the survey, which was aided by a pre-tested questionnaire. However, some households were dropped after data cleaning, leaving only 169 household-respondents included in the analysis (table 9.1). Primary data on household socio-economic profile, physical and economic food access indicators, experiences of extreme weather events and their perceived impacts on household food security components, perceived household food security status, and household coping strategies for extreme weather events and food shortage were gathered during the survey. Though small, the sample size is believed to be statistically sufficient, given the homogeneity of the geographic and socio-economic characteristics of the households and the robustness of the sampling method used.

Apart from the household survey, focus group discussions and key informant interviews were conducted to validate and support the information generated from the survey. Secondary data were also collected from the provincial and municipal agricultural offices, national government agencies, and from related previous studies.

Table 9.1. Description of study sites and number of household survey respondents

Study Sites	Elevation ^a	Vulnerability ^b	Number of Household Respondents
Nagcarlan, Laguna	High (more than 470 meters above sea level)		
- San Francisco		Less vulnerable	28
- Bucal		Vulnerable	28
Liliw, Laguna	Medium (20-470 meters above sea level)		
- Calumpang		Less vulnerable	27
- Bungkol		Vulnerable	28
Sta. Cruz, Laguna	Low (10-20 meters above sea level)		
- Patimbao		Less vulnerable	29
- San Pablo		Vulnerable	29
Total number of respondents	-	-	169

^a Elevation categories are based on the hydrologic atlas of the 24 sub-basins of Laguna Lake provided by the Laguna Lake Development Authority

^b Vulnerability categories are based on the flood and landslide hazard maps generated by the Mines and Geoscience Bureau, Department of Environment and Natural Resources

Analytical Methods

The study employed descriptive statistics (i.e., using frequency counts, percentages, and cross tabulations) to describe the socio-economic characteristics, food access, and coping strategies for food security of households under an extreme event condition. The five-point Likert scale method (i.e., strongly disagree=1, disagree=2, don't know=3, agree=4, and strongly agree=5) with factor analysis (i.e., Principal Component Analysis) and Chi-square test of significance were used to assess the knowledge, attitude, and perceptions of households about extreme weather events and food security. All the analyses were done across all sampled barangays in the various elevations to further describe the food vulnerable households with respect to their level of exposure to the risks of extreme weather events. From here, selected household characteristics were used as explanatory variables to determine the likelihood of a household to become food vulnerable during the occurrence of an extreme weather event. Specifically, dynamic parameters, such as physical and economic risk factors, coping capacity enablers (e.g., income, access to assistance, knowledge, etc.), and the number of coping strategies employed during an extreme event and food shortage, were hypothesized to affect the vulnerability of households to food insecurity.

Food vulnerability index

Since the 1990s, there has been an increased emphasis on the subjective dimension of food security—that is, how household members perceive their own food security (Maxwell 1990; Gillespie and Mason 1991). This subjectivity is considered an important dimension of food security analysis because coping strategies against food shortage are often designed based on the perceived threats of food deficit rather than on the objective indicators of food security. Guided by this notion, this study was cast in a stochastic framework with a dynamic and forward-looking approach that analyzed household vulnerability to food insecurity in terms of their perceived food security status.

Vulnerability to food insecurity or simply, food vulnerability, is defined here as the people's propensity to fall or remain below a certain threshold of food security in the near future. It is primarily determined by people's exposure to risk factors associated with food insecurity and their ability and capacity to cope with the effects of those risks in order to survive the crisis (FAO 1996). Two sets of indicators, which came from retrospective information about the past experiences of households, were used to construct a food vulnerability index for this analysis. The first indicator is the households' "vulnerability as experienced" or their perceived impact of the extreme weather event that they consider the "worst" on the different aspects of their lives associated with food security. The second is their perception of household food security when there is an extreme weather event.

For the perceived impact of an extreme weather event, respondents were asked to give a score rating for the extent of damage caused by the worst extreme weather event that they had experienced since 2004. The rating may range from one to five, where one is the lowest score, indicating no or minimal impact and five is the highest, indicating a highly severe impact. The eight aspects of life or impact categories considered included the following: impact on assets and properties, logistics, job or source of income, food sources, food consumption, health and nutrition, education of children, and emotional well-being. The scores for these impact categories were combined to get the total score of each respondent, which may range from a minimum score of eight to a maximum of 40 points.

On the other hand, households' perception of food security during an extreme event was measured by creating a food security index composed of a composite of three food security-related statements. These statements, which were all given equal weight, include the following: (a) "Food security can be affected by extreme weather events;" (b) "Food are less available and accessible during times of extreme weather event;" and (c) "We are less food secure during times of extreme weather event." The households' responses were given scores using a five-point Likert scale, and combined to get the summated score, which may fall between three and 15 points.

To get the food vulnerability index, the scores from the two sets of indicators described above were summated, so that a respondent may get a summative score of as low as 11 points or as high as 55 points. The summative scores were then divided by 11 to generate the mean score rating that would categorize the respondents into either one of the following:

- *Less likely to be food vulnerable (1.00-2.99)*: Respondents in this category registered a food vulnerability score of at most 32 points out of the 55 possible points. They were perceived to be less likely to be vulnerable to food insecurity when an extreme weather event occurs as indicated by their disagreement to the statements considered and by their perceived extent of the damage incurred by the extreme weather event on them.
- *More likely to be food vulnerable (3.00-5.00)*: Respondents in this category registered a food vulnerability score of at least 33 points out of the 55 possible points. They were perceived to be more likely to be vulnerable to food insecurity when an extreme weather event occurs as indicated by their agreement to the statements considered and by their perceived extent of the damage incurred by the extreme weather event on them.

Given the food vulnerability index, the factors that could significantly affect the likelihood of a household to fall under the state of food insecurity during an extreme weather event can be determined using a binary logit model, which is defined as:

$$FSVUL = \alpha + \beta_1 INC + \beta_2 TENURE + \beta_3 ASSIST + \beta_4 FSKNOW + \beta_5 EEINFO + \beta_6 ELEV + \beta_7 VUL + \beta_8 FARMING + \beta_9 FARMINC + \beta_{10} CROPDIV + \beta_{11} MKTDEP + \beta_{12} MKTKM + \beta_{13} INCDIV + \beta_{14} CS_EE + v\beta_{15} CSFS$$

where the food vulnerability index is the dependent variable, which is defined as a function of 14 explanatory variables listed in table 9.2.

Table 9.2. Variables used in the binary logit model of food vulnerability during extreme weather event

Variable Name	Variable Description	Definition
Dependent Variable		
FSVUL	Food vulnerability during extreme weather event	1 if household is more likely to become food vulnerable in times of extreme weather event, 0 otherwise
Independent Variables		
<i>Human risks</i>		
FSKNOW	Knowledge about food security	1 if household has an understanding of the concept of food security, 0 otherwise
EEINFO	Information about the arrival of a calamity	Number of hours the household received an information before a calamity comes
<i>Physical risks</i>		
ELEV	Barangay with high elevation	1 if household lives in barangay with high elevation, 0 otherwise
VUL	Vulnerability of barangay	1 if household lives in vulnerable barangay, 0 if living in less vulnerable barangay
<i>Economic risks</i>		
INC	Household income	Total annual income of household during the year with extreme weather event (PHP/year)
TENURE	Ownership of farmland	1 if household owns the farm land he is tilling, 0 otherwise
INCDIV	Diversity of income sources	Total number of income sources of household during the year with extreme weather event
FARMING	Farming as source of income	1 if household engages in farming for a living (farm household), 0 otherwise
FARMINC	Proportion of farm income	Proportion (%) of farm income to total household income per year
ASSIST	Assistance received	1 if household received assistance to cope with the effects of extreme weather event, 0 otherwise
<i>Food access risks</i>		
MKTDEP	Market dependency for food	1 if the primary source of rice of household during the year with extreme weather event is the market, 0 otherwise
MKTKM	Distance to source of food	Average distance to primary source of food of household (kilometer)
CROPDIV	Number of agricultural commodities produced	Total number of types of agricultural commodities (crops and animals) produced by households during extreme weather event
<i>Coping strategies</i>		
CS_FS	Coping strategies against food shortage	Total number of coping strategies of household against food poverty/deprivation
CS_EE	Coping strategies against the impacts extreme weather event	Total number of coping strategies of household before, during, and after the occurrence of extreme weather event
α and β	Parameters to be estimated	

The indicators represent the different risks to household food security and the ability or capacity of the household to cope with them in order to minimize the threats and impacts to their food security and survival during an extreme weather event. The risks are categorized in this study into physical risks, economic risks, food access risks, and human risks. The selection of these factors was guided by the climate change and food security (CCFS) framework developed by the Climate Change and Bioenergy Unit of the Food and Agriculture Organization of the United Nations (FAO/NRCB) (FAO 2008). The CCFS framework is a conceptual framework on climate change and food security interactions, which underlines the variables that define the risks imposed by or the potential impacts of climate change on food systems and on the dimensions food security. Also, included here are the adaptive and coping mechanisms of households to minimize the climate impacts. Although not incorporated in the framework, human risks, which involve the knowledge of households on extreme weather events and food security, were added as an explanatory variable since it is one of the enabling mechanisms shaping the adaptive capacity to adjust to climate change and climate variability and to cope with its consequences (Watson and Core Writing Team 2001).

The other risks to a household's ability to acquire food, such as income source and diversity, source of food, and crop diversity, were also included as explanatory variables. Lastly, coping strategies employed for food shortage employed were incorporated in the model to represent severity of household food stress, which is hypothesized to also have an effect on the probability of food vulnerability during extreme weather events. The selection of these additional variables was patterned after the determinants used by the World Food Programme in its Emergency Food Security Assessment (World Food Programme 2009). However, the model does not include market-related food security indicators such as market characteristics and prices due to limitation of data.

Households' coping strategies against food shortage

Coping strategy is a widely accepted indicator of food security. It is relatively simple and quick to use, straightforward, and correlates well with more complex measures of food security. This section discusses the status and severity of household food insecurity using the type and number of coping strategies for food shortage as the proxy indicator. With guidance from The Coping Strategy Index Manual developed by Maxwell and Caldwell (2008) and on the information obtained from the focus group discussions, the coping strategies were pre-identified in the survey. While the frequency of application of coping strategies is a common component of coping strategies indices for food security, information on this was not deduced from the survey as food shortage was examined without any particular time frame.

The likelihood of households to employ the five most common coping strategies was also determined using a binary logit analysis. Each coping strategy was considered the dependent variable in the logit model, with physical, demographic, economic and livelihood, extreme event-related, and other food-security related factors as the explanatory variables (table 9.3). In addition, a binary logit model for non-adoption of any coping strategy was also estimated to examine the factors affecting the likelihood of a vulnerable household remaining food secure.

The logit model of the relationship between the adoption of the i^{th} coping strategy (CS $_i$) and its explanatory variables is specified as,

$$CS_i = \alpha + \beta_1 VUL + \beta_2 ELEV + \beta_3 HHSIZE + \beta_4 EDUC + \beta_5 INC + \beta_6 INC DIV + \beta_7 FARMING + \beta_8 FARM INC + \beta_9 ASSIST + \beta_{10} MKT DEP + \beta_{11} MKT KM + \beta_{12} FSKNOW + \beta_{13} FSISSUE + \beta_{14} FSVUL$$

Table 9.3. Definition of variables used in the binary logit model of coping strategies

Variable Name	Variable	Definition
Dependent Variable		
CS ₁ (Model 1)	Use savings	1 if household adopted the use of saving as coping strategy, 0 otherwise
CS ₂ (Model 2)	Borrow money/ use credit	1 if household adopted the borrowing of money or use of credit as coping strategy, 0 otherwise
CS ₃ (Model 3)	Substitute preferred food with cheaper/less preferred food items	1 if household adopted food substitution as coping strategy, 0 otherwise
CS ₄ (Model 4)	Consume less quantity or quality of food	1 if household adopted the reduction of food intake in terms of quantity or quality as coping strategy, 0 otherwise
CS ₅ (Model 5)	Produce own food	1 if household adopted the production of own food as coping strategy, 0 otherwise
CS ₆ (Model 6)	Did nothing	1 if household did not adopt any coping strategy, 0 otherwise
Independent Variables		
VUL	Vulnerability of barangay	1 if household lives in vulnerable barangay, 0 if living in less vulnerable barangay
ELEV	Barangay with high elevation	1 if household lives in barangay with high elevation, 0 otherwise
HHSIZE	Household size	Number of members in the household
EDUC	Years in school of household head	Number of years in school of household head
INC	Household income	Total annual income of household during the year with extreme event (PHP/year)
INCDIV	Income diversification	Total number of income sources of household during the year with extreme event
FARMING	Engagement in farming	1 if household engages in farming for a living (farm household), 0 otherwise
FARMINC	Farm income contribution	Proportion (%) of farm income to total household income per year
ASSIST	Assistance received	1 if household received assistance to cope with the effects of extreme event, 0 otherwise
MKTDEP	Market dependency for food	1 if the primary source of rice of household during the year with extreme event is the market, 0 otherwise
MKTKM	Distance to source of food	Average distance to primary source of food of household (kilometer)
FSKNOW	Knowledge about food security	1 if household has an understanding of the concept of food security, 0 otherwise
FSISSUE	Food insecurity as a problem	1 if household considers food insecurity as an issue or a problem, 0 otherwise
FSVUL	Food vulnerability index	Food vulnerability index mean score of household

The parameter estimates of the logit models for food vulnerability index and coping strategies only provide the direction of the effect of the independent variables on the dependent variable or response probability. Thus, all the equation models were differentiated with respect to the explanatory variables in order to compute for the marginal effects of the explanatory variables. The marginal effects or marginal probabilities provide the expected change in probability of a particular choice made with respect to a unit change in an independent variable from the mean.

RESULTS AND DISCUSSION

Households of the Vulnerable Areas of the Sta. Cruz Subwatershed

The majority of the 169 households interviewed for the study are male (82 percent), married (76 percent), have a household size of four to six members (55 percent), and are elementary graduates and high school undergraduates (40 percent) (table 9.4).

In the high elevation barangays, 60 percent of household heads were farmers or farm-related jobs. It was where the lowest average household income was recorded at PHP 159,548 per year. On the other hand, household heads in the medium and low elevation barangays were mostly unskilled laborers and service workers. The average household income in these areas was PHP 191,110 per year in the medium and PHP 174,113 in the low elevation barangays.

Table 9.4. Household profile, by elevation, Sta. Cruz Subwatershed (%)

Socio-Economic Characteristics	Elevation			All Households (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Sex				
- Male	84	82	81	82
- Female	16	18	19	18
Marital status				
- Single	5	7	2	5
- Married	84	73	71	76
- Widow/widower	7	13	12	11
- Separated	0	5	3	3
- Live-in	4	2	12	6
No. of years in school	9.08	9.04	9.36	9.15
- Elementary level	13	5	2	7
- Elementary graduate/ high school level	46	45	28	40
- High school graduate	34	27	38	33
- College level/graduate	7	22	33	21
Primary occupation				
- Farming/Farm-related activities	61	20	9	30
- Laborer	11	31	26	22
- Trade-related jobs	7	7	19	11
- Service worker	7	31	28	22
- Government employee	2	0	3	2
- Others	13	11	16	13
Household size	4.04	4.65	4.64	4.44
- 1-3 members	36	31	34	34
- 4-6 members	61	54	50	55
- more than 6 members	4	15	16	11
Average annual household income (PHP/year)	159,548	191,110	174,113	174,818

Extreme Weather Events Experienced by Vulnerable Households

All household respondents had observed and felt climate impacts in different forms over the past 10 years. Among the common climate impacts identified were related to extreme weather events, such as changes in weather patterns and air temperature, stronger and more frequent typhoons, and more severe flooding and drought. Particularly, 88 percent of the respondents observed changes in weather patterns, 60 percent of them felt the increase in air temperature, and 58 percent said that there have been stronger and more frequent typhoons (table 9.5). Other climate impacts include more severe flooding (43 percent) and drought (34 percent).

Table 9.5. Observed climate impacts, by elevation, Sta. Cruz Subwatershed 2003-2014 (%)

Observed climate impacts	Elevation			All Households (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Change in weather patterns	91	91	83	88
Stronger/more frequent typhoons	61	55	59	58
More severe flooding	21	36	71	43
More severe drought	52	27	24	34
Increased air temperature	62	53	64	60
Sea level rise	0	0	9	3
Decrease in fresh water supply	50	11	9	23
Effects on flora and fauna	29	20	9	19
Food supply-related issues	20	16	10	15
Health-related issues	32	27	24	28

The respondents living in the high elevation barangay were more cognizant of the changes in air temperature (62 percent) and weather patterns (91 percent) than those in medium and low elevation communities. Also, as expected, a high percentage of the respondents living at low elevation (71 percent) observed more severe flooding compared to residents in the high and medium elevation areas.

