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Farmers' Adaptation to Climate Variability: Assessment of Effectiveness and Barriers Based on Local Experience in Southern Philippines

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ABSTRACT

This study assessed the effectiveness of and barriers to adaptation of upland farming households in Bukidnon Province, Southern Philippines to climate variability. Using focus group discussions, key informant interviews and household surveys combined with the analysis of climate variability in the area, the study described key adaptation strategies commonly practiced at the household and community levels in relation to crop production and income generation, domestic and farm water supply, soil conservation, health and livelihood; and assessed the effectiveness and barriers in the implementation of these strategies. There were few variations in adaptation strategies across different crops grown by farmers. While few ineffective adaptation strategies were noted, current strategies were perceived to be generally effective although some barriers exist in their implementation. Among these barriers include high cost, limited adaptation options, and difficulty in implementation. Despite the perceived effectiveness, future uncertainty is a major concern since climate variability is likely to worsen, threatening health, food and livelihood security. Planned adaptation founded on robust current and future vulnerability assessments is necessary to address the future risks associated with the changing climate. Moreover, to realize effective farmers' adaptation to future climate change impacts, the anticipated critical adaptation barriers should be successfully overcome.

Key words: *climate change adaptation, adaptation barriers, climate variability, upland farming, Philippines*

INTRODUCTION

Numerous studies assessing the adverse effects of climate change on agriculture in Southeast Asia (SEA) were conducted (*Cruz et al. 2007 and Hijioka et al. 2014*). Many of these ascertained that the abnormalities in rainfall and temperature patterns exacerbated water stress, infestations, erosion and soil degradation, hence causing significant decrease in agricultural production; and to a broader extent threatens food security (*Zhai and Zhuang 2009*).

Among the SEA countries, Philippines is perhaps the most vulnerable to climate change. From 2011 to 2013 alone, record-high damages of typhoons to agriculture were reported to at least US$ 24M (*Pulhin and Tapia 2015*). The Global Climate Risk Index for 2014 ranked it fourth among the 10 most affected countries of the world by climate-related disasters (*Kreft et al. 2015*).

The Department of Agriculture of the Philippines also reported yield loss of various crops at different growth stages that are due to climate variability (*BAS 2014*). Rice production loss due to flooding was largest at the panicle initiation and flowering stages, with up to 100% and 70% estimated losses, respectively, under seven days of floodwater submergence. The reproductive stage for corn was found most vulnerable, with 55% and 60% estimated loss if 101 to150 km h^{-1} wind velocity for <12 and ≥ 12 hours, and 80% and 80 to 100% estimated loss at >150 km h^{-1} wind velocity for <12 and ≥ 12 hours, respectively. Moreover, damage to infrastructures, farm supply routes and markets, and worse, death or injury to farm workers are likely and severe during typhoons and flooding.

El Niño Southern Oscillation (ENSO) events also pose great threat to the country's agriculture. El Niño events can be categorized into: (a) late onset of the rainy season, (b) early termination of the rainy season, (c) weak monsoon events characterized by isolated heavy rainfall events of short-duration, and (d) weak tropical cyclone activity characterized by less intense cyclones and less number of tropical cyclones occurring within Philippine territory (*Lansigan et al. 2000*). Over the recent decade, year 2010 was recorded as among the driest and most extensive in terms of impact. About 977,208 ha covering almost the whole country were observed to be under a dry spell, incurring an estimated damage of US$ 580M on agriculture (*Pulhin and Tapia 2015*). The *Asian Development Bank*

(*2009*) noted that as much as 23.4% of the agricultural production in developing world including the Philippines will be lost by 2080 if no interventions to cope with climate change impacts will be done. Such forecast implies the need for immediate climate change adaptation in order to ensure continuous and sustainable agriculture production.