From the focus group discussions and household survey, it was discovered that the most distinct phenomenon that the respondents related to an extreme weather event was the intense tropical cyclones or typhoons they experienced. Table 9.6 shows that the majority of households (60 percent) were hit by Typhoon Ondoy, which most of them consider as the “worst” or the most damaging extreme event they had experienced in the past ten years (2004-2013). Typhoons Santi and Milenyo followed with 30 percent and 27 percent of the respondents reporting having experienced them, respectively, while 22 percent and 15 percent considered them as the worst they had experienced, respectively.

When asked if they were aware or were informed beforehand that a typhoon was approaching, 162 out of the 169 respondents said that they received information before the arrival of the calamity. The warning about the forthcoming typhoon was received by some respondents as early as eight days and as late as one hour before it hit, giving households time to employ adaptation strategies to minimize the effects of the event. Among the most common adaptation strategies were buying and storing food before the event and reinforcing the house after the calamity. Details on this are discussed in Chapter 10.

Table 9.6. Extreme weather events experienced by household respondents from 2004-2013, Sta. Cruz Subwatershed

Extreme weather events	Year of Occurrence	Experienced the extreme event (%) (n=169)	Considered as the worst extreme weather event (%) (n=169)
Typhoon Yolanda (Haiyan)	2013	11	7
Typhoon Ondoy (Ketsana)	2009	60	52
Typhoon Milenyo (Xangsane)	2006	27	15
Typhoon Santi (Nari)	2013	30	22
Others ^a	various years	12	4

Note: Multiple responses were allowed. Words in parentheses are the respective international names of the typhoons.

^aOthers include other typhoons (i.e., Frank, Pablo, Sendong, Osang, and Reming), El Niño phenomenon, and monsoon rain (habagat).

In terms of the number of coping strategies employed, each household did an average of three to four coping strategies to minimize the risks and impacts associated with the extreme weather event (table 9.7). In contrast, only 6 percent of all households employed only one coping strategy and seven percent indicated that they did not employ any coping strategies. There was no statistical significance found in the differences in the number of coping strategies adopted by households at all elevations.

Table 9.7. Number of coping strategies employed for extreme weather events, by elevation of barangay (%)

Number of coping strategies employed	Elevation			All Households (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
None	11	4	7	7
Only 1	4	11	3	6
2 to 3	41	45	35	40
4 to 5	32	29	38	33
More than 5	12	17	23	14
Average no. of coping strategies F-ratio = 0.57 (Prob. > F = 0.566) ^{ns}	3.41	3.27	3.66	3.45

"Prob. >F" indicates p-value and "ns" denotes no statistical significance based on F-test.

Food Security Status of Vulnerable Households

Household knowledge and perception of food security

Most of the household respondents related food security to having sufficient food at the micro level. The most common definition mentioned by 49 percent of the respondents was that "food security is generally about having enough food supply for their families" (table 9.8). Few respondents (12 percent) described food security with a short-term view of "having enough daily meals." In contrast, about 21 percent of the households did not know or understand the concept of food security. This was more prominent among respondents from the low elevation sites, of whom 34 percent were not able to define food security, as compared to those from the medium and high elevation areas, of whom 24 percent and 7 percent, respectively, did not know what food security is. The difference in knowledge of food security across elevations was found to be statistically significant.

Table 9.8. Household knowledge and perception of food security, by elevation of barangay, Sta. Cruz Subwatershed (%)

Definition of Food Security/ Statement	Elevation			All Households (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Having enough food supply	71	45	29	49
Having enough daily meals	9	13	16	12
Having available and accessible food	5	5	7	6
Having safe and nutritious food	4	0	5	3
Others	4	13	9	8
Don't know/No answer	7	24	34	22
$\chi^2 = 27.0389$ (Prob. $> \chi^2 = 0.003$)**				
"I consider food insecurity as a problem or issue."				
Strongly Agree/ Agree	93	82	86	87
Disagree	2	4	7	4
Undecided	5	15	7	9
$\chi^2 = 7.6394$ (Prob. $> \chi^2 = 0.0266$)**				

Prob. $> \chi^2$ indicates p-value. *** and ** indicate statistical significance at 1% (p-value ≤ 0.01) and 5% (p-value ≤ 0.05), respectively.

In terms of households' perception about food insecurity, a great majority of the respondents considered food security as a problem or issue that needs to be resolved, with 93 percent of the respondents from high elevation areas agreeing with the statement, 82 percent of those from medium elevation areas, and 86 percent of those from low elevation areas. These proportions of respondents were found to be significantly different across elevations.

Household physical and economic access to food

Food access is an essential component of household food security. It can be influenced by different economic, physical, and socio-political factors. The threats to economic access to food can be examined in terms of household income, diversity of sources of income, and dependence on farming as a key source of income. Most of the households have at most one or two income sources (table 9.9), with the most common sources being farming activities, unskilled labor, and service-related jobs. Compared to an average annual household income of PHP 174,818 in a normal year, average income during the time of the worst extreme event was only PHP 130,509, although the difference may be smaller if adjusted for inflation. Lastly, in terms of ownership of farm land as an asset, at least 20 percent of the households who are farming owned the land they tilled while the rest were mostly tenanted or rented.

The source of food is also a critical factor that can affect the food access of consumers. Generally, access to food of market-dependent consumers or net food buyers is more likely to be affected by economic shocks (e.g. price inflation) and market risks (e.g. food supply deficit) compared to consumers who produce their own food. Most households (92 percent), regardless whether they farmed or not, were found to be net buyers of the staple food, rice, with those from high elevation areas having the highest proportion of market-dependent food consumers (98 percent) (see table 9.9).

Table 9.9. Food access characteristics of household respondents, by elevation of barangay, Sta. Cruz Subwatershed

Food Access Indicators	Elevation			All Households (n=169)	F-ratio / Chi-square (χ^2) statistic
	High (n=56)	Medium (n=55)	Low (n=58)		
Household income (PHP/year) ^a					
Normal year	159,548	19111	174,113	174,818	0.55 (0.5778) ^{ns}
Year with extreme weather event	121,951	127,783	141,358	130,509	0.35 (0.708) ^{ns}
Income diversity (number of sources of income during extreme weather event)					10.945 (0.205) ^{ns}
One	23	40	40	34	
Two	50	44	38	44	
Three	23	13	12	16	
4 to 5	4	4	10	4	
Households with income from farming/farm activities	73	22	9	34	58.390 (0.000) ^{***}
Proportion of farm income to total household income (%)	46.32	17.17	4.04	22.32	10.21 (0.000) ^{***}
Tenurial status (%)					
Owns the land used in farming	49	20	20	29	4.666 (0.097) [*]
Source of rice (%)					11.074 (0.026) ^{**}
Own-produced	2	13	2	4	
Bought	98	84	95	92	
Given	0	4	3	2	
Distance from home to the source of food bought(km)	1.52	2.18	2.23	1.98	1.59 (0.208) ^{ns}
Food stocks (rice, fruits, and vegetables)					
Proportion of total food production used for home consumption (%)	2.82	39.91	8.43	9.44	17.292 (0.000) ^{***}
Number of types of commodities produced					37.887 (0.000) ^{***}
None	25	59	0	36	
One	62	3	60	42	
Two	7	28	40	16	
3 to 5	5	10	0	6	

^a Average exchange rate of Philippine pesos (PHP) per U.S. dollar (US\$) was PHP 44.45 in 2013 (BSP 2014).

Values in parentheses in the last column are p-values. *, ** and *** indicate statistical significance at 10% (p-value $\leq$ 0.10), 5% (p-value $\leq$ 0.05) and 1% (p-value $\leq$ 0.01), respectively while "ns" indicates no statistical significance based on χ^2 test or F-test.

The farming households often produced only one or two types of commodity, which were primarily sold in the markets or to the traders and consumers. In their last cropping season of 2013, only about nine percent of the total produce of every household was used for home consumption while the rest was mostly sold. However, in the medium elevation areas, where households were mostly vegetable farmers, the

proportion of produce used for home consumption was higher, averaging at 40 percent of their total harvest.

The distance to source of food is another factor that can particularly affect physical access to food. The farther the consumer is from the source of food, the more likely their access to food can be affected by extreme weather events. The main source of food of the households was at an average of 1.98 km away.

Household Food Security and Extreme Weather Event Nexus

Perceived impacts of extreme weather events

As perceived by the respondents, the logistics aspect of life—access to roads, infrastructure, water, and electricity—appears to be the most affected by the extreme weather event, given its average impact score of 3.43, the highest among all impact categories (table 9.10). This is followed by the job or source of income, which received a rating of 3.18. The impact rating for assets and properties is also remarkably high for respondents living in low elevation areas (3.02). Overall, households in low-lying areas were found to be the most affected by extreme weather events as reflected in its highest total impact rating of 21.47. The difference in the extent of perceived impacts of extreme weather events across elevations was found to be statistically significant.

Table 9.10. Mean score rating of the perceived impact of extreme weather event on households, by elevation of barangay, Sta. Cruz Subwatershed, 2004-2013

Impact Categories	Mean Score Rating			
	High Elevation (n=56)	Medium Elevation (n=55)	Low Elevation (n=58)	All Households (n=169)
Assets/ properties	1.96	2.69	3.02	2.56
Logistics	2.98	3.95	3.36	3.43
Job/source of income	3.25	3.04	3.26	3.18
Food sources	2.20	2.56	2.62	2.46
Food consumption	2.16	2.04	2.40	2.20
Health and nutrition	1.45	1.62	2.17	1.75
Education of children	1.96	1.89	2.19	2.02
Emotional well-being	2.04	2.25	2.45	2.25
Total Mean Score (40/40)	18.00	20.04	21.47	19.85
F-ratio = 3.82 (Prob. > F = 0.024)**				

"Prob. >F" indicates p-value and ** denotes statistical significance at 5% (p-value ≤ 0.05) based on F-test.

In terms of households' perception of food security during extreme weather events, most of the households (83 percent) believed that food security can be affected by an extreme weather event (table 9.11). More than 60 percent of them also agreed that food was less available and accessible and that they were less food secure during times of extreme weather events. Overall, the respondents reported an average total mean score of 11 out of a total possible score of 15 points for their perceived food security status during extreme weather events.

Table 9.11. Mean score rating of perceived household food security status during extreme weather event, by elevation of barangay, Sta. Cruz Subwatershed, 2014

Statements	Mean Score Rating				Percentage of Households that Agree and Strongly Agree
	High Elevation (n=56)	Medium Elevation (n=55)	Low Elevation (n=58)	All Households (n=169)	
Food security can be affected by extreme weather events.	4.02	3.96	3.91	3.96	83
Food is less available and accessible during times of extreme weather event.	3.70	3.54	3.53	3.59	68
We are less food secure during times of extreme weather event.	3.41	3.62	3.53	3.52	65
Total Mean Score (15/15)	11.12	11.13	10.98	11.08	
F-ratio = 0.06 (Prob. > F = 0.943) ^{ns}					

"Prob. > F" indicates p-value and "ns" denotes no statistical significance based on F-test.

Food vulnerability of households during extreme weather events

Combining the total mean score ratings from Tables 9.10 and 9.11, results show that more households (62 percent) were more likely to be vulnerable to food insecurity when there is an extreme weather event (table 9.12). Particularly, a larger proportion of households in high-lying areas (73 percent) appears to be more prone to food insecurity during calamities compared to those in medium (58 percent) and low elevation areas (55 percent).

Table 9.12. Perceived food vulnerability of households during extreme weather event, by elevation of barangay, Sta. Cruz Subwatershed, 2014

Food Vulnerability Index Score/ Food Vulnerability Category	Elevation			All Households (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Food vulnerability index score				
Min	1.18	1.54	1.36	1.18
Max	4.09	4.18	4.82	4.82
Mean	2.65	2.83	2.95	2.81
F-ratio = 2.67 (Prob. > F = 0.072)*				
Food vulnerability category (% of n respondents)				
More likely to be food vulnerable	73	58	55	62
Less likely to be food vulnerable	27	42	45	38
$\chi^2=4.4819$ (Prob. $>\chi^2 = 0.106$) ^{ns}				

"Prob. > F" and "Prob. $>\chi^2$ " indicate p-values. * indicates statistical significance at 10% (p-value ≤ 0.01) while "ns" denotes no statistical significance.

Nine factors were found to significantly affect the likelihood of a household becoming food vulnerable when there is an extreme weather event. These included the timing of information about the event prior to its arrival (in terms of number of hours), the elevation of the barangay, household income and diversity of its income sources (number of income sources), ownership of farmland or tenurial status, access to assistance for coping with the effects of extreme weather events, distance from the source of food bought, variety of crop produced (number of types of food commodities produced), and number of employed adaptation strategies against extreme weather events (table 9.13).

Table 9.13. Marginal effects of the explanatory variables in the binary logit model of food vulnerability, Sta. Cruz Subwatershed, 2014 (n=169)

Variable Name	Coefficient	p-value	Level of Significance
Dependent Variable: Food vulnerability index			
FSKNOW	0.7696	0.100	ns
EEINFO	-0.0055	0.085	*
ELEV	0.2780	0.030	**
VUL	0.1521	0.356	ns
INC	-0.000001	0.052	*
TENURE	0.3592	0.010	**
INCDIV	0.1712	0.078	*
FARMING	-0.2702	0.612	ns
FARMINC	-0.0006	0.208	ns
ASSIST	0.3998	0.049	**
MKTDEP	0.2666	0.342	ns
MKTKM	-0.0508	0.050	**
CROPDIV	-0.1151	0.076	*
CS_EE	-0.0789	0.068	*
CS_FS	-0.0416	0.178	ns
Likelihood Ratio test (χ^2)	36.31		
Pseudo R ²	51.07		
p-value	0.0026		

Note: Refer to Table 9.2 for definition of the variables. *and ** indicate statistical significance at 10% (p-value≤0.10) and 5% (p-value≤0.05), respectively while “ns” denotes no statistical significance.

Prior information about upcoming extreme weather events is critical in preparing coping strategies for calamities. The shorter the interval between warning and occurrence, the greater the probability of falling below the food security threshold when the extreme weather event occurs. Households in the high-lying barangays were also found to have greater chances of being food vulnerable when hit by a calamity than those in medium or low elevation areas. This is plausibly due to the fact that many from the high elevation households perceived themselves as already food insecure even without extreme weather events and could then feel even less food secure when there is an extreme weather event. They may not be prepared enough to handle food risks and shocks brought about by the extreme weather event to their food security.

The economic factor, income, is negatively related to food vulnerability, which means that the higher the income, the less likely it is for a household to be vulnerable

to food insecurity during extreme weather events. This could be related to the notion that the poorer the household, the more of its income is proportionately spent on food. Households with a high share of food expenditure (e.g. at least 70 percent of income) are generally vulnerable as they are likely to have limited reserves to meet their food needs once their income is reduced due to risks such as natural disaster, disease onset, or price hikes (Fernandez-San Valentin and Berja 2012). Besides, households with higher incomes are likely to have more capacity to handle extreme weather events and food security risks because they are financially able to employ coping strategies.

What is surprising is the positive influence of land ownership and income source diversity to the likelihood of a household to becoming food vulnerable. This can be explained by the finding that the majority of the sources of household income, which include farming, construction, and office work, though diverse, are mostly climate-sensitive. Land ownership data, on the other hand, might have failed to represent asset ownership in the analysis because of the very small area (less than a hectare) of landholdings of most households. Households that received assistance from the outside during extreme weather events are also found to have a greater probability of becoming food vulnerable as this manifests their high dependence on government or private institutional aid (e.g., relief goods and donations) which has the risk of being inadequate or delayed.

For food access factors, the number of commodities grown by a household and the distance from home to the source of food bought are found to both negatively affect the probability of a household to become vulnerable to food insecurity when there is an extreme weather event. These results are rational since having more commodities produced would mean more choices for consumption and more ease in shifting to other commodities that are more resilient to climate hazards. As such, effects of the extreme weather event on food security can be minimized. Moreover, households acquiring their food from distant sources are more likely to experience physical access problems when a calamity happens, for instance, when the roads going to the market are flooded or when it is raining too hard, making it unsafe to travel.

Finally, the number of coping strategies against extreme weather events employed by households is found to significantly affect their likelihood to become food vulnerable when hit by a calamity. The negative coefficient indicates that the fewer the coping strategies employed, the greater the probability of becoming food vulnerable. Understandably, if a household is not able to cope with the effects of an extreme weather event, particularly on its economic and livelihood activities, then it can be expected that its food security, particularly food access, will suffer from the impacts of the extreme weather event.

The Coping Strategies of Households for Food Shortage

Coping strategies are generally defined as the practices that households employ in order to minimize the risks threatening their survival (Maxwell and Caldwell 2008). According to the World Food Programme (2009), it is the nature of people to respond using coping strategies when they feel that they do not have enough food to eat. They do not wait until they completely have nothing to eat but rather find strategies to minimize risks to their livelihoods and food security. The hypothesis is that the more coping strategies a household employs, the more it suffers from food shortage. The type of coping strategy adopted by households also reflects the severity of the disruptive conditions that put their food security at risk. For instance, a household that sold assets

as a coping strategy can be inferred to be suffering less serious food shortage compared to a household that resorted to reducing the number of meals consumed per day.

Types of coping strategies employed by households

The most commonly employed coping strategies were the income-related ones. Generally, income-related coping strategies imply a less severe food insecurity problem compared to food consumption-related coping strategies, except if the household strategy is to produce its own food. About 42 percent of the household respondents use their savings to buy sufficient food for their families (figure 9.1). The use of savings to cope with food shortage is a mechanism that makes use of monetary savings or saved commodities (e.g. seed stock and fruits and vegetables for sale) to augment the cash available for food or to have readily available food stocks for consumption, respectively. With this type of strategy, it can be assumed that households have savings that can be used in times of food stress. This indicates only a mild form of food insecurity since food availability and access are immediately maintained because of the availability of emergency funds or food reserves.

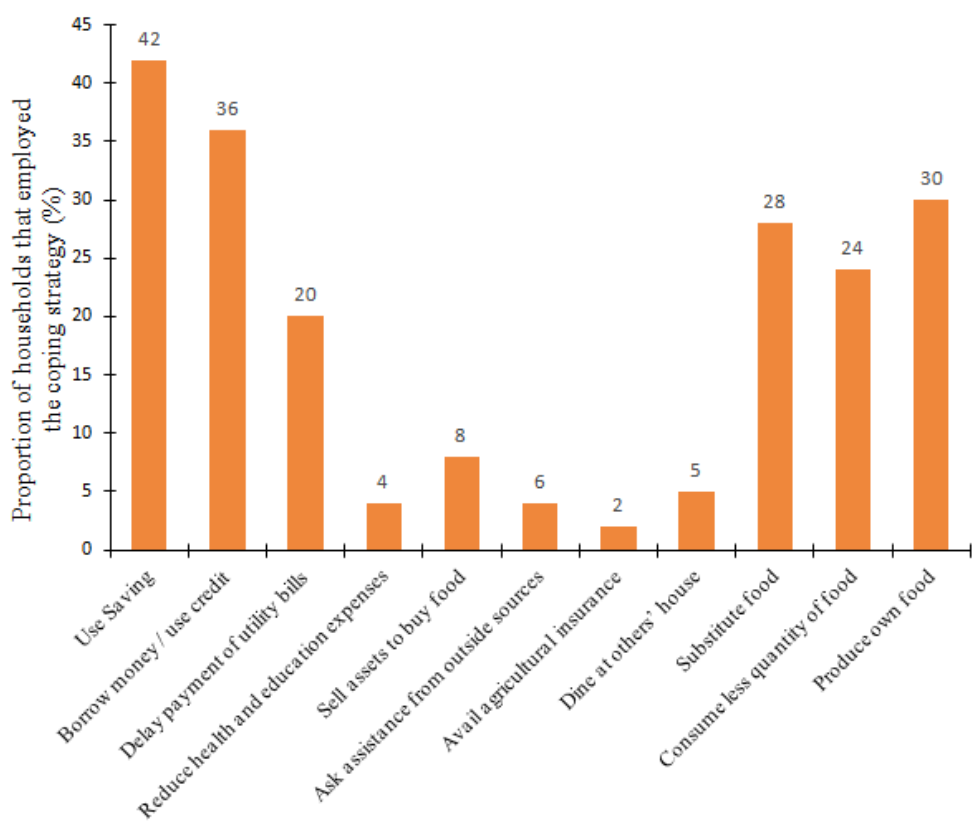


Figure 9.1. Household coping strategies for food shortage, Sta. Cruz Subwatershed, 2004-2013 (n=169; multiple responses allowed)

Note: Values above the bars are the percentage values of households that adopted the coping strategy
Source: Quilloy et al. (2014)

The next prevailing coping strategy is borrowing money or purchasing food on credit (36 percent), which is a short-term strategy used to immediately augment a household's food supply. Unlike the use of savings, purchasing food on credit or borrowing money to buy food implies a moderate food insecurity problem because it suggests that the household does not have the financial means to buy food, hence the need to rely on credit. From the interviews, the respondents said that they usually borrow money from their friends and relatives (75 percent) and buy food in retail stores ("sari-sari stores") on credit (24 percent). Only one respondent indicated that he borrowed money from a formal microfinance institution—the CARD Bank, Inc.

Other income-related coping strategies employed by the households included delaying their payment of utility bills (20 percent); reducing health and education expenses (4 percent) to prioritize food spending; and selling assets to generate income for buying food (8 percent). All these coping strategies reflect a moderate household food insecurity problem (figure 9.1). For farming households, availing of agricultural insurance was a distinctive way to cope with the risk of food insecurity due to unexpected losses in farm income and food production. While income-related coping strategies initially affect household assets and reflect a tolerable state of food stress, food insecurity may worsen in the long run if these strategies are continuously adopted over a long period of time until its impacts, especially on economic access to food, become irreversible.

In terms of consumption-related coping strategies, two appeared to be dominant. One is the production of own food (30 percent), particularly of vegetables, instead of relying on the market. Like availing of agricultural insurance, this strategy is a positive mechanism, which is most likely intended to prevent problems related to the availability of affordable food in the markets. The capacity of a household to produce its own food suggests that it has the capacity and the means to engage in food production despite experiencing food shortage. The other food consumption-related coping strategy commonly employed by households is the substitution of preferred food with less preferred and cheaper ones (28 percent). Unlike the former, this coping strategy implies that a household's capacity or purchasing power to buy their preferred food is already affected by food stress, and is therefore likely to be suffering from a more serious form of food insecurity. As some of the respondents specified, they shifted from eating rice to sweet potato during the time they experienced food shortage. Others did not buy protein-rich food like meat and fish anymore and instead settled for vegetables, which are relatively cheaper. While such dietary change can be reversible, employing it in the long run could worsen the state of household food insecurity due to its serious repercussion on the dimension of food utilization.

A related coping strategy deals with the rationing or managing the shortfall by lessening food intake, which was adopted by 24 percent of the households. Among all the coping strategies adopted by the respondents, consuming smaller quantities of food is apparently the most destructive for households. Households resorting to such a coping mechanism are presumed to be suffering from very serious food shortage. This rationing strategy may involve cutting the portion size consumed by each household member during mealtimes, restricting consumption of adults to prioritize adequate consumption of children, reducing the number of meals eaten in a day, or the worst, skipping entire days without eating. Like shifting to less preferred food, this coping strategy can be reversed if no longer needed. However, if done regularly in the long run, food insecurity may worsen due to its serious consequences, especially on health and nutrition.

Number of coping strategies

The number of coping strategies that a household employs is also a reflection of the severity of the food shortage that they are experiencing. Less food-secure households are presumed to adopt more coping strategies to survive food insecurity problems. Not employing any coping strategy conversely suggests that a household is not suffering from any serious food stress. Out of the 169 household respondents, 20 percent indicated that they did not employ any coping strategy against food shortage mainly because they have never suffered from such a problem. Specifically, about a quarter of the households living in the medium and low elevations did not employ any mechanism, while of those in high elevation areas, 11 percent had no coping strategies. For respondents that employed coping strategies, the majority (27 percent to 29 percent) were found to adopt only one type of coping strategy (figure 9.2).

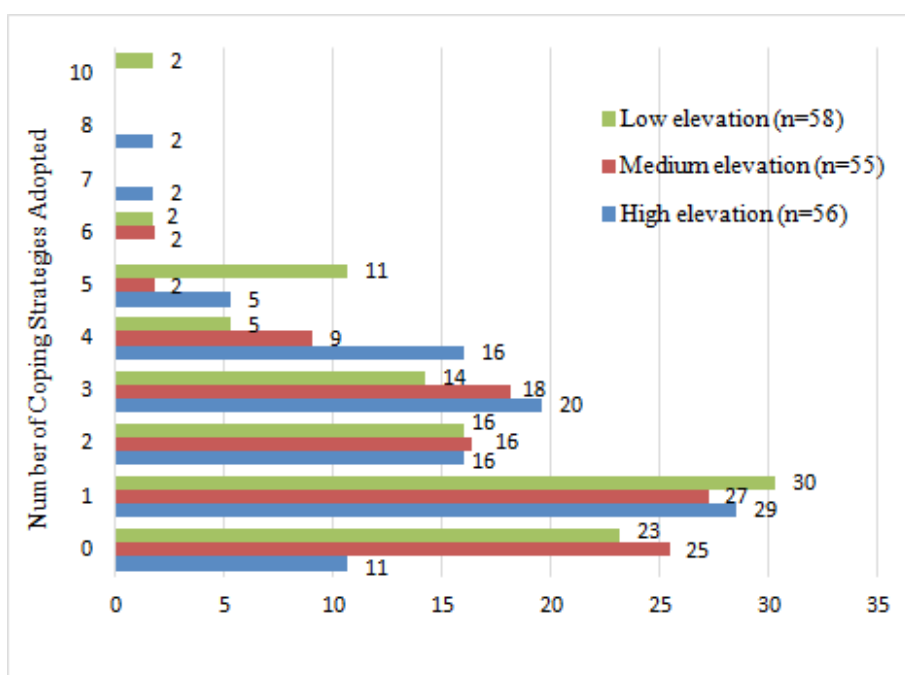


Figure 9.2. Number of coping strategies adopted by households, by elevation, Sta. Cruz Subwatershed (n=169; multiple responses allowed)

Source: Quilloy et al. (2014)

About 16 percent employed at most two coping strategies and 14 percent to 20 percent adopted three strategies. Very few employed more than five coping strategies, comprising only about 4 percent of all respondents.

Factors affecting the adoption of coping strategies for food shortage

From the data gathered on the type and number of coping strategies taken by households for food security, a typology of household food security status has been made particularly for this study (table 9.14). The perceived severity of each of the coping strategies served as the basis for inferring about the food security status of households exposed to extreme events. From the results of the analysis, it can be deduced that most of the households were generally likely to be experiencing a moderate form of food insecurity, with only a few suffering from severe food insecurity.

Table 9.14. Typology of household food insecurity status based on coping strategies for food shortage

	Slightly Food Insecure	Moderately Food Insecure	Severely Food Insecure
Income-related strategies	• Use savings • Avail agricultural insurance	• Delay payment of utility bills • Reduce health and education expenses • Sell assets • Borrow money/ buy food on credit	
Food consumption-related strategies	• Produce own food	• Substitute preferred food with cheaper or less preferred food	• Consume smaller volume of food (rationing) • Dine at other's house • Ask for food assistance from the outside
Number of coping strategies employed	1	2-3	more than 3

Considering the top five most commonly adopted coping strategies, including the non-adoption of any strategy, the factors that significantly affect the likelihood of a household to employ each strategy are summarized in table 9.15. Focusing only on the variables that are found significant, the logit model estimates reveal that households that are likely to be food secure (as indicated by non-adoption of any coping strategy) are those who live at low-lying barangays (less than 470 masl), consider food insecurity a serious problem, and appear to be less likely to be food vulnerable when hit by a calamity (based on their food vulnerability index).

For households that are likely to be slightly food insecure as indicated by taking measures to use savings and produce their own food as coping strategies, market dependency, farming engagement, and elevation of barangay turn out to be significant factors. The negative coefficient of market dependency indicates that net staple food buyers and non-farming households are less likely to produce own food as a coping strategy for food shortage. In addition, employing this strategy could be expected more from households living at high elevation as the physical characteristics of barangays here are more suitable for farming and less prone to flooding than in the low elevation areas.

However, the coefficient for farming households is positively related to the use of savings as a strategy, which means that households engaged in farming are more likely to use their savings to prevent food shortage than non-farming households. This could be logical since farming households have the opportunity to save a portion of their harvest, like seed stocks held for next season or to have harvestable vegetables in times of calamity. Savings in this case is in the form of commodities saved from their harvests rather than monetary savings. Similarly, households in the high-lying areas are found to have a greater probability of using these savings than those at low-lying barangays since most of them are into farming.

Table 9.15. Marginal effects from the binary logit models of coping strategies for food shortage

Typology	Food Secure	Slightly Food Insecure		Moderately Food Insecure		Severely Food Insecure
Variables	Did Nothing	Use savings	Produce own food	Borrowing/ purchasing food on credit	Substitute preferred food with less expensive food items	Consume less quantity food
VUL	-0.0579 (0.440)	0.1498 (0.142)	-0.0436 (0.642)	0.0382 (0.688)	0.0373 (0.661)	0.0525 (0.534)
ELEV	-0.1558** (0.043)	0.5122*** (0.000)	-0.2069** (0.033)	-0.3382*** (0.001)	0.2452** (0.033)	0.0379 (0.713)
HHSIZE	-0.0263 (0.118)	0.0190 (0.446)	-0.0180 (0.455)	0.0171 (0.462)	0.0117 (0.581)	-0.0048 (0.822)
EDUC	-0.0049 (0.668)	-0.0018 (0.913)	-0.0200 (0.163)	0.0025 (0.869)	0.0015 (0.914)	-0.0225* (0.079)
INC	2.41x10 ⁻⁷ (0.335)	4.44x10 ⁻⁷ (0.231)	-1.41x10 ⁻⁷ (0.702)	-1.19x10 ⁻⁷ (0.724)	-4.24x10 ⁻⁷ (0.208)	-1.16x10 ⁻⁷ (0.679)
INCDIV	0.0293 (0.394)	-0.0030 (0.951)	-0.0531 (0.260)	0.0171 (0.700)	-0.0694 (0.107)	-0.0110 (0.779)
ASSIST	0.0484 (0.504)	-0.1069 (0.281)	-0.1437 (0.103)	-0.0773 (0.400)	0.0442 (0.594)	0.0013 (0.987)
FARMING	-0.0092 (0.925)	0.2440** (0.044)	-0.2738** (0.035)	-0.2449* (0.077)	0.0791 (0.444)	0.7648 (0.469)
FARMINC	-0.0002 (0.859)	0.0000 (0.998)	0.0024* (0.096)	0.0015 (0.262)	-0.0016 (0.241)	-0.0001 (0.889)
MKTDEP	not estimable	-0.3581** (0.024)	-0.1037 (0.611)	0.2496*** (0.007)	-0.1349 (0.496)	not estimable
MKTKM	0.0028 (0.844)	-0.0230 (0.237)	0.0025 (0.880)	-0.0316 (0.111)	0.0048 (0.717)	-0.0196 (0.201)
FSKNOW	0.0149 (0.858)	0.0683 (0.558)	0.1024 (0.279)	0.1997** (0.018)	0.1116 (0.140)	0.0394 (0.644)
FSISSUE	-0.4231*** (0.003)	0.1427 (0.258)	0.1633* (0.088)	0.1599 (0.130)	0.1779 (0.017)	0.2256 (0.000)
FSVUL	-0.0855* (0.067)	-0.0196 (0.750)	-0.0159 (0.782)	0.1220** (0.032)	0.2059*** (0.000)	0.1422*** (0.004)
Prob. >χ²	0.0916	0.0040	0.0006	0.0190	0.0033	0.0409

Note: Values in parentheses are p-values. ***, **, and * indicate significance at 1%, 5%, and 10% probability level. Highlighted cells are significant coefficients.

For those who are likely to be moderately food insecure as indicated by borrowing money or purchasing food on credit, elevation, farming engagement, market dependency for staple food, knowledge about food security, and food vulnerability index. Households at lower elevations, non-farming households, net staple food buyers, and those with knowledge of the concept of food security have a higher probability of resorting to borrowing or purchasing food on credit to cope with food shortage. This could be explained by the presence of more market establishments in low-lying barangays where they can purchase food on credit compared to barangays in high elevation areas. Non-farming households who buy their food are the ones who depend on the market for food and thus, are more likely to purchase food on credit when their purchasing power

for food becomes weak. Households who understand the concept of food security are also more likely to borrow money or purchase food on credit to have enough food than those who do not know what food security is. Households living in high elevation areas have a greater propensity to substitute their preferred food with less expensive items as a coping strategy during times of food shortage. A reason for this could be the greater availability of and accessibility to cheaper food like root crops and vegetables at high elevation areas since there are more farmers in these areas compared to low-lying areas.

Finally, for those who are forced to consume less food, the coping strategy which implies severe food insecurity or vulnerability, educational attainment and food vulnerability index are the factors that are found to significantly characterize the of households adopting such coping strategy. The less educated the household head is, the greater the probability of employing this coping strategy. This is plausible since this person may not have an adequate understanding of the importance of consuming enough food as well as the serious repercussions of not being able to eat enough. But more importantly, educational attainment may reflect the socio-economic status of a household that possesses little means of accessing food.

As expected, households who are found to be more likely to be food vulnerable when there is an extreme event, as indicated by the food vulnerability index, were found to be the ones likely to use coping strategies that imply moderate food insecurity and severe food insecurity. These are the households that are predicted to be exposed to more food insecurity risks brought about by calamities and that most probably cannot manage to maintain their food security status when a calamity arrives.