Adaptation generally refers to the response of the society or ecosystems to cope with climate change impacts. Responses can be protective (preventive measures against negative impacts) and opportunistic (taking advantage of potential beneficial effects of climate change) (*EPA 2014*). However, adaptation puts forward challenging problems for vulnerable communities today. Some key questions related to the process of adaptation that need to be answered include: whether and how effective adaptations can be realized; under what conditions, and what are the costs and barriers involved (*Adger et al. 2007*). Researches on the effectiveness and limits of adaptation are critical to fully understand the potential weaknesses and strengths of interventions (*Adger et al. 2009; Barnett et al. 2015*). The concepts of barriers and limits and the need to understand them were underscored in the Intergovernmental Panel on Climate Change (IPCC) Fourth and Fifth Assessment Reports (*Adger et al. 2007; Klein et al. 2014*) as well as in other more recent literatures (*Biesbroek et al. 2013; Kassie et al. 2013; Agyei et al. 2015; Nambi et al. 2015*).

Helping provide answers to the above-mentioned questions requires the conduct of studies that will delve on spatial and temporal dimensions of climate change adaptation. Adaptation options range from those widely practiced in several geographic regions to those employed in specific localities. Since adaptation is context-specific, it is therefore important to understand the particular geographic, socioeconomic, and environmental contexts that influence the conduct and effectiveness of certain adaptation practices. Furthermore, adaptation may involve present-day practices (present adaptation) employed in response to current climate variability or in anticipation of future climate change or plans or strategies to be employed in the future (future adaptation) to reduce foreseen climate change impacts. While climate change is futuristic in its orientation, the challenge in researches is therefore not only supporting adaptation response to future climatic scenarios but also responding sufficiently to the present challenges.

Within the rural sector, upland farmers are among the most vulnerable groups to climate change impacts (*Pulhin et al. 2008*). The Philippine uplands are inhabited by more than 26 million people who are heavily dependent on rainfall for farming (*Espiritu et al. 2010*). These people are mostly with limited economic and technical resources to adapt to climate change. Others are impoverished that even the basic necessity in life such as food, shelter and clothing are hardly met. This study was therefore conducted to identify common local adaptation strategies of the upland farmers and assess their effectiveness and limits. Famers of Lantapan in Manupali Watershed in Bukidnon Province, Philippines were selected because of three important reasons: exposure to various climate variability events; agriculture is the main form of local livelihood being one of the major fruit-producing municipalities in the country; and limited study on climate variability and change since the area was traditionally noted to possess fertile soil, favorable climate, and outside the typhoon belt.

This study formed part of the "Advancing Capacity to Support Climate Change Adaptation (ACCCA) Project" involving selected countries in Asia and Africa which addressed climate risks and adaptation in an integrated, and multidisciplinary way through capacity building of the local stakeholders. In Asia, five pilot actions were implemented including the one in Philippines which involved the mainstreaming of climate change adaptation into watershed management and upland farming in Bukidnon. The study provided additional scientific basis for the capacity building activities done in all the barangays in the municipality of Lantapan and the different concerned institutions involved in the management of the Manupali watershed.

Site Description

The study site lies within the Manupali watershed in the Province of Bukidnon in Northern Mindanao, Philippines (**Figure 1**). It encompasses three municipalities namely, Valencia, Talakag and Lantapan. Geographically, the site is located between 7° 50' and 8° 09' north and 124° 48' and 125° 05' east; and bounded by the Kitanglad Mountain Ranges in the north; Barangays Mailag and Bantuanon in the east; Kalatungan Mountains in the south; and Sitios Fauralas and Teniago of the Talakag municipality in the west. Manupali Watershed is generally rugged and steep rising from 500 to 2,980 masl and covering a total area of 38,150 ha. Five sub watersheds drain the area, namely: Alanib, Tugasan, Timago, Maagnaw and Manupali River.

Manupali Watershed belongs to Type IV Climate under the Corona Classification. The long-term average annual rainfall of about 2,350 mm is almost evenly distributed throughout the year. Nevertheless, the period of heavy rainfall is evident during the months of May to September while low precipitation months are from January to March with less than 100 mm rainfall. The area does not fall within the typhoon belt region hence not frequented by typhoons. The average annual temperature is around 19.7°C with the