SUMMARY AND CONCLUSION

The Philippines has been facing increasing impacts of climate change, particularly in terms of increasing frequency and intensity of extreme weather events like typhoons which pose serious threats to household food security. Understanding the factors that can push a household to a state of food insecurity or hinder their access to adequate food can help policymakers, community groups, and households themselves choose and apply effective strategic actions in order to survive food insecurity risks and shocks. This chapter shed light on this matter by providing an analysis of the food security status of vulnerable households and their likelihood to fall under a state of food insecurity when affected by an extreme weather event, using evidence from the Sta. Cruz Subwatershed, Laguna, Philippines.

While the majority of households in this location already experienced food shortage in the past and consider food insecurity as a problem, the number and types of coping strategies that they employed to mitigate food shortage simply that most of them have not yet experienced severe food insecurity nor suffer from chronic food insecurity. However, when faced with climatic stress like extreme weather events, their food security status could possibly worsen if the impacts of the extreme event on their food access are not minimized or successfully managed.

The key findings of the study reveal that households are heavily affected by extreme events in terms of job or source of income, logistics, and assets or properties, which all have a direct effect on the access of households to food. Based on the food vulnerability index, the majority of households were found to be more likely to fall or stay below the food security threshold when hit by a typhoon or extreme event. Different human, physical, economic, and food access risks appear to significantly increase (or decrease) their food vulnerability in times of extreme weather event. Furthermore, the ability

of households to minimize the impacts of climatic stress through coping strategies is another significant factor contributing to the food vulnerability of households.

The food security status of the vulnerable households is further examined using coping strategies as proxy indicators. The analysis shows that those residing in low elevation areas do not consider food security as a serious problem and are less likely to become food vulnerable when there is an extreme event. They are likely not to adopt any coping strategies for food shortage, which implies a food secure household.

Based on the results of the analysis, it can be concluded that, at the micro level, households from the vulnerable areas of the Sta. Cruz Subwatershed are generally still in a tolerable state of food insecurity. It is apparent that households living in barangays with high elevation and are net staple food buyers are more likely to be less food secure than those at lower elevations and are net food producers. However, most of the households were found likely to become food vulnerable when an extreme weather event, specifically a typhoon, occurs.

POLICY IMPLICATIONS

For most households, resilience to food insecurity during extreme weather events depends largely on having enough economic access to food, meaning how affordable the price of food is. Thus, strategic efforts that can strengthen the purchasing power of the households play an important role in achieving or maintaining their food security. Strengthening public distribution systems that offer a wide variety of cheaper food substitutes, like secondary crops that can nutritionally compensate for the relatively expensive food items, would be helpful especially if there is an extreme weather event. Existing food assistance programs also need to be improved to cater to the immediate needs of the households to effectively resolve short-term food insecurity. However, the assistance programs should have effective targeting of the food insecure and food vulnerable, and should be implemented with control to prevent households from becoming over-dependent on assistance to survive food insecurity. In addition, an important strategic action is to improve the early warning system in the barangay and municipality in terms of reach and timeliness, as well as to continue education on effective coping strategies to manage the impacts of disasters more effectively.

More aggressive promotion of sustainable home gardening of food plants like fruits and vegetables and indigenous crops, coupled with trainings on agricultural practices to encourage own production of food for the family can contribute to minimizing the risks involved in being a net food buyer. This strategy can protect households from the effects of food price inflation and may also guarantee food availability, especially in times of calamity. Such an initiative can also support households in diversifying their food base, thereby improving their dietary balance and nutrition. Similarly, for households who are already farming, encouraging the diversification of commodity production will not only support food diversification but will also minimize the risk of total productivity loss due to shocks like typhoons as some commodities may be resilient to climate impacts.

In putting into action the above recommendations, special attention should be given to the households living in barangays in high elevation areas as they were found to be less food secure and more vulnerable to food insecurity.

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CHAPTER 10

DIVERGENCE BETWEEN VALUE OF DAMAGES DUE TO EXTREME EVENT AND COST OF COPING MECHANISMS OF HOUSEHOLDS IN A WATERSHED

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The elevation where a community is located greatly determines the kind and value of impact that it will suffer from a disaster. As such, the disaster damage valuation and coping mechanisms of a household are relative to its location. Through the analysis of gathered data and testimonies of households, disaster-susceptible locations and appropriate coping mechanisms can be identified. The study focuses on the valuation of damage to and adaptation strategies of households in the Sta. Cruz watershed to an extreme climate event, i.e., a strong typhoon.

Results showed that on the average, households in high elevation areas incurred the highest damages, while those at the low elevation had the lowest. In general, losses from crops and livestock contributed to more than half (53 percent) of the total value of damage, while cost of illness had the lowest with 8 percent. Those at the high elevation had the highest average value of damage per household, while those located in the low elevation had the lowest. For coping mechanisms, the highest expenses were incurred after the typhoon. The values also differ by location of households. In contrast to the value of damage, households at the low elevation spent more on coping mechanisms than those living in the high elevation areas.

Keywords: watershed, valuation, autonomous adaptation, forgone earnings

INTRODUCTION

Background of the Study

As an archipelagic country in the Pacific Rim, the Philippines is a hotspot for the occurrence of natural hazards and climate change induced disasters. An average of 20 typhoons a year pass through the country's area of responsibility and about nine of them cross land, causing tremendous damage to the population, agricultural crops and properties. Furthermore, the occurrence of typhoons has become more frequent in the last decade. Typhoons that are particularly memorable include Ondoy (Ketsana) in 2009, which raised havoc in Luzon; typhoon Pablo (Bopha) in 2012 brought serious damage to Davao del Norte; and Typhoon Yolanda (Haiyan) in 2013 devastated the Visayas. Reports of damages oftentimes neglect damages incurred in the household level. Thus, the household is an oft neglected sector in policy formulation related to extreme events. Very few studies (Advento 2008; Predo et al. 2009; Espaldon et al. 2014) have looked into the value of damage at the microlevel particularly the households. This study is an attempt to provide additional information on the value of damage brought about by an extreme event, in this case typhoon Ondoy, among households in the Sta. Cruz Watershed.

Objectives of the Study

In general, this study aims to assess the value of damage and coping mechanisms of households during an extreme event. Specifically, the study was guided by the following objectives:

1. to determine the type of damage suffered by households in different elevations;
2. to assess the value of damage incurred by households in different elevations;
3. to determine and estimate the cost of coping mechanisms of households in different elevations to extreme events; and
4. to draw policy implications based on the results.

METHODOLOGY

Place of the Study and Method of Data Gathering

The study was conducted among 169 randomly selected households in six selected barangays representing high, medium and low elevations from three municipalities in the Sta. Cruz watershed. Two barangays were chosen for each elevation. Elevation of the study sites' location was determined based on its meters above sea level (masl). Elevation was further classified into high (above 408 m), medium (20-470 m) and low (10-20 m) categories.

Primary information related to damage due to the most damaging typhoon (Typhoon Ondoy in 2009) that hit the areas were gathered using a pre-tested survey questionnaire. Primary data on respondent's socio-economic characteristics, type and value of damage in crops and livestock, assets and properties as well as the forgone income and cost of adaptation strategies to minimize the effects of the typhoon. The household survey was supplemented by information gathered through focus group discussion (FGDs) among

barangay officials, women and the elderly, and key informant interviews (KIIs) among key people in the municipalities and barangays covered by the study. The primary data were supplemented by secondary data that were obtained from barangay reports (e.g., barangay integrated development plan, and the Disaster Risk Reduction and Management Council (DRRMC) Plan.

Data Analysis

Valuation of damage and cost of adaptation strategies and coping mechanisms before, during and after the typhoon were estimated using the market based approach and forgone earning or income. Descriptive analysis using frequencies, percentages and means was used to describe the socio-economic characteristics of respondents and the values of damage and coping mechanisms. To determine if there are significant differences in the mean values of damage incurred and coping mechanisms among households under each elevation, the one way analysis of variance (ANOVA) was used.

RESULTS AND DISCUSSION

Socioeconomic Profile of the Respondents

The socioeconomic characteristics of the respondents are summarized in table 10.1. The respondents are mostly male, representing 82 percent of the total. More than three-fourths of the respondents are married while 11 percent are widowers. The average number of years in school of the respondents is 9.15. Except for those in the low elevation, more than a third reached the tertiary level; most of the respondents have completed only elementary and secondary education. The average household size is four but majority have four to six members in the family. Respondents from the medium and low elevations are mostly unskilled laborers and service workers. Correspondingly, the respondents from the high elevation had the least household income per year, averaging at PHP 159,548, while average household income in the medium and low elevation areas was recorded at PHP 191,110 and PHP 174,113, respectively. The average annual household income of all the respondents is PHP 174,818, ranging from PHP 500 to PHP 480,000.

Type and Value of Damage due to Typhoon

Based on feedback from the respondents, the value of damages brought about by the typhoon was determined by accounting for damages to crops and livestock, assets and properties, and inability to work or forgone earnings.

Table 10.1. Socioeconomic characteristics of respondents, by elevation, Sta. Cruz Watershed

Soil fertility status	Elevation			All Respondents (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Sex				
Male	84	82	81	82
Female	16	18	19	18
Marital status				
Single	5	7	2	5
Married	84	73	71	76
Widow/widower	7	13	12	11
Others ^a	4	7	15	9
No. of years in school	9.08	9.04	9.36	9.15
Elementary level	13	5	2	7
Elementary graduate/ high school level	46	45	28	40
High school Graduate	34	27	38	33
College level/graduate	7	22	33	21
Primary occupation				
Farming	61	20	9	30
Laborer (off farm)	11	31	26	22
Trade-related jobs	7	7	19	11
Service worker	7	31	28	22
Others ^b	15	11	19	15
Household size	4.04	4.65	4.64	4.44
Average annual household income (PHP/year)	159,548	191,110	174,113	174,818

^ainclude separated, common-law spouse^binclude government employee, self-employed, driver**Type, quantity and value of damage crop, poultry and household assets**

The number of household respondents who incurred damages due to extreme events by elevation is provided in table 10.2. Thirty-seven (22 percent) of the total households have had crops and poultry damages while 40 percent have reported house damages during extreme events. Of those who claimed damages to their crops, majority (74 percent) said that damage was to their vegetable farms. Ninety-nine percent of the respondents who experienced house damages reported that the damages were only partial. Of the 65 (38 percent) household respondents who reported damages to their appliances, damages to televisions and cabinets were the most common as cited by 32 percent and 17 percent of the respondents, respectively. Seventy-eight (46 percent) of household respondents claimed that at least one member of their household is unable to work during extreme events while a total of 100 household members were not able to go to work due to extreme events. The top reasons for their inability to report for work are the following: heavy rains and flooding (59 percent), attending to repairs of damaged properties (25 percent), and damaged properties used for livelihood (16 percent).

Half of the high elevation respondents have had crop and poultry damages while 13 percent of the medium elevation respondents and only 3 percent of the respondents in the low elevation have had crop and poultry damages. This is attributed to the nature of work of the respondents by elevation. Since majority of the high elevation respondents are involved in farming or farm-related activities, while a majority of the low elevation respondents are non-farming households, the possibility of experiencing crop and poultry damage among the former is relatively higher.

Survey results indicate that households residing in medium (44 percent) and low (45 percent) elevated sites have experienced more damage to their houses and appliances compared to households located in high elevation areas, with only 30 percent. Only 7 percent of the respondents living in high elevation areas reported damaged appliances while 62 percent and 47 percent of the medium and low elevations, respectively, have had damage to their appliances. A damaged television set has been the most cited among appliances mentioned with 75 percent, 24 percent and 37 percent reporting for the high, medium and low elevations, respectively (table 10.2).

Table 10.2. Household respondents who incurred damages due to typhoon, by elevation and type of damage, Sta. Cruz Watershed

Item		Elevation		All Respondents (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Crops and Poultry				
Household respondents who had crop and poultry damages ^a	28(50)	7(13)	2(3)	37(22)
All Crops ^b	27(96)	7(100)	1(50)	35(95)
Rice	1(3)	2(29)		3(9)
Vegetables	24(89)	1(14)	1(100)	26(74)
Perennials	1(3)	4(57)		5(14)
Sweet Potato	1(3)			1(3)
Poultry ^b	1(4)		1(50)	2(5)
Duck			1(100)	1(50)
Chicks	1(100)			1(50)
Assets and Properties				
Households with House Damage ^a	17(30)	24(44)	26(45)	67(40)
House Totally Damaged	1(6)			1(1)
House Partially Damaged	16(94)	24(100)	26(100)	66(99)
Households with Damaged Appliances ^a	4(7)	34(62)	27(47)	65(38)
Refrigerator		1(3)	3(11)	4(6)
Television	3(75)	8(24)	10(37)	21(32)
Radio		2(6)	1(4)	3(5)
Sofa		1(3)	4(15)	5(8)
Cabinet		3(9)	8(30)	11(17)
Other Properties Total ^c	1(25)	19(56)	1(4)	21(32)

^aFigures in parentheses are percentages based on number of respondents for each elevation

^bFigures in parentheses are percentages based on those who had crop and poultry damages

^cDining tables, small tables, small chairs and mini drawers

Note: Multiple Responses

Quantity of crops and poultry damages

The quantities of damage to crops and poultry among household respondents due to extreme events of the households are exhibited in table 10.3. An average damage of 1,063 kg for rice, 1,939 kg for vegetables, and 1,416 pieces for perennial crops were reported. Three ducks and 30 chicks were also lost due to the typhoon. The most damaged crops in the high elevation areas were vegetables (2,094 kg) and perennial crops (6,000 pieces). Damages to rice crops (1,450 kg) among medium elevation-based households were noted and only a minor damage (500 pieces) was reported for perennial crops. As expected, farm households in the high elevation areas have reported huge damages to crops while very minor damage was reported by households in low elevation areas.

Table 10.3. Quantity of damage to crops and poultry of typhoon-affected household respondents, by elevation, Sta. Cruz Watershed

Item	Elevation			All Affected Households
	High	Medium	Low	
Rice (kg)	250(250-250)	1,470(460-2,450)		1,063(250-2,450)
Vegetables (kg)	2,094(90-6,500)	50(50-50)	120(120-120)	1,939(50-6,500)
Perennials (pcs)	6,000(6,000-6,000)	540(30-1,050)		1,416(30-6,000)
Sweet Potato (kg)	50(50-50)			50(50-50)
Duck (heads)			3(3-3)	30(3-3)
Chicks (heads)	300(300-300)			300(300-300)

Note: Figures inside the parentheses are the minimum and maximum values

Value of damaged crops, poultry and properties

The estimated monetary values of damages attributed to the typhoon among household respondents are summarized in table 10.4. As a whole, households incurred an average of PHP 19,113 damage to crops and PHP 5,400 to poultry. Damage to vegetables was the highest among crops, with an average of PHP 1,016 per affected household. Losses incurred in rice farms closely followed at PHP 18,200 per household. Damage to poultry production (i.e., lost chicks) was estimated at PHP 10,500.

Meanwhile, an average of PHP 3,308 was the estimated cost of house damage. A lone resident of the high elevation study site lost his entire house, which he valued at PHP 5,000. The rest of the respondents experienced only partial damages to their houses, which were monetized for an average of PHP 3,283. The average damage to appliances amounted to PHP 3,602; the most expensive damaged items were the refrigerator and sofa sets, with average costs amounting to PHP 5,250 and PHP 4,200, respectively. The television was the most common damaged appliance costing an average of PHP 3,383. The average forgone income, due to the inability to work, was estimated at PHP 4,088.

Those who are primarily farm households in the high elevation recorded an average damage to crops amounting to PHP 20,252. This figure was the highest estimated damage among the three elevation categories as respondents in the medium and low elevations registered an estimated average crop damage values of only PHP 10,028 and PHP 6,000, respectively. Damage to vegetables largely contributed to crop losses among farm households in high elevation areas with an average value of PHP 22,497 per household. On the other hand, households in the medium elevation areas were mostly affected by the damage to rice production, with an estimated average cost of PHP 25,113.

Table 10.4. Average value of damage to crops, poultry and properties of typhoon-affected households respondents, by elevation, Sta. Cruz Watershed (PHP/household)

Item		Elevation		All Affected Households
	High	Medium	Low	
Crops and Poultry				
Crops	20,252 (900-79,000)	10,028 (500-40,425)	6,000 (6,000-6,000)	19,113 (500-79,000)
Rice	4,375 (4,375-4,375)	25,113 (9,800-40,425)		18,200 (4,375-40,425)
Vegetables	22,497 (1,700-79,000)	500 (500-500)	6,000 (6,000-6,000)	21,016 (500-79,000)
Perennials	1,620 (1,620-1,620)	7,535 (240-20,700)		6,352 (240-20,700)
Sweet Potato	900(900-900)			900(900-900)
Poultry	10,500 (10,500-10,500)		300 (300-300)	5,400 (300-10,500)
Duck			300 (300-300)	300 (300-300)
Chicks	10,500 (10,500-10,500)			10,500 (10,500-10,500)
Total for Crops and Poultry ^a	19,904 (900-79,000)	10,028 (500-40,425)	3,150 (300-6,000)	18,372 (300-79,000)
Assets and Properties				
House Damage	2,784 (25-10,000)	3,679 (50-25,000)	3,309 (300-15,000)	3,308 (25-25,000)
House Totally Damaged	5,000 (5000-5000)			5,000 (5000-5000)
House Partially Damaged	2,645 (25-10,000)	3,679 (50-25,000)	3,309 (300-15,000)	3,283 (25-25,000)
Total Appliances	3,750 (1,000-6,000)	3,774 (550-10,000)	3,548 (100-10,000)	3,602 (100-10,000)
Refrigerator		10,000 (10,000-10,000)	3,667 (2,000-5,000)	5,250 (2,000-10,000)
Television	4,000 (1,000-6,000)	3,294 (550-6,300)	4320 (500-7,000)	3,883 (500-7,000)
Radio		1,900 (1,800-2,000)	1,000 (1,000-1,000)	1,600 (1,000-2,000)
Sofa		4,000 (4,000-4,000)	4,250 (1,000-10,000)	4,200 (1,000-10,000)
Cabinet		1,667 (1,000-3,000)	2,200 (100-6,000)	2,055 (100-6,000)
Other Properties ¹	3,000 (3,000-3,000)	2,953 (150-7,500)	6,000 (6,000-6,000)	2,862 (150-7,500)
Total Damage to Assets and Properties ^b	3,276 (25-10,000)	3,727 (50-25,000)	3,429 (100-15,000)	3,495 (25-25,000)

¹Dining tables, small tables, small chairs and mini drawers

Note: Figures inside the parentheses are the minimum and maximum values; US\$1:00 = PHP45.00

^aMean differences are statistically significant at 5% level (p-value= 3.37e-12)

^bMean differences are not Significant at both 5% and 10% probability level (p-value= 0.6694)

The distribution of crop damage can be attributed to the nature of crop specialization at each elevation. High elevation-based respondents generally concentrate on vegetable production due to the area's cooler climate while medium elevation-based respondents generally produce rice due to more favorable conditions and the presence of irrigation facilities for palay and paddy production. The respondents in the low elevation, meanwhile, have the least damage with an average of PHP 6,000.

In terms of house damages, high elevation-based respondents recorded the least cost, estimated at PHP 2,784, while the medium elevation-based respondents had the highest amount of damage with an average of PHP 3,679. The difference between the above mentioned estimates may partly be explained by the cost of construction/acquisition between high and lower elevation-based respondents, with the former needing only light materials for housing.

There is not much difference in the total costs of damages to appliances among all elevations. The difference, however, is in the type of appliance that tallied the most damage costs; for the high elevation-based respondents, it was the television with an average estimated cost of PHP 4,000; for the medium elevation-based respondents, it was the refrigerator with an average estimated cost of PHP 10,000; and for the low elevation-based respondents, it was the dining table with an average estimated cost of PHP 6,000.

Foregone Income

There have been cases where respondents and household members were not able to work due to the typhoon. The values of these lost work days represent the forgone income of households due to typhoon. In the low elevation, 44 residents (33 percent) lost their source of income; 31 residents (21 percent) for the medium elevation; and 25 residents (43 percent) for the high elevation. Residents in the low and medium elevation areas are mostly engaged in trade-related jobs, service work and government work; 65 percent in the medium and 70 percent in the low elevations have cited heavy rains and flood as the major reason for their failure to report for work. Meanwhile, in the high elevation, 32 percent of residents attribute the damage of properties used for livelihood, and the heavy rains and flooded areas as the main reasons for the loss of their sources of income (table 10.5).

The average work-loss days of household members were 19, with a maximum value of 120 days. Damage to farm inputs, which resulted in the loss of commodities to trade, is the most cited reason for the loss of income, causing an average of 24 work-loss days. The heavy rains and flooding that prevented household members from reporting to work caused an average of 22 work-loss days while damage to properties used for livelihood-related work caused an average of 19 work-loss days.

High elevation-based respondents were not able to work for an average of 26 days due to the damage to their properties used for livelihood. In the case of medium elevation-based respondents, the longest average number of days that they were unable to work was estimated at 16 days, which was attributed to damaged infrastructure. Among the three categories of respondents, low elevation-based households recorded the longest duration of work absence with an average of 36 days (table 10.5). The major reason that prevented low elevation-based household members from going to work was heavy rains and or flooding.

Table 10.5. Households with members unable to work due to extreme events, reasons and number of days unable to work, by elevation, Sta. Cruz Watershed

Item	Elevation			All Respondents (n =169)
	High (n = 56)	Medium (n = 55)	Low (n = 58)	
Household with members unable to work due to extreme event ^a	24 (43)	21 (38)	33 (57)	78 (46)
Total number of all household members unable to work due to extreme events	25	31	44	100
Number of household members unable to work due to: ^b				
Damage of properties used for livelihood	8(32)	7(23)	1(2)	16(16)
Attend to repairs	5(20)	7(23)	13(30)	25(25)
Heavy Rains/Flooding	8(32)	20(65)	31(70)	59(59)
Damaged Infrastructure	2(8)	7(23)		9(9)
Others ^c	8(32)			8(8)
Average days the household respondents were not able to work due to extreme events	19 (1-120)	9 (1-60)	26 (1-90)	19 (1-120)
Damage of properties used for livelihood	26(2-120)	12(1-60)	1(1-1)	19(1-120)
Attend to repairs	4(1-8)	13(4-30)	3(1-7)	6(1-30)
Heavy Rains/Flooding	6(1-30)	7(2-20)	36(1-90)	22(1-90)
Damaged Infrastructure	7(7-7)	16(2-30)		14(2-30)
Others	24(2-80)			24(2-80)

Note: Figures in parentheses are minimum and maximum values

^aFigures in parentheses are percentages based on number of respondents for each elevation

^bMultiple Responses; Figures in parentheses are percentages based those who were unable to work for each elevation

^cDamaged farm inputs, no deliveries for sale, no commodities to trade

Table 10.6 summarizes the average forgone income of residents who were not able to work due to typhoon. The respondents in the low elevation areas had the highest loss, which is estimated at PHP 5,988. This is due to the longer duration of work absences, which resulted in a deduction of their salaries. Medium elevation-based respondents had the least forgone income at PHP 2,106, which is surprisingly lower than the high elevation respondents with an average forgone income of PHP 3,203. Respondents from the medium elevated areas had a relatively lesser problem contending with floods compared to respondents in the low elevation areas and were able to report for work ahead of the latter thus recording lower average of forgone income. In the case of respondents from the high elevation areas, who are mostly upland farmers, work stopped because of the damages to their farms.

The highest forgone income recorded in the high elevation (PHP 7,072) was due to the damage to properties used for livelihood; the highest forgone income in the medium elevation (PHP 2,768) was due to damaged infrastructure; and the highest forgone income in the low elevation (PHP 10,008) was mainly due to flooding, the duration of which prevented residents from working or going to work for a significant length of time.

Total Value of Damages

The value of total damages per household is summarized in table 10.7. The average total damage of all households is PHP 17,679. Among the three elevations, the high elevation area had the highest total damage on average, amounting to PHP 26,279, primarily because of damages to high-valued crops.

Table 10.6. Foregone income of the households affected by typhoon, by elevation, Sta. Cruz Watershed (PHP/household)

Item	Elevation			All Affected Households
	High	Medium	Low	
Damage of properties used for livelihood	7,072 (544-10,000)	2,076 (173-14,400)	278 (278-278)	5,225 (278-14,400)
Attend to repairs	1,088 (272-2,176)	2,249 (692-5,190)	834 (278-1,946)	1,650 (272-5,190)
Heavy Rains/Flooding	1,632 (200-8,160)	1,211 (346-3,460)	10,008 (100-45,000)	3,850 (100-45,000)
Damaged Infrastructure	1,904 (1,904-1,904)	2,768 (266-5,190)		2,576 (266-5,190)
Others ^a	6,528 (544-10,000)			6,528 (544-10,000)
Average Foregone Income	3,203 (200-10,000)	2,106 (266-14,400)	5,988 (100-45,000)	4,088 (100-45,000)

^aDamaged farm inputs, no deliveries for sale, no commodities to trade

Note: Figures in parentheses are min and max values; US\$1:00 = hP45.00

Medium elevation-based respondents had crop and poultry damages as well, which produced the highest percentage of their total value of damages; meanwhile, forgone income was the highest contributor for the low-elevation dwellers.

Table 10.7. Average total value of damages by elevation and type of damage, Sta. Cruz watershed (PHP/Household)

Item	Elevation			All Affected Households
	High	Medium	Low	
Total Damage ^a (PHP/households)	26,279	15,813	12,560	17,679
Percent Contribution				
Damaged Crops and Poultry	76	64	25	58
House and other Properties	12	23	27	20
Forgone Income	12	14	48	23

^aValues are statistically different at 5% level (p-value= 0.019838)

Note: US\$1:00 = PHP45:00

Aggregate Value of Damage

To determine the value of damage for the entire study area, the aggregate value of each type of damage in each elevation was calculated and totalled. Results showed that the total value of damages amounted to PHP 43.456 million. Forgone income accounted for almost 47 percent of the total value while losses due to crop and poultry damage registered the least damage costs at 23 percent of the total value (table 10.8).

The low elevation site had the highest value of damage, amounting to an estimated PHP 27.232 million or 67 percent of the total value; this is because of the high population density in the area, which contributed to 64 percent of the total number of households surveyed, and the long duration before residents were able to recover from the floods. Households in this area also suffered huge losses from damages to their houses and appliances. On the other hand, the medium elevation site had the lowest value of damage at 14 percent of the total; they had the lowest numbers in crop damage and forgone income. The high elevation site, meanwhile, had the highest value for all crop and poultry damages; this was due to the high values of vegetables that were damaged by the typhoon.

Table 10.8. Aggregate value of damage for all study sites, by elevation, Sta. Cruz watershed (PHP)

Item	Elevation			Total (N = 4855)
	High (N = 835)	Medium (N = 920)	Low (N = 3100)	
All Crops and Poultry	8,310,084	1,352,668	336,724	9,999,476
House and Properties	929,355	3,623,328	9,718,500	13,093,159
Forgone Income	1,954,854	1,235,660	17,176,566	20,367,080
Aggregate Value of Damage	11,194,293	6,211,656	27,231,790	43,459,715

Note: US\$1:00 = PHP45:00

Adaptation Strategies or Coping Mechanisms

Households were asked about the strategies they adopted to cope with the effects of the typhoon; they were also asked about how and where they got their information about the typhoon and how much time they had to prepare before the typhoon came.

Source of Information about the Typhoon

Table 10.9 shows the number of residents in the survey sites who had prior knowledge about the typhoon's arrival as well as their sources for this information and the number of hours between receiving the information and the typhoon's arrival. On average, almost all of the respondents had knowledge of the forthcoming typhoon 25 hours prior to its landfall. Television news had been cited by 93 percent of household respondents as their primary source of information. Other notable sources of information included radios (23 percent) and barangay officials (13 percent). Respective averages of 28, 25, and 23 hours were reported as the lead times for the high, medium, and low elevation respondents before the calamity hit their respective areas. These findings imply that their sources of information appeared to have been able disseminate the news ahead of the calamity's arrival. Weather information from television was the most common source among the three elevations.

Table 10.9. Information about the arrival of the typhoon and source of information of households, by elevation, Sta. Cruz Watershed

Item	Elevation			All Respondents (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Information about the arrival of the typhoon ^a	55(98)	55(100)	58(100)	168(99)
Source of information ^b				
Television	55(100)	48(87)	53(91)	156(93)
Radio	9(16)	21(38)	9(15)	39(23)
Barangay Officials	9(16)	5(9)	8(14)	22(13)
Personal	1(2)	0	3(5)	4(2)
Other people	0	0	1(2)	1(1)
Hours information were received before typhoon landed ^c	28(1-68)	25(1-192)	23(1-72)	25(1-192)

^aFigures in parentheses are percentages based on number of respondents for each elevation

^bMultiple responses; Figures in parentheses are percentages based on those who had information about the arrival of the calamity Coping strategies (before, during and after) and recovery period

^cFigures inside the parentheses of means are the min and max value

Since households had prior information about the typhoon's arrival, they were able to adopt coping strategies to minimize the effects of the calamity. The coping strategies performed by households before, during and after the typhoon, and the number of days it took to recover from the calamity, are detailed in table 10.10.

Results of the survey revealed that before the typhoon, the coping strategies by 90 percent of the households were autonomous in nature. Fifty-one percent of the respondents implemented adaptation strategies during the typhoon while all respondents have expectedly resorted to coping measures after the extreme event occurred. The three most common adaptation or coping strategies before and after the calamity were: buying and storing food, reinforcing the house, and securing assets. Adaptation strategies during the typhoon included the same three measures before the calamity and the relocation to a safer area. The average recovery period from the typhoon was 26 days for all households.

Adaptation strategies have evolved to cope with changes in weather patterns and their resultant effects. Respondents from the low (41 percent) and medium (18 percent) elevations have emphasized percent that family relocation has been included in the measures they employ to cope with strong winds and damaging floodwaters; this was, in fact, the most common adaptation strategy for households in the low elevation site since their area was the most susceptible to flooding. When weather becomes more permitting, respondents attend to their damaged assets and properties.

The average recovery period from the typhoon decreases as elevation of the household location increases. A recovery period of 14 days for the high elevation, 16 days for the medium elevation and 46 days for the low elevation was reported. Consequent flooding due to heavy rains was the principal reason why low elevation households took an average of 46 days to recover from the typhoon.

Table 10.10. Coping strategies performed by household and days recovered from effects of typhoon, by elevation, Sta. Cruz watershed

Item	Elevation			All Respondents (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Before the typhoon ^a				
Households who did adaptation strategies ^b	56(100)	38(64)	58(100)	152(90)
Buy/Store Foods	42(75)	20(53)	32(55)	94(62)
Secure Assets	8(14)	13(34)	18(31)	39(27)
Reinforce House	24(43)	1(3)	20(34)	45(30)
Relocate Family	2(4)	1(3)	2(3)	5(3)
Relocate Farm animals	1(2)	1(3)	1(2)	3(2)
Harvest Crops	9(16)			9(6)
Others ^c	2(4)	2(5)		4(3)
During the typhoon ^a				
Households who did adaptation strategies ^b	26(46)	22(40)	39(67)	87(51)
Buy/Store Foods	7(27)	3(14)	3(8)	13(15)
Secure Assets	4(15)	7(32)	11(28)	22(25)
Reinforce House	7(27)	7(32)	5(13)	19(22)
Relocate Family		4(18)	16(41)	20(23)
Relocate Farm animals	3(11)	1(4)	1(3)	5(6)
Harvest Crops	2(8)			2(2)
Others ^c	3(11)		3(8)	6(7)
After the typhoon ^a				
Households who did adaptation strategies ^b	56(100)	55(100)	58(100)	169(100)
Buy/Store Foods	13(23)	9(16)	12(21)	34(20)
Secure Assets	22(39)	26(47)	29(50)	77(46)
Reinforce House	39(70)	47(85)	49(84)	135(80)
Relocate Family	4(7)		1(2)	5(3)
Relocate Farm animals	4(7)	4(7)	4(7)	12(7)
Harvest Crops	5(9)		2(3)	7(4)
Others ^c	2(4)		1(2)	3(2)
Days Recovered ^d	14(0-120)	16(0-365)	46(1-365)	26(1-365)

^aFigures in parentheses are based on those who did adaptation strategies before, during and after the typhoon

^bMultiple responses; Figures in parentheses are percentages based on number of respondents for each elevation

^cCharge phones, store candles, store batteries, use of power banks

Note: Figures in parentheses after the means are the minimum and maximum values

Value of adaptation/coping strategies (before, during and after)

The values of adaptation strategies before, during and after the typhoon are shown in figure 10.1. In general, the average total value of autonomous adaptation strategies amounted to PHP 4,238 per household. However, it can be noted that, regardless of elevation, highest shares of the adaptation costs were incurred after the typhoon. The most expensive adaptation strategy employed before and during the typhoon was the buying and storing of food, with an average of PHP 515 and PHP 327, respectively. After the calamity, the most costly adaptation measure was the relocation of farm animals, with an average cost of PHP 4,467 for each household that did this, as it entailed transporting their animals to relatives in other areas.