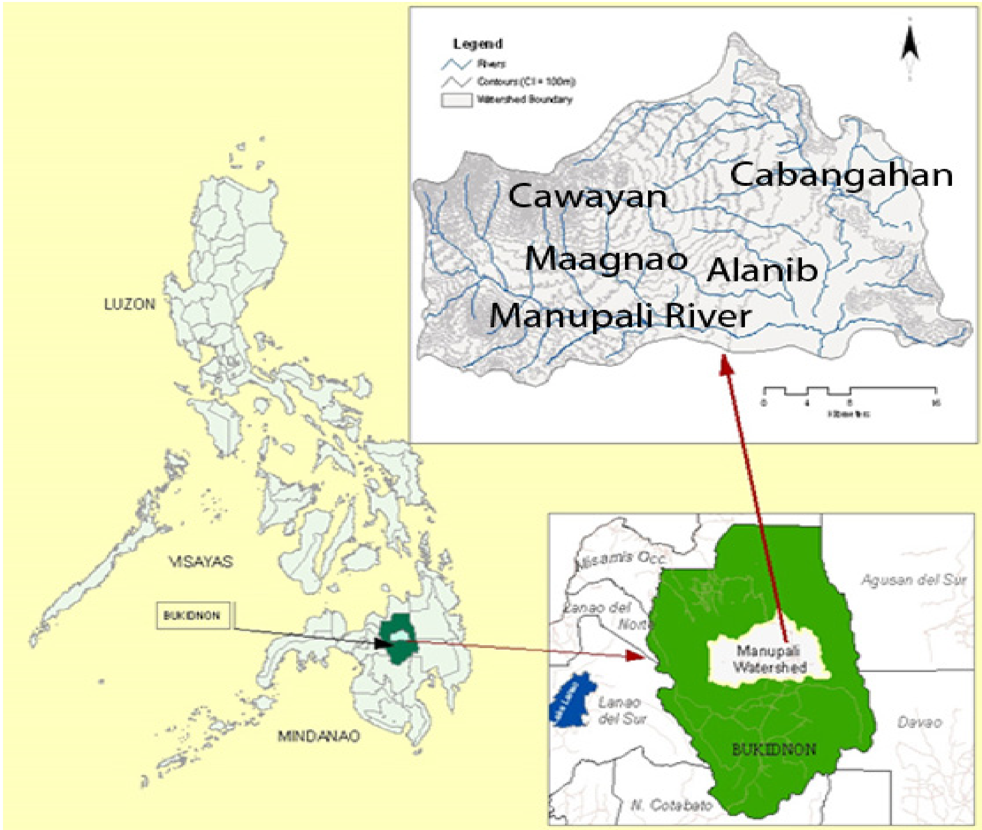

Figure 1. Location map of the Manupali Watershed, Bukidnon, Philippines.

average monthly temperature not exceeding 23°C.

The vegetation consists primarily of brushland and agricultural crops interspersed with grassland. The remaining forests are located on rugged headwaters. The hill slopes is dominated by agricultural crops mixed with some grasses, a sight typical of cultivated areas under fallow. Lantapan has a total land area of 32,970.9 ha composed of agricultural lands, forest and built-up areas (**Table 1**).

Manupali watershed is home to the Talaandig tribe who are semi-nomadic in nature, practicing shifting cultivation along the slopes of Mt. Kitanglad. Hunting and gathering serves as supplementary source of their subsistence. Migrant ethnic groups were also housed by the watershed totaling to around 53% of the entire ethnic group population, i.e. Cebuano-speaking (41%) and Igorots (12%). Migration is one of the factors that led to the increasing population in the watershed particularly in Lantapan. available records show that population is around 55,934 with 3.12% annual growth rate (*NSO 2010*).

Table 1. Land-use categories in the Municipality of Lantapan, Bukidnon.

Classification	Area (ha)	Percentage
Agricultural	17,804.3	54
Forest (Pasture, grasslands and forest lands)	12,199.2	37
Built-up areas (commercial, residential and agro-industrial)	1978.254	6
Others	989.127	3
Total	32,970.90	100

*Source: *Rola et. al. (2004)*

Farming is the primary livelihood in Lantapan (*Coxhead and Shively 2005*). Farm sizes are generally small, around 1 to 3 ha. Statistics also showed that around 90% of households in Lantapan are still dependent on smallholder farming until two companies like Mt. Kitanglad Agriventures Inc. (MKAVI) and Dole Skyland Philippines started operating their banana plantations in the area in the 1990s (*Catacutan 2007*). These companies employed 60% of the labor force of the municipality.