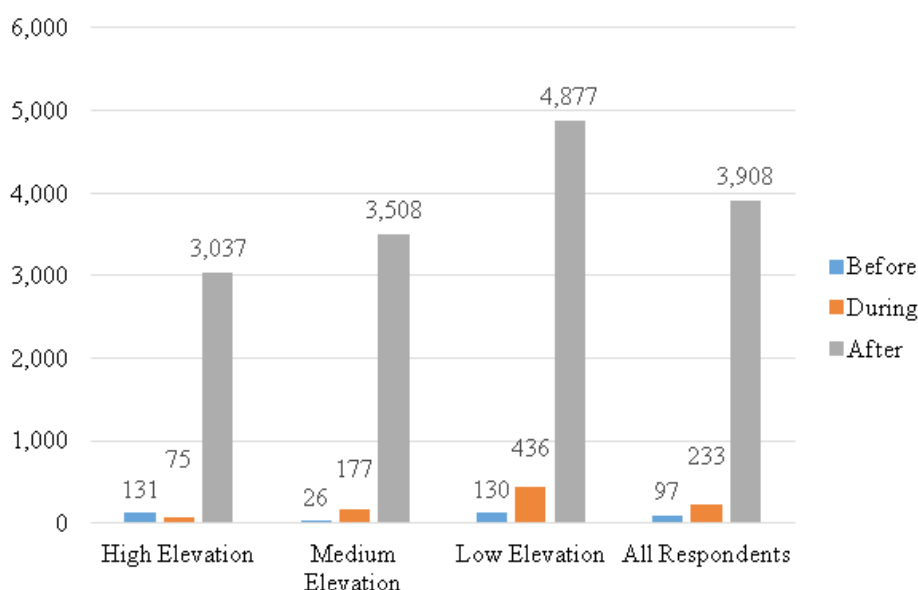


Figure 10.1. Average value of adaptation/coping strategies, by elevation, Sta. Cruz Watershed (PHP/household)

Aggregate Value of Adaptation Strategies

Figure 10.2 and table 10.11 recapitulate the aggregate value of coping strategies of households. The aggregate total value of all the coping mechanisms amounted to PHP 8,760,106. Analogous to the average estimates, the highest shares of the aggregate adaptation costs were acquired after the typhoon. The most costly adaptation strategy done before and during the typhoon, just like in the average estimates, was buying and storing foods with an aggregate value of PHP 1,546,254 and PHP 122,122, respectively. The most costly adaptation strategy implemented after the typhoon, with an aggregate value of PHP 4,676,256 was the securing of assets. This differed from the most costly measure based on average values, which was the relocation of farm animals. The aggregate value of adaptation mechanisms was highest for the low lying area due to the high number of households who suffered damages.

DIVERGENCE BETWEEN VALUE OF DAMAGES DUE TO EXTREME EVENT AND COST OF COPING MECHANISMS OF HOUSEHOLDS IN A WATERSHED

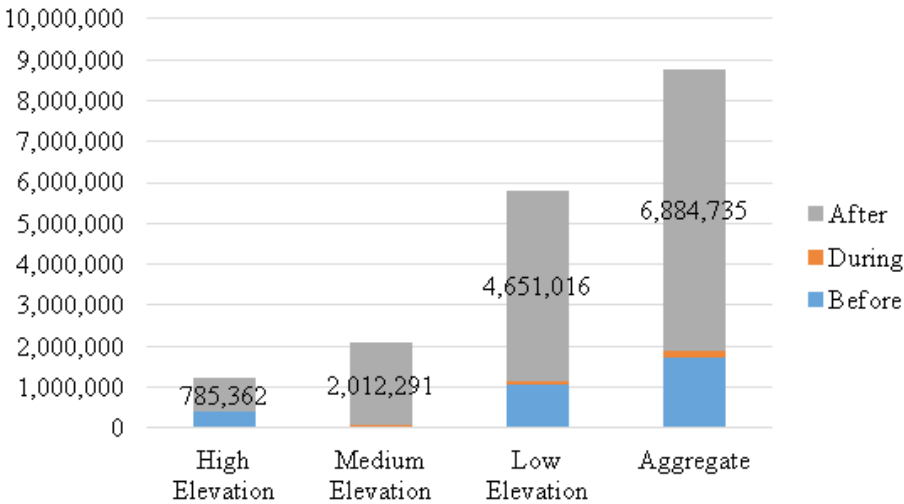


Figure 10.2. Aggregate value of coping strategies in Sta. Cruz watershed

Table 10.11. Aggregate value of coping strategies of all typhoon-affected households in the study area by elevation, Sta. Cruz Watershed (PHP)

Item	Elevation			Total (N = 4855)
	High (N = 835)	Medium (N = 920)	Low (N = 3100)	
Before the typhoon				
Buy/Store Foods	356,963	6,295	976,607	1,546,254
Secure Assets	2,982	36,195	17,317	22,422
Reinforce House	15,030	-	62,000	90,552
Harvest Crops	37,307	-	-	79,916
Subtotal	412,281	42,489	1,055,924	1,739,144
During the typhoon				
Buy/Store Foods	14,926	25,091	93,481	122,122
Secure Assets	-	3,396	-	5,688
Reinforce House	731	-	3,474	3,821
Relocate Family	-	-	7,697	4,596
Subtotal	15,656	28,487	104,652	136,227
After the typhoon				
Buy/Store Foods	66,681	106,285	291,186	467,861
Secure Assets	428,415	1,661,788	2,943,450	4,676,256
Reinforce House	1,745	-	-	3,878
Relocate Family	8,946	-	267,241	160,876
Relocate Farm animals	260,938	244,218	1,149,138	1,539,926
Others	18,638	-	-	35,938
Subtotal	785,362	2,012,291	4,651,016	6,884,735
TOTAL	1,213,300	2,083,267	5,811,591	8,760,106

Planned Strategies

When asked about their planned strategies for forthcoming extreme events, majority (80 percent) of the respondents expressed their plans which are summarized in Table 10.12. Respectively, 80 percent, 76 percent and 83 percent of high, medium and low elevation-based households reported that they have planned for the extreme event. However, it can be noted that all adaptation plans were short term in nature such as securing their properties (58 percent), and reinforcing their houses (30 percent). No long term adaptation strategies were mentioned by the respondents. The same results were consistent with the findings of Arias et al. 2014, Espaldon et al. 2014 and Francisco et al. 2011. Those without plans had claimed that they will not be affected by the extreme event since their houses in low elevation are well-built and can relatively withstand an extreme event. However, many households are still vulnerable to extreme events, particularly flooding.

Table 10.12. Planned strategies of households to adapt to extreme events, by elevation, Sta. Cruz watershed

Item	Elevation			All Respondents (n=169)
	High (n=56)	Medium (n=55)	Low (n=58)	
Household with Planned Strategies ^a	45 (80)	42 (76)	48 (83)	135 (80)
Strategies ^b				
Secure Properties	29(64)	19(45)	30(62)	78(58)
Reinforce house	5(11)	22(52)	14(29)	41(30)
Cleaning	5(11)	1(2)	0	6(4)
Avoiding burning of trash	2(4)	0	0	2(1)
Others ^c	4(9)	0	4(8)	8(6)
No Plans/No Response ^a	11(20)	13(24)	10(17)	34(20)
TOTAL	56(100)	55(100)	58(100)	169(100)

^aFigures in parentheses are percentages based on number of respondents for each elevation

^bFigures in parentheses are percentages based on number of those with planned strategies for each elevation

^cPraying, getting ready

CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

The results presented above pointed to some important considerations related to the damage brought about by climate-induced extreme event. For one, it is apparent that in using the watershed approach, we can see that damages due to typhoons, and perhaps other climate-induced disasters, differ by location.

Those in the upland who are engaged in agriculture suffered more on the average. Households in the high elevation areas are more prone to bear a greater share of the damage brought about by typhoons because of the damage to crops, including high value vegetables and rice, compared to those in the lower elevation.

Households located in the lowland suffered from floods caused by the typhoon, this rendered them unable to report for work, which resulted in forgone earnings.

Households in the upland had the lowest cost for implementing coping strategies,

which are purely autonomous in nature. They are also the one who can easily recover from a typhoon since they can plant the crops again.

Households in the low elevation, meanwhile, had the smaller damage, on average, even if they had higher work-loss days due to the flood. However, they also had the longest recovery period due to damaged properties and household appliances. Based on aggregate values, however, total damage in the lowland areas is higher due to the number of population affected by the calamity.

One striking reality is the huge difference between the values of damage due to the typhoon, amounting to PHP 43,459,715 and the cost or value of coping or adaptation strategies, which amounted to PHP 8,760,106. This may be due to the autonomous nature of the coping strategies, which is a reflection of their low adaptation capability. It may also be because households have been used to rely on the relief assistance of the local government units and non-governmental organizations during calamities.

Policy Implications

Based on the results, several policy implications and recommendations are offered. Policy related to long-term adaptations of agriculture to typhoons and any climate-induced extreme event must be strengthened. Farmers must be assisted with long term plans for withstanding the effects of climate-induced disasters. Agricultural technologies that could withstand extreme climates must be extended to upland farmers. Weather-index insurance for the upland farmers must also be explored. The local government should prioritize flood control measure programs. It would also help residents if early warning systems are put in place to enable the households to be more prepared for extreme climate events. Households in the low lying areas that are prone to flooding must be assisted through infrastructure improvement.

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CHAPTER 11

ADDRESSING IMPACTS OF FOOD SECURITY AND ENVIRONMENT INTERACTIONS DURING EXTREME EVENTS

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This chapter summarizes the results shown in the earlier chapters. There are differential sensitivities among the communities at the three elevations of the watershed with the lowlands being the most affected by exposure to climate hazards.

At the watershed level, there has been an increase in agricultural areas in the uplands. This has served to promote food security. The downside is that it has caused environmental degradation, such as soil erosion, and other hazards, such as landslides and flooding downstream. Government policy should promote watershed development planning that will be consistent with municipal development plans and comprehensive land use plans to minimize the trade offs between food security and environmental integrity, especially with climate change.

At the household level, upland households can be characterized as both subsistence and commercial in nature. The households did not feel that they are food insecure despite climate change and the hazards it exacerbates because the people produce their own food. Households in the lowlands, on the other hand, were more vulnerable although this is mitigated by markets that continue to work even during calamities. Lowland farmers also availed of crop insurance that minimized their losses from extreme weather events. Thus, food security was not considered a problem.

INTRODUCTION

The project described in this book aimed to do three things: (a) to understand how changes in climate affect the environment and food security in the watershed as a whole and in the communities and households; (b) to identify technological strategies that may be undertaken to minimize the adverse effects of environment-food security interactions on the welfare of communities; and (c) to recommend policies to minimize these adverse effects and improve well-being of communities. The study was guided by a framework that: (a) identified the exposure of households to climate hazards and their sensitivities to those hazards; (b) analyzed the impacts of those hazards on agriculture, the markets, communities and households; (c) described the adaptation strategies employed by the farmers and traders, communities and households; and (d) determined the impacts on food security of these adaptation strategies. The data were taken from secondary sources. Primary data were also generated through household surveys of 346 farm and non-farm households, 12 focus group discussions, and 58 key informant interviews with traders, farmers and local government officials. The analysis is mainly descriptive and is done at four levels: policy, watershed, community and household. The largest unit of analysis is the watershed. The use of the watershed as a unit of analysis supports the contention that the upstream-downstream relationship is important in mitigating harsh climate change impacts in the watershed communities that may lead to a decline in food security status. The smallest unit of analysis is the farm and non-farm households which bear the major brunt in coping with climate change.

SUMMARY OF RESULTS OF THE MULTI-SCALE ANALYSIS

Policy Level

In this study, policy and governance is crucial in addressing the following dimensions: how resources are shared—access, right to use; how responsibilities are distributed and shared to protect, conserve, and sustain resources; and how benefits, risks and burdens are shared and allocated (Gupta and Lebel 2010). The influence of the social and political arena, i.e., social relations and processes, capabilities, power, and interest cannot be ignored.

The action arena is a social space where individuals interact, solve problems, dominate one another, fight, etc. In the case of the Sta. Cruz Subwatershed and basin, the challenge is organizing stakeholders to contribute resources for the protection and conservation of the watershed resources (e.g., Laguna de Bay) so that its sustainability is assured. From an operational perspective, the challenge is to facilitate the interaction of actors in order to generate outcomes; from a policy perspective, the challenge is upon decision makers who routinely have to make decisions based on existing policies.

In general, the various actors involved in the policy and governance arena for Laguna de Bay include the resource users, spanning from the upland communities, farmers, and fisher folk to the industrial and business sectors and local government units (LGUs). In the Sta. Cruz Watershed, Nagcarlan, Liliw, Sta. Cruz, Magdalena, and Rizal comprise around 80 percent of the sub-basin area. In the policy-making and regulatory arena, the Laguna Lake Development Authority (LLDA) is the primary institution that exercises policy, regulatory, and developmental functions covering the entire lake and its watershed. The LLDA watershed interventions are along four themes—waste management, flood protection and soil erosion control, eco-tourism, biodiversity, and

inland forestry. These contribute to the overall objective of improving the environment of Laguna de Bay and its watershed (Nepomuceno 2010).

Emerging policy issues

- Based on the KIIs and LGU reports, researchers have found issues arising in relation to the subwatershed governance system. These include the following:
- Based on the delineation of watershed boundary, the Sta. Cruz Watershed does not cover the whole areas of some municipalities (e.g., portions of Majayjay and Magdalena lie within the Pagsanjan Subwatershed). This complicates the comprehensive watershed planning of LGUs.
- No explicit policies and programs at the subwatershed scale, only at the LGU level.
 - » Each LGU (municipality) has its own policies and programs on food security, e.g., Sta. Cruz and Rizal have a food security component in their Comprehensive Land Use Plans (CLUPs).
 - » Each LGU has its own policies and programs on climate change, but not expressly from a food security perspective; for instance, Nagcarlan and Rizal have mainstreamed climate change adaptation in their plans and programs.
 - » Climate change-related actions were in compliance with national policies, e.g. the Climate Change Act and the Disaster Risk Reduction and Management (DRRM) Act. These include putting up a municipal DRRM offices and installing rain gauges.
- There is limited institutional arrangement among LGUs on food security and climate change programs at the subwatershed level.
- Agriculture programs and projects focus on farmers' training and seed distribution.
- The watershed conservation program is focused on tree planting.
- Municipal ordinances usually only cover solid waste management, tree planting, and deforestation.

Watershed Level

From a watershed management perspective, resources are shared and trans-boundary impacts from upstream to downstream and from one local government unit to another are likely to happen. The sustainability of watershed resources therefore requires implementation of sustainable environment and natural resources management programs through an effective policy and governance system as articulated above.

However, the present state of the Sta. Cruz Watershed is a cause for alarm in terms of watershed sustainability. Data has shown an increase in built-up areas in the watershed between 1993 and 2014, which can be attributed to the increasing population in the different municipalities within the watershed. This continued growth in population signifies more demand for food, which is usually addressed by further expanding agricultural areas or increasing agricultural productivity and quality. It is already evident through change detection analysis that annual and perennial crops have had significantly increased in the Sta. Cruz Watershed from 1993 to 2014 (Tiburan et al. 2014). Most of the conversions into agriculture were in the forest and grassland areas. This increase in area for agricultural production may be viewed as a solution to food security issues on one hand, but on the other, it could be perceived negatively in the sense that it can exacerbate the adverse impacts of climate change.

According to the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA), the projected annual rainfall change from 2006 to 2035 using the PRECIS (Providing Regional Climates for Impact Studies) model is about -7.8

mm. The highest decrease in rainfall is expected to be observed in the months of March, April, and May (34.0 mm) and in the months of December, January, and February (21.9 mm). However, the model also projected that there will be an increase of 3.3 mm and 2.4 mm in the months of June, July, and August; and in the months of September, October, and November, respectively. In terms of mean temperature, PAGASA has projected an annual increase of approximately 1°C in the 2020s (2006-2035). This implies that further conversion of the remaining forest areas into other land cover classes will significantly aggravate the future state of the watershed (Tiburan et al. 2014). Given the current trend of land cover changes from 1993 to 2014, and with the projected annual and seasonal changes in rainfall and in mean temperature in Laguna, the Sta. Cruz Watershed may experience severe drought during the dry season. Inversely, the watershed can also experience a significantly higher amount of rainfall during the rainy season that may cause flooding in low lying areas. It is therefore recommended that a comprehensive watershed management plan for the Sta. Cruz Watershed be crafted to abate future adverse impacts of climate change and, at the same time, address issues on food security. The Integrated Water Resources Management (IWRM) approach employs integrated and holistic strategies in order to harmonize and rationalize river basin plans and programs in order to achieve manageable spatial boundaries for effective planning and river basin management. The National Integrated River Basin Management and Development Framework Plan was prepared by the River Basin Council Office (RBCO) to provide guidance for the action-oriented planning at the basin level (Tuddao, 2009). Furthermore, because future climate scenarios may affect the growth, productivity and quality of agricultural crops in the area, more climate-resistant crops should be used and appropriate adaptation strategies must be developed to mitigate the effects of climate change.

In terms of market behavior in the watershed, specifically the volume of rice handled, the levels of buying and selling prices and the profit per kilogram of rice sold are the same with or without extreme events. The number of kilograms of rice sold, however, is reduced. Root crops, fruits, chicken and pork are sold only in some barangays during extreme events. While traders of root crops and fruits obtain higher profits per kilogram, traders of chicken and pork make more or less the same profit per kilogram as the buying and selling prices of these meat products do not change with or without extreme events. Fish and shellfish are not available for sale in all the study sites during extreme events (Chupungco et al. 2014). The problems encountered by traders include limited capital, delayed payment by buyers, high prices and price fluctuations, and spoilage of agricultural commodities, especially during the rainy season. Moreover, traders' activities are adversely affected by worsening cases of flooding. Adaptation strategies of traders during extreme events include resting for two to three days, decreasing or increasing the volume of commodities handled, refraining from slaughtering pigs, and mixing frozen cuts of chicken with fresh ones.