In the early years, corn and cassava have dominated most of the farmlands. These crops were primarily for subsistence level only with the surplus locally sold to cattle ranchers. Nowadays, the improvement of Bukidnon's economy made corn production a booming business making it the primary commercial crop in both Lantapan and Bukidnon Province.

METHODOLOGY

This study employed mixed methods in data gathering and analysis to assess the effectiveness and limits of local climate change adaptation based on the experience of upland farming households in Bukidnon Province, Southern Philippines. As explained by *Johnson et al.* (*2007*), "Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration". The methods used in this study included reconnaissance survey, focus group discussions (FGDs), key informant interviews (KIIs), household survey and regression analysis, as well as collection of secondary data and analysis of rainfall pattern. The study was conducted by a team with multi-disciplinary backgrounds on biophysical and social sciences. It built on the team's previous work on integrated assessment of climate change impacts, vulnerability and adaptation in Pantabangan-Carranglan Watershed in Northern Philippines; the major outputs of which were published as chapters in a two-volume book on climate change vulnerability *(Leary et al. 2008a*) and adaptation (*Leary et al. 2008b*).

A reconnaissance survey through farm visits was conducted to observe visible climate change impacts on the farm's biophysical condition, and some existing adaptation strategies. Farm visits were done with the help of local guides who are also farmers. Local perception of climate variability and extreme events, as well as the degree of effectiveness of the different adaptation strategies were assessed through a series of focus group discussions. These FGD activities were conducted in five barangays namely Baclayon, Balila, Bantuanon, Kibangay and Songco. These barangays were selected because they represent and produce the major agricultural crops of the municipality. FGDs helped triangulate the information gathered from the household survey as well as from the secondary data available (*Cavestro 2003*). At least 12-15 community members were invited for the discussion with equal number of male and female representing different age brackets.

To support the information obtained from FGD, key informant interviews were also done. Key informants included the Barangay Captains, Municipal Environment Natural Resource Officer (MENRO) of Lantapan, local water district officer, head of the local agriculture office and the Datu from Barangay Songco. The stakeholder' s perspectives is important in the triangulation process where the consistency of impacts and adaptation strategies from the households and community were checked in terms of the corresponding programs the local government units (LGUs) are providing to the community. This enabled the study to look on the important role of institutions in providing the needed assistance for local community's adaptation to climate-related events.

The study also conducted household interviews covering the 13 barangays of Lantapan, Bukidnon with 157 Landcare and non-Landcare farmer-respondents (**Table 2**). The interview focused on determining the effectivity of the households adaptation strategies particularly on the perceived impacts of El Niño and rainfall variability (prolonged rain) on six important aspects central to the well-being of upland farmers (*Pulhin et al. 2008*), i.e. crop yield, household income, domestic water, farm water, health and livelihood. La Niña, delay onset of rains and early onset of rains were not considered due to very low turn-out of responses in the survey. A survey questionnaire was developed and pre-tested to determine the overall impact of El Niño and rainfall variability (prolonged rains/ changing rainfall patterns) on the farmers' major agricultural crops. The adaptation strategies identified by the same set of respondents during the FGDs earlier conducted were summarized and included in this questionnaire. The adaptation strategies applied by the respondents as well as the strategies seen in the community as effective were considered in the analysis. Each strategy was rated using Likert scale of 1-5 corresponding to the degree of effectiveness such as 1 = Very Ineffective; 2 =Ineffective; 3 = Neither Effective nor Ineffective; 4 = Effective; and 5 = Very Effective. The reasons and barriers for applying the adaptation strategy were also included in the survey instrument.

Regression analysis was done to determine the factors that are significantly associated with the effectiveness of adaptation strategies. For the purpose of this study, effectiveness of an adaptation strategy is viewed as a function of the different positive reasons that encouraged farmers to adapt a certain strategy. These positive reasons

Table 2. The number of respondents interviewed in Lantapan, Bukidnon.