Community Level

Table 11.1 summarizes the significant results generated by the study at the community level. The observed climate change impacts on agriculture are damage to rice, crops, fruit trees and vegetables and a decrease in yield. In the low elevation areas, where about 30-50 percent of the land area is agricultural area, damaged irrigation systems suspended planting rice for one to three seasons. Also observed was damage to infrastructure such as irrigation systems, bridges, and housing. In the higher elevation, over 70 percent

of the land is devoted to agriculture. In these communities, exposure to heavy rains throughout the year damage the vegetable farms. The yields of fruit trees were also observed to be seasonal; in some years, the yields are better than in other years.

The current adaptation options were reported as follows: extension of loans to farmers, distribution of seeds and other farm inputs to farmers, dispersal of livestock, distribution of relief goods, distribution of free medicine, and meeting the other basic needs for those affected by typhoons. The provision of livelihood programs, repair of damaged infrastructure, and creation of watershed management strategies were other steps taken to adapt to the new situation.

While there were reports of climate change impacts affecting the environment, no significant impact was found on food security. This was because farmers produced enough to cover their own consumption, the community members easily accessed alternative food sources, markets and commercial centers were accessible, LGUs and charitable organizations provided relief goods and food rationing especially in barangays in the low elevation areas, and social networks of relative and neighbors enabled the sharing of food during extreme events. These were also the factors that prevented the occurrence of food shortages in these communities.

Table 11.1. Summary of results of the food security and environment interactions under climate change, Sta. Cruz Watershed, community level, 2013-2014

Climate Change Impacts	Current Adaptation Strategies	Impact on Food Security
▪ Adverse effect on agriculture (such as damage to rice, crops, fruit trees and vegetables); decrease in yield » Agricultural lands comprise 30-50 percent of land area in low elevation barangays and over 70 percent in higher elevation barangays. » Exposure to rain throughout the year damage vegetable farms in barangays in high elevation. » Damaged irrigation systems suspended planting rice for 1-3 seasons. ▪ Damage to infrastructure (irrigation systems, bridges, housing)	▪ Loan to farmers ▪ Distribution of seeds and other farm inputs to farmers ▪ Livestock dispersal ▪ Distribution of relief goods, free medicine, and other basic goods for those affected by typhoons ▪ Livelihood programs ▪ Repair of damaged infrastructure ▪ Watershed management (flood control measures – tree planting)	▪ With the climate change impacts identified, no significant impact was found on food security because of the following: ▪ Farm produce stock for own consumption ▪ Easily accessed alternative food sources ▪ Proximity to markets/ commercial centers ▪ Relief goods/food rationing done by LGUs, NGOs and other organizations (esp. in barangays in low elevation) ▪ Food sharing by social networks (neighbors, relatives) during extreme events ▪ No experience yet on food shortage during extreme events

Farm Level

Farm household survey respondents were asked to describe the current agricultural technologies they use. The results are summarized in table 11.2.

Table 11.2. Current agricultural technologies and practices by farmers, by elevation, Sta. Cruz Subwatershed

Practices/ Technologies	Elevation		
	High	Medium	Low
Cropping Patterns	Major crops planted in the area include vegetables and perennial fruit trees like coconut, rambutan and lanzones. Vegetables are planted anytime of the year when rainfall permits; during the wet season. Lanzones and rambutan are usually planted under coconut trees.	Major crops planted in the area include rice, vegetables, fruit trees, banana and coconut. Rice is planted once a year and is followed by upland crops like corn and vegetables. Corn is also planted twice a year and is followed by cassava. Coconut areas are usually intercropped with lanzones or rambutan.	Continuous two rice crops in a year with few annual crops after the first rice crop.
Crop Varieties	Adopted modern varieties of most vegetables usually from seed companies. Traditional varieties of chayote, sweet potato, taro are also planted.	Adopted modern varieties of most vegetables usually from seed companies. Few used traditional varieties in rice and vegetables	Adopted modern early maturing high yielding rice varieties.
Livestock, Poultry, Swine	Horses are common as they are used as a means for transporting farm inputs and produce. Few raised swine and chicken. Native animals depend on locally available feeds, while exotic animals rely on commercial feeds.	Hybrid swine are commonly raised for economic purposes. Other animals raised are chicken and cattle. Except for swine, breeds of animals are commonly native. Native animals depend on locally available feeds, while exotic animals rely on commercial feeds.	Ducks are most commonly raised in the low elevation areas where alternative feed resources are available (such as snails in rice fields).
Soil Management	Inorganic fertilizers are commonly used with urea as the most common for annual and perennial crops. Ammonium sulfate, complete, and organic fertilizers are also used by few with urea (vegetables). Fertilizers were applied through broadcasting, side-dress, foliar and drill.	Same as in high elevation.	Inorganic fertilizers are commonly used. Urea, ammonium sulfate, and complete are the most commonly used fertilizers. Few apply organic fertilizers. Fertilizers were applied through broadcasting.
Pest Management: Insects, Weeds, Diseases, other pests	Cultural Rotational cropping is one of the approaches to manage pests	Cultural Same as in high elevation	N/A

ADDRESSING IMPACTS OF FOOD SECURITY AND ENVIRONMENT INTERACTIONS

	Insect pest management ▪ Spraying of insecticides ▪ Occasional removal of infested plant or plant parts ▪ Coconut Scale Insect (CSI) - mixture of dishwashing liquid, coconut oil and water is spray on the underside of leaves	Insect pest management ▪ Spraying of insecticides (on vegetables) ▪ Occasional removal of infested plant or plant parts ▪ Stem borers and green leafhoppers insecticides ▪ Black bug - light trapping ▪ CSI and lanzones scale insect-concoction of dishwashing liquid/ soap and coconut oil/ vegetable oil in water. ▪ CSI- trunk injection (recommended by the LGU)	Insect pest management ▪ Spraying of commonly-used insecticides like Deltamethrin, Carbofuran, and Lambacyhalothin ▪ Black bug – insecticides and light trap ▪ Rice stem borer – insecticides ▪ CSI- pruning of leaves
	Weed management ▪ hand weeding/ manual weeding ▪ Herbicide application ▪ glyphosate and paraquat are commonly used as directed post emergence sprays to control weeds prior to planting or against weeds in-between crop rows	Weed management ▪ Hand weeding/ manual weeding ▪ Water management and herbicide application ▪ Glyphosate and paraquat are commonly used as directed post-emergence sprays to control weeds prior to planting or against weeds in-between crop rows.	Weeds management ▪ Hand weeding/ manual weeding ▪ Herbicide application ▪ Butachlor, 2,4-D, butachlor + 2,4-D, or Metsulfuron-Methyl+ Chlorimuron-Ethylapplied pre-emergence or early post-emergence
	Disease management ▪ Application of fungicides ▪ Occasional removal of infested plant or plant parts (roguing) ▪ Tungro infestation is being controlled with roguing or removal of plant parts/the plant	Disease management ▪ Application of fungicides ▪ Occasional removal of infested plant or plant parts (roguing) ▪ Bacterial leaf blight, sheath blight, rice blast, and bacterial leaf blight - managed through chemical treatment.	Disease management ▪ Application of fungicides ▪ Occasional removal of infested plant or plant parts (roguing) ▪ Tungro - insecticide treatments ▪ Bacterial leaf blight -Spraying Funguran-OH
	Mollusk management Golden snail is controlled by hand picking	Mollusk management Golden apple snail-chemical control (Molluscides)	Mollusk management Golden snail is controlled by: ▪ handpicking ▪ duck grazing ▪ chemical treatment (Niclosamide)
	N/A	Rodent management ▪ Baiting with acute poison	Rodent management ▪ Trapping or physically destroying burrows ▪ Baiting with acute poison like zinc phosphide or with anticoagulant like coumatetralyl ▪ Flame throwing
Water Management: Groundwater, Surface Water	N/A	During typhoon season- opening and closing of flood gates	Use of shallow tube well during dry season

Cropping Patterns

The major crops planted in the high elevation areas include vegetables and perennial fruit trees like coconut, rambutan, and lanzones. Vegetables were planted at anytime of the year when rainfall permits; during the wet season. Lanzones and rambutan were usually planted under coconut trees. In the medium elevation areas, the crops planted include rice, vegetables, fruit trees, banana and coconut. Rice was planted once a year and is followed by upland crops like corn and vegetables. Corn was planted twice a year; and cassava is usually planted after the second corn cropping. Coconut areas were usually intercropped with lanzones or rambutan. In the low elevation areas, continuous two rice crops in a year with few annual crops after the first rice crop was practiced.

Crop Varieties

In the high elevation areas, modern varieties of most vegetables, usually made available by seed companies, were grown. Traditional varieties of chayote, sweet potato, taro were also planted. In the medium elevation areas, modern varieties of most vegetables are also grown. Few farmers planted traditional varieties in rice and vegetables. In the lowlands, modern, early maturing high yielding rice varieties were planted.

Livestock, Poultry, Swine

Horses are commonly raised in the high elevation areas as they are used as a means of transporting farm inputs and produce by residents. Few of them raised swine and chicken. Native animals such as native chickens, ducks, and pigs depend on locally available feeds, while exotic animals such as the hybrids rely on commercial feeds.

In the medium elevation areas, hybrid swine are commonly raised for economic purposes. Other animals raised are chicken and cattle. Except for swine, the animals are commonly native. Native animals depend on locally available feeds, while exotic animals rely on commercial feeds.

In the low elevation areas, ducks are most commonly raised as alternative feed resources are available (such as snails in rice fields).

Soil Management

For soil management, inorganic fertilizers are popularly used in all elevations. Organic fertilization is practiced by a few farmers in the low elevation areas. The practice of lowland farmers with using organic fertilizers could be due to the trainings conducted by the Department of Agriculture. In the high elevation areas, however, farmers usually mix organic fertilizers, (which is an indigenous practice for them) and use urea for their vegetables.

Pest Management

The various pests reported by farmers in the three areas are insects, weeds, diseases, mollusks (such as golden snails) and rodents (except in the high elevation areas). Coconut scale insects are observed to be prevalent in the study areas. Across the three elevations, different strategies are used to control these pests. In general, high elevation farming is not as dependent on chemical control as farming in low elevation. The reasons for this could be the easy access to these chemicals by lowland farmers and the inability of upland farmers to acquire such inputs.

Water Management

Water management is not applicable in high elevation areas; irrigation control valves are located in the medium elevation areas and are used to manage the flow of irrigation

water. In the low elevation areas, shallow tube wells are used during the dry season to complement irrigation water.

Household Level

As reported in Sumalde et al. (2014), households reported several climate change effects, and they are as follows: (a) some households were heavily affected by extreme events in terms of damage to sources of income, logistics, and assets or properties, thereby directly affecting their access to food; (b) households who are engaged in agriculture suffered more due to the impact of typhoons; (c) households in the high elevation areas are more prone to damage by typhoons compared to those in the lower elevation areas due to damage to crops, including high value vegetables and rice, but they are also the ones who can easily recover from typhoon damage since they can plant the crops again; (d) households in the high elevation areas are also the households with the lowest value of coping strategies to an extreme event; (e) households in the low elevation areas, though prone to flooding that results in higher work-loss days and, consequently, forgone income, had smaller damage; and (f) although households have longer recovery periods, this was due to damaged properties and household appliances rather than damages to crops (table 11.3)

Households' adaptation strategies, as reported in the survey, include (Quilloy et al. 2014): (a) availing of agricultural insurance and seeking assistance or support; (b) using savings, in the form of either money or food reserves; (c) borrowing money or purchasing food on credit; (d) substituting normally consumed food with less expensive food; (e) rationing or lessening food intake; and (f) producing food for home consumption.

Most of the households employed an average of only one to two coping strategies, an indication that the majority of them do not suffer from serious, long-term food insecurity. About 20 percent of the households did not employ any coping strategy for food security, implying that these households were not suffering from any food stress. The practice of producing their own food and using their savings indicate a relatively less severe food shortage. Meanwhile, borrowing money or purchasing food on credit, substituting preferred food with cheaper food, and lessening food intake denote a more severe problem of food shortage.

Area elevation and farms as a source of food and income were found to have a significant effect on a household's likelihood for adopting food security coping strategies. In this case, farming households in the high elevation carried out less severe forms of coping strategies while the more severe forms of coping strategies were carried out by households that had higher market dependence for food and a sole dependence on non-farm incomes, as illustrated by respondents who borrowed money to buy food or purchased food on credit. Knowledge about food vulnerability and education on food security is also a factor that leads to the adoption of coping strategies, particularly the rationing or lessening of food intake.

The significant determinants that could increase (or decrease) the likelihood of becoming "food vulnerable" during extreme events are the following: how soon information or warning was provided before an extreme event; the elevation of barangay; household income; tenurial status; number of commodities planted or raised (crop diversification); variety of income sources (income diversification); access to assistance before, during or after extreme events; distance from the market; and number of coping strategies employed by households against extreme events. Analysis also showed that those living in the lower elevations did not consider food security as a problem, and

were less likely to become food vulnerable when there is an extreme event. They are the ones who are more likely to be food secure. The combination of coping strategies suggests that households experience different levels of severity of food insecurity.

Research has revealed that most of the coping strategies for food security are carried out on the household level. As stated by Predo, Dargantes, and Francisco (2010), “it is intriguing that the most preferred options involve individual household responses rather than requiring community cooperation (as would be the case with broader strategies or major defensive engineering works).” Insomuch as this has been the case, community-level responses do exist as evidenced by the establishment of relief shelters and the distribution of relief goods in times of calamity. Affected households thus take advantage of these provisions and stay in relocation centers during extreme events. There is a perception among respondents, however, that climate event impacts are short-lived and that life will return to normal; relief and relocation are therefore temporary and the household is expected to cope on its own after such events.

Upland households who engage in agriculture suffered more on the average from the typhoons. These households are more prone to bear a greater share of the damage because of the damage to crops, including high value vegetables and rice, compared to those in the lower elevation.

Households located in the lowland suffered from floods caused by the typhoons, this rendered them unable to report for work, which resulted in forgone earnings.

Households in the upland had the lowest cost for implementing coping strategies. They were also the ones who could easily recover from typhoon damage since they could plant the crops again.

Households at the low elevation, meanwhile, suffered relatively smaller damage on average, even if they had higher work-loss days due to the flood. However, they also had the longest recovery period due to damaged properties and household appliances. Based on the aggregate values, however, total damage in the lowland areas is higher due to the number of population affected by the calamity.

One striking reality is the huge difference between the values of damages due to typhoons, amounting to PHP 43,459,715, and the cost or value of coping or adaptation strategies, which amounted to PHP 8,760,106. This may have been due to the autonomous nature of the coping strategies which is a reflection of their low adaptation capability. It may also be because households are used to relying on relief assistance by the local government units and non-governmental organizations during calamities.

Table 11.3. Summary of results of the food security and environment interactions under climate change, Sta. Cruz watershed, household level, 2013-2014

Climate Change Impacts	Current Adaptation Strategies	Impact on Food Security
- Households heavily affected by extreme events in terms of source of income, logistics, and assets or properties, which all have direct effect on access of households to food. - Those in the upland who were engaged in agriculture suffered more due to typhoon. - Households in the high elevation areas were more prone to have greater share of the damage brought about by typhoon compared to those in the lower elevation due to the damage to crops including high value vegetables and rice but they are the ones who can easily recover from typhoon since they can plant the crops again. - The households in the high elevation are also the households with lowest value of coping strategies to extreme events, which are purely autonomous in nature. - The households at the low elevation, though suffering from flooding resulting in higher work lossdays had smaller damage, which is due to foregone income. - Although they have longer recovery period, this was due to damaged properties and household appliances.	- All coping strategies were perceived to be effective, except for market- and institution-based coping strategies—availing of agricultural insurance and seeking assistance or support. - Most of the households employed an average of only one to two coping strategies, an indication that the majority of them did not suffer from long-term serious food insecurity. - About 20 percent of the households did not employ any coping strategy for food security, implying that these households were not suffering from any food stress. - The most common coping strategies were the use of savings, which is either monetary savings or food reserves; borrowing money or purchasing food on credit; substitution of preferred food with less expensive food; rationing or lessening food intake; and producing own food for home consumption. - Households adopting production of own food and use of savings as coping strategies indicate a relatively less severe food shortage while borrowing money or purchasing food on credit, substitution of preferred food with cheaper food, and lessening food intake denote more severe problem. - The less severe form of coping strategies, elevation and having farms as a source of income and food were found to have significant effects on the likelihood to adopt the strategies while more severe form of coping strategies, elevation and food vulnerability during extreme events were the common significant factors. - Market dependence, sole dependence on non-farm income, and knowledge on food security were also found significant for the “borrowing money or purchasing food on credit” as well as education for the coping strategy “consume less quantity of food.”	- The probability of becoming food vulnerable during an extreme event appeared that majority of households are more likely to fall or stay below food security threshold when affected. - The significant determinants that could increase (or decrease) likelihood of becoming food vulnerable during extreme event were the number of hours of getting information or warning before the arrival of a calamity, elevation of barangay where the household lives, household income, tenurial status of the land tilled by farm household, number of commodities planted or raised (crop diversification), number of income sources (income diversification), access to assistance before, during or after extreme event, distance from the market, and number of coping strategies employed by households against extreme event. - Analysis showed that those living in lower elevations, do not consider food security as a problem, and are less likely to become food vulnerable when there is an extreme event are the ones who are more likely to be food secure. - The combination of the coping strategies suggests that households have different levels of severity of food insecurity problems.

CONCLUSIONS

Households in the uplands were characterized as both subsistent and commercial in nature; they did not feel that they were food insecure despite suffering from climate change and its hazards because they produced their own food. Households in the lowlands were more vulnerable. But the food market still worked properly even during calamities. They also had savings or they could take out loans to buy food. Farmers also had crop insurance that minimized their losses during these extreme events. Communities felt that food security was attained even during extreme events because of the good performance of the markets. Overall, this study has shown that if markets work, then food security will still be attained.

Results also showed that areas allotted to annual and perennial crops had significantly increased from 1993 to 2014. Most of the conversions into these land cover classes were from forest and grassland areas. This increase in area for agricultural production may be viewed as a solution to food security issues. But from another perspective, one may perceive it negatively as one that can exacerbate the adverse impacts of climate change. Technological interventions, especially sustainable upland agricultural technologies for soil and water conservation, can address productivity and sustainability issues.

This study's results reveal that, because of the absence of a comprehensive watershed plan in terms of land cover and land use, flooding and other environmental problems are being experienced by communities and households. There are differential sensitivities among the three elevations of the watershed, with the lowlands being the most affected by exposure to the climate hazards. Balancing the positive and negative trade-offs of changes in land use between food security and environmental integrity during climate change should be recognized by our policy makers.

Policy recommendations include the passage of the Land Use Act at the national level, the development of a comprehensive watershed level land use plan that will harmonize the land use plans contained within the watershed, the promotion of climate resilient municipal agricultural development plans and more education campaigns at the barangay level on the use of sustainable agricultural technologies by farmers.

TECHNOLOGY AND POLICY RECOMMENDATIONS

This section will discuss the technology adaptation strategies and policy recommendations that can be pursued by concerned stakeholders at the watershed, community and household levels. Such strategies are necessary in order to sustain food security in more vulnerable environments that are affected by climate hazards.

Technology Adaptation Recommendations

There are available long-term climate change adaptation technologies for the agricultural sector that have been piloted in some areas of the Philippines and have been found to be effective. These include the diversification in production and consumption, the breeding of crop varieties that are adaptable to abiotic stresses (flooding, drought, saline condition), and water-saving technologies (Bouman, Lampayan, and Toung 2007).

As discussed in the previous section, the study participants felt that they were not food insecure despite the occurrence of extreme events (see also García et al. 2014; Bariuan et al. 2014; Vega et al. 2014; Villano et al. 2014). However, agricultural

productivity did decline when extreme events occurred. In most cases, the higher and medium elevations had the same recommended technology options that were distinctly different from the low elevation areas (table 11.4).

Table 11.4 Recommended technology adaptation strategies within the watershed, by elevation, Sta. Cruz watershed

Practices/Technologies	Elevation		
	High	Medium	Low
Cropping Patterns	- Since rainfall pattern has not changed though the amount has increased, the same cropping pattern could be followed but select varieties that are resilient to the climate hazards - Promotion of agroforestry systems including windbreaks - Integration of climate resilient crop species	- Since rainfall pattern has not changed though the amount has increased, the same cropping pattern could be followed but select varieties that are resilient to the climate hazards - Promotion of agroforestry systems including windbreaks - Integration of climate resilient crop species	Since rainfall pattern has not increased, the same cropping pattern could be followed but select rice varieties that are short duration and tolerant to submergence
Crop Varieties	Use of climate change resilient varieties	Use of climate change resilient varieties (e.g. submergence tolerant rice on frequently flooded areas)	Use of climate change resilient varieties (e.g. submergence tolerant rice on frequently flooded areas)
Livestock Poultry Swine	- Raising hybrid crosses of pigs and chickens developed by crossbreeding exotic breed with commercial breed - Strategic feed management calendar for the livestock	- Raising hybrid crosses of pigs and chickens developed by crossbreeding exotic breed with commercial breed - Strategic feed management calendar for the livestock	- Raising hybrid crosses of pigs and chickens developed by crossbreeding exotic breed with commercial breed - Strategic feed management calendar for the livestock
Soil Management	- Building up of soil organic matter to reduce soil erodibility, and increase soil fertility - Establishment of soil and water conservation measures to reduce soil erosion including modification of the existing Gliricidia trellis system to follow the contour of the land	- Building up of soil organic matter to reduce soil erodibility, and increase soil fertility - Establishment of soil and water conservation measures to reduce soil erosion including modification of the existing Gliricidia trellis system to follow the contour of the land	Building up of soil organic matter to increase soil fertility

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Pest Management Insects Weeds Diseases	▪ Use of pest resistant crop varieties ▪ Management of pervasive pests ▪ Introduction of appropriate varieties of crops ▪ Diversification of crop species ▪ Crop rotation for upland annual crops	▪ Information dissemination on pest and pesticide management ▪ Use of pest resistant crop varieties ▪ Management of pervasive pests ▪ Diversification of crop species ▪ Crop rotation for upland annual crops	▪ Information dissemination on pest and pesticide management ▪ Use of pest resistant varieties ▪ Management of pervasive pests
Water Management Groundwater Surface Water	▪ Promote soil and water conservation measures ▪ Promote alternative water management technologies such as rainwater harvesting; Runoff impoundment ponds such as the small farm reservoir (SFR) and small water impoundment (SWIP); ▪ Monitor and maintain irrigation systems: check dams along gullies/ tributaries of streams; gully check dams and plugs; runoff diversion ditch; hillside ditch; grass waterways; stone ditches and walls; ▪ Stream bank stabilization (e.g., use of “gabions”) ▪ Implementation of artificial recharge pits ▪ Increase efficiency of existing irrigation systems ▪ Implementation of landslide control measures, e.g., ripraps or gabions	▪ Promote soil and water conservation measures ▪ Promote alternative water management technologies such as rainwater harvesting; Runoff impoundment ponds such as the small farm reservoir (SFR) and small Water Impoundment (SWIP); ▪ Monitor and maintain irrigation systems: check dams along gullies/ tributaries of streams; gully check dams and plugs; runoff diversion ditch; hillside ditch; grass waterways; stone ditches and walls; ▪ Stream bank stabilization (e.g., use of “gabions”) ▪ Implementation of artificial recharge pits ▪ Increase efficiency of existing irrigation systems ▪ Implementation of landslide control measures, e.g., ripraps or gabions	▪ Installation of more shallow tube wells (STW) to farms at the tail-end of the SCRIS and BRIS which frequently experience irrigation water shortages during the dry season cropping. ▪ Promotion of water conservation technologies (e.g., alternate wetting and drying technology for lowland rice).

Cropping Patterns and Crop Varieties

Since rainfall patterns have not changed, farmers in all elevations can continue with their current cropping patterns. However, amount of rainfall has increased so farmers need to select crop varieties that are resilient to the climate hazards that more rain brings. In the medium and high elevation areas the promotion of agroforestry systems, including windbreaks, is advisable. The integration of climate resilient crop species in the cropping pattern will be ideal. For low elevation areas, farmers are advised to select rice varieties that have a shorter harvest time and are tolerant to submergence.

Livestock, poultry and swine

In all areas across the watershed, it is recommended that farmers raise pig and chicken hybrids—crosses of exotic and commercial breeds. Farmers are also recommended to use a strategic feed management calendar for the livestock.

Soil Management

In the high and medium elevations, it is necessary to build up soil organic matter to reduce soil erodibility and increase soil fertility. In addition, farmers can also establish soil and water conservation measures to reduce soil erosion, including the modification of the existing Gliricidia trellis system to follow the contour of the land. In the low elevation areas, building up of soil organic matter to increase soil fertility is also recommended.

Pest Management: Insects, Weeds, Diseases

For high elevation areas, the use of pest resistant crop varieties is recommended. Increasing the endurance of upland annual crops can be achieved by the management of pervasive pests, introduction of appropriate varieties of crops, diversification of crop species, and crop rotation. At the medium elevation, farmers may need information on pest and pesticide management; further recommendations for safeguarding harvests include the use of pest resistant crop varieties, management of pervasive pests, diversification of crop species and crop rotation. At the low elevation areas, information dissemination on pest and pesticide management is also needed; the use of pest resistant crop varieties and the management of pervasive pests are recommended as well.

Water Management: Groundwater and Surface Water

Conserving water resources can be accomplished in the high and medium elevations through the following measures: promote alternative water management technologies such as rainwater harvesting; establish runoff impoundment ponds such as the small farm reservoirs (SFRs) and small water impoundments (SWIPs); monitor and maintain irrigation systems by checking dams along gullies and tributaries of streams; build gully check dams and plugs; create runoff diversion ditches, hillside ditches, grass waterways, and stone ditches and walls; stabilize the stream bank (by using gabions, for instance); implement artificial recharge pits; increase efficiency of existing irrigation systems; and implement landslide control measures (e.g., use ripraps or gabions). In the low elevation areas where rice is predominantly grown, irrigation systems can be improved by the installation of more shallow tube wells (STWs) in farms at the tail-end of the SCRIS and BRIS, which frequently experience water shortages during the dry season cropping; the promotion of water conservation technologies (e.g., alternate wetting and drying technology for lowland rice) is also highly recommended.

Policy Recommendations

The policy recommendations presented in table 11.5 focuses on ways to sustain the food security of all residents in all three levels of the watershed for the long term. These recommendations include strategic policies (Tiburan et al. 2014; Villano et al. 2014) at the watershed level, operational policies at the community level (Abrigo et al. 2014; Sumalde et al. 2014; Chupungco et al. 2014) and practical recommendations for households (Quilloy et al. 2014).

Watershed Level Strategic Policy

Having a comprehensive watershed development plan for the Sta. Cruz Watershed is one of the primary concerns that need to be addressed. Currently, the various municipalities have their own municipal development plans (CLUP), which are not consistent with the resource plans of the individual municipalities that compose the watershed. This inconsistency becomes a source of conflicts, especially when it comes to externalities due to land and water use.

A watershed development plan could contain the assignment of forest reserves, purely agricultural areas, built up areas, and other land uses that will not be harmful especially to the lowland areas that suffer from flooding and soil erosion. A watershed development plan could also identify the landslide-prone areas and can introduce activities to minimize its negative impacts on communities living in these areas. Additional components of the plan could include programs for institutional strengthening, measures for the strict implementation of regulatory policies, and other water management strategies and agricultural activities (table 11.5).

Community Level Operational Policies

At the community level, the most relevant course of action would be to enhance knowledge, education and information systems so that communities have the appropriate weather data for making agriculture-related decisions. With the help of the local governments, communities can set up weather instruments and early warning systems to aid in preparing adaptation measures for extreme events. Climate field schools can also be established for farmers so that they can learn about other climate resilient adaptation strategies (Quilloy et al. 2014). Climate field school lessons are mitigation measures that can benefit farmers and the whole community of learners. LGUs can develop climate change advisories to aid farmer decision making as well.

Also, since vegetables, rootcrops, fruits, and some fish in the study sites are sold higher during extreme events, there should be a monitoring of prices for these commodities during these events. The imposition and enforcement of price ceilings at the barangay level, and ensuring the adequacy, accessibility, affordability, and safety in consuming the agricultural products, should be given the utmost consideration by the country's government planners and policy-makers. Some traders noted that a bagsakan or trading center for agricultural commodities is a necessity in the barangay (Chupungco et al. 2014).

Practical Recommendations for Households

There are three practical recommendations being put forward by some researchers for household action: (a) promotion of sustainable home gardening of food plants like fruits and vegetables and indigenous crops, coupled with technical training on agricultural practices; (b) household agricultural production diversification; and (c) diversification of income sources to include non-climate sensitive sources (Quilloy et al. 2014, Sumalde et al. 2014).

Table 11.5. Policy recommendations, by level of analysis

Level of Analysis	Policy Recommendations
Watershed Level	
Land Cover, Land Use and Land Use Plans	• Development of a comprehensive watershed development plan for the Sta. Cruz Watershed • Protection and reforestation of declared forest reservation or protected areas (Stop forest conversion into agricultural areas) • Strict implementation of land conversion policy to stop conversion of prime agricultural lands to built-up areas • Promote and support the implementation of appropriate measures and strategies for the protection and enhancement of the watershed's capacity to nurture its water resources. • A massive educational campaign on the issue of climate change starting with the Sangguniang Pambayan and concerned units of the province then with the municipalities and barangays. The Sangguniang Pambayan could then pass needed resolutions and the Governor to issue executive orders for the adoption of policies and strategies, their institutionalization, and the provision of financial resources to strengthen the capacities of the municipalities against the impacts of climate change. • Enhancing institutional partnerships/institution-building – public-private partnership, subwatershed conference/summit • Stricter enforcement of regulatory system on development activities in the watershed • Policies to make available to the public basic information such as climate and hydrologic data gathered through the use of government funds, and for the LGUs to require private entities monitoring climate and hydrologic data in their political jurisdiction to provide them with such data. • Integrate/institutionalize climate change adaptation/DRRM planning at the watershed level and address trans-boundary impacts of climate-related risks and other disasters • Enhance institutional partnerships /institution building – public-private partnership, subwatershed conference/summit • Stricter enforcement of regulatory system on development activities in the watershed
Water Management	• Strengthening the river council, e.g., capacity building, financial autonomy for conflict management, integrated watershed management. Fast track creation of DRRM office and integrate/institutionalize climate change adaptation/DRRM planning at the watershed level and address trans-boundary impacts of climate-related risks and other disasters • Formulating/enhancing policies on soil and water governance in responding to food security and livelihoods and climate change adaptation • Support the implementation of the MBSCPL Master Plan being coordinated by the PAMB of the DENR • Policies to promote better/improved agricultural drought/flood management—cropping patterns and crop varieties suited to drought/flood conditions, early warning system • Control water quality degradation • Integrate climate change concerns in the planning, design and rehabilitation of water resources project • Improve the generation and sharing of climatic and hydrological information • Formulate/enhance policies on soil and water governance in responding to food security and livelihoods and climate change adaptation
Farming Systems and Soil Quality	• Passage of a Land Use Act which classifies the country into appropriate land uses • Economic/financial schemes for farmers to cope with impacts of climate change-related events (e.g. crop insurance system) • Policies and programs on livelihood to improve household resilience/food security • Promote sustainable agriculture • Development of climate change farm advisory for farmers to cope with the hazards
Livestock	• Enhancement and improvement of certification and feed regulatory processes by issuing process checking and unwanted residue detection

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Crop and Pest Dynamics	• Information dissemination on pest and pesticide management • Surveillance and monitoring system of pest outbreaks and emerging pests • Development of pest-tolerant crop varieties • Educate farmers on the biology of pests, mode of attack, epidemiology and population dynamics • Dissemination of proper information on pesticide nature and modes of action, and practical pesticide management procedures to farmers.
Community Level	• Institutional strengthening of LGUs to generate sources and build capacity in implementing food security and livelihood programs • Enhancing financial capability of the communities, e.g., from external sources, to enhance utilization of adaptation skills/technologies to reduce risks to agriculture • Enhancing knowledge, education, and information system for communities to realize the need for preparedness for climate hazards • Setting up weather instruments/early warning system to aid in preparedness measures in response to extreme events • Identifying relocation sites outside of the community and providing livelihood opportunities to affected households • Building social capital by strengthening linkages and communication with various sectors and local constituents to enhance adaptation • Community planning integrating climate change concerns • Identification/introduction of other staples/crops resilient to climate change • Increase cognitive ability and linguistic capacity among residents • Improve communication system within the community so climate change messages can easily be disseminated • Product development for climate change damaged crops • Promotion of soil and water conservation technologies • Strengthening of public distribution systems that offer a wide variety of cheaper food substitutes like secondary crops; • Improvement of existing food assistance programs; • Improving early warning system in the barangay and municipality; • Continuing education on the effective coping strategies to manage the impacts of disasters
Household Level	• Promotion of sustainable home gardening of food plants like fruits and vegetables and indigenous crops, coupled with technical trainings on agricultural practices; • Household agricultural production diversification; • Diversification of income sources to include non-climate sensitive sources

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ENVIRONMENT AND FOOD SECURITY INTERACTIONS AMID CLIMATE CHANGE: A MULTI-SCALE ANALYSIS IN A PHILIPPINE WATERSHED

This book analyzes the food security and environment interactions, and the corresponding community adaptation, amid climate change in the rural communities located in the Sta. Cruz watershed, Laguna, Philippines. It aims to do three things: understand how changes in climate affect the environment and the food security in the watershed as a whole and in the communities and households; identify technological strategies that may be undertaken to minimize the adverse effects of these interactions; and recommend policies towards the food security of communities within the watershed.



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