Barangay	Number of Respondents	%
Alanib	10	6.37
Baclayon	15	9.55
Balila	6	3.82
Bantuanon	5	3.18
Basac	6	3.82
Capitan Juan	25	15.92
Cawayan	19	12.10
Kaatuan	10	6.37
Kibangay	16	10.19
Kulasihan	6	3.82
Poblacion	5	3.18
Songco	18	11.46
Victory	16	10.19
TOTAL	157	100.00

served as the criteria used by farmers in assessing the effectiveness of the adaptation strategy which includes cost-effectiveness (the higher the positive return from the given input over costs, the more cost-effective); ease of implementation (the strategy is easily employed, absence of barriers for implementation); acceptability to local stakeholders (social acceptability, the more acceptable to greater number of stakeholders, the more effective); timeframe (the duration of realizing the positive impacts of adaptation strategy); institutional capacity (ability of the institution to appropriately implement the adaptation strategy); size of beneficiary group (more positive impacts to greater number of people the more efficient the adaptation strategy); absence of adverse impacts on other group; and environmental soundness. During the FGD, these eight criteria were further reduced to three and weights were assigned to reflect the most dominant criteria of adaptation effectiveness used by farmers. A full 100% implies that an adaptation strategy provides immediate solution to problem (40%), does not require costs or involves low costs (20%), and relevant to the farmer's situation (40%).

A list of possible determinants of adaptation effectiveness was identified based on existing literature, the initial observations from reconnaissance survey, and key informant interviews. They were assessed through household survey and FGD in terms of relevance in the context of the local socio-economic and biophysical conditions. These determinants include: gender, civil status, education, main occupation, native of the area, membership in organization, percent (%) of crops used for household consumption, farm income, household income, number of parcels owned (lots), type of land ownership, sharing agreement, area of farm land, distance of farm to house, distance of farm to market, distance of farm to road, number of livestock's, distance of house to road, distance of house to market, distance of house to municipal office, distance of house to hospital, distance of house to health services, household consumption, number of farm practices applied, information sources, loans, familiarity with Manupali Watershed, rate of awareness for climate variability, climate extremes, climate change and greenhouse, number of general coping mechanisms applied, crop yield barrier category, household income barrier category, domestic water barrier category, farm water barrier category, health barrier category, and livelihood barrier category.

Lastly, a simple climate trend analysis was done using rainfall data from years 1967 to 2012 to determine and cross-check the climatic variability and extreme events that were identified by the respondents. This information was obtained from the local meteorological station of Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA) in Malaybalay City, Bukidnon.

RESULTS AND DISCUSSION

Climate Variability and Extremes

Climate variability and extremes have long been experienced in the area. Prolonged rains (changing climatic patterns) was the dominant climatic event experienced by the farmers followed closely by El Niño. Many respondents specifically identified the December 2007 prolonged rains, which they have mistakenly referred to as La Niña (**Table 3**). Similarly, the 1982-1983 and 2006 El Niño events that brought severe drought not only in Bukidnon but also in the different parts of the country were frequently mentioned. The occurrence of abnormal volume of precipitation, change in climatic pattern or unpredictable rainfall patterns concur with the recorded precipitation in the watershed.

The climatic events experienced by Lantapan farmers coincided with the varying amount of rainfall data collected from the gauging station at the Manupali Watershed. Variation in the annual rainfall showed that rainfall pattern in the past 50 years had dramatically changed (**Figure 2**). The erratic climate variation started in the 1971 up to present. The pattern was still regular from 1960 until 1970 where the amount of rains decreases in summer time usually during April and slowly increasing to its peak in May and then gradually decreases until December. This evidence is in contrast beginning 1971, where predicting rains became too difficult for ordinary farmers. In like manner, the pattern on the onset of rains remained unpredictable to farmers. In the past, farmers were expert in foretelling the onset of rainy season but with the changing climate, even the onset of rainy season becomes unpredictable to them.

The changing climate had tremendous impacts on the cropping pattern of agricultural crops grown in the area such as sugarcane, banana and corn. A 30-year period rainfall pattern (1982-2012) was used to determine the associated impacts of change in rainfall on the cropping pattern of farmers. The selection of 1982 as a reference year was based on the observation that farmers can still

Table 3. Climate variability and extremes experienced by upland farmers in Lantapan, Bukidnon.

Climatic event	Frequency	Percentage
Rainfall variability (prolonged rain)	120	28.9
El Nino	115	27.7
Delay onset of rainy season	91	21.9
Early onset of rainy season	60	14.5
La Nina	29	7.0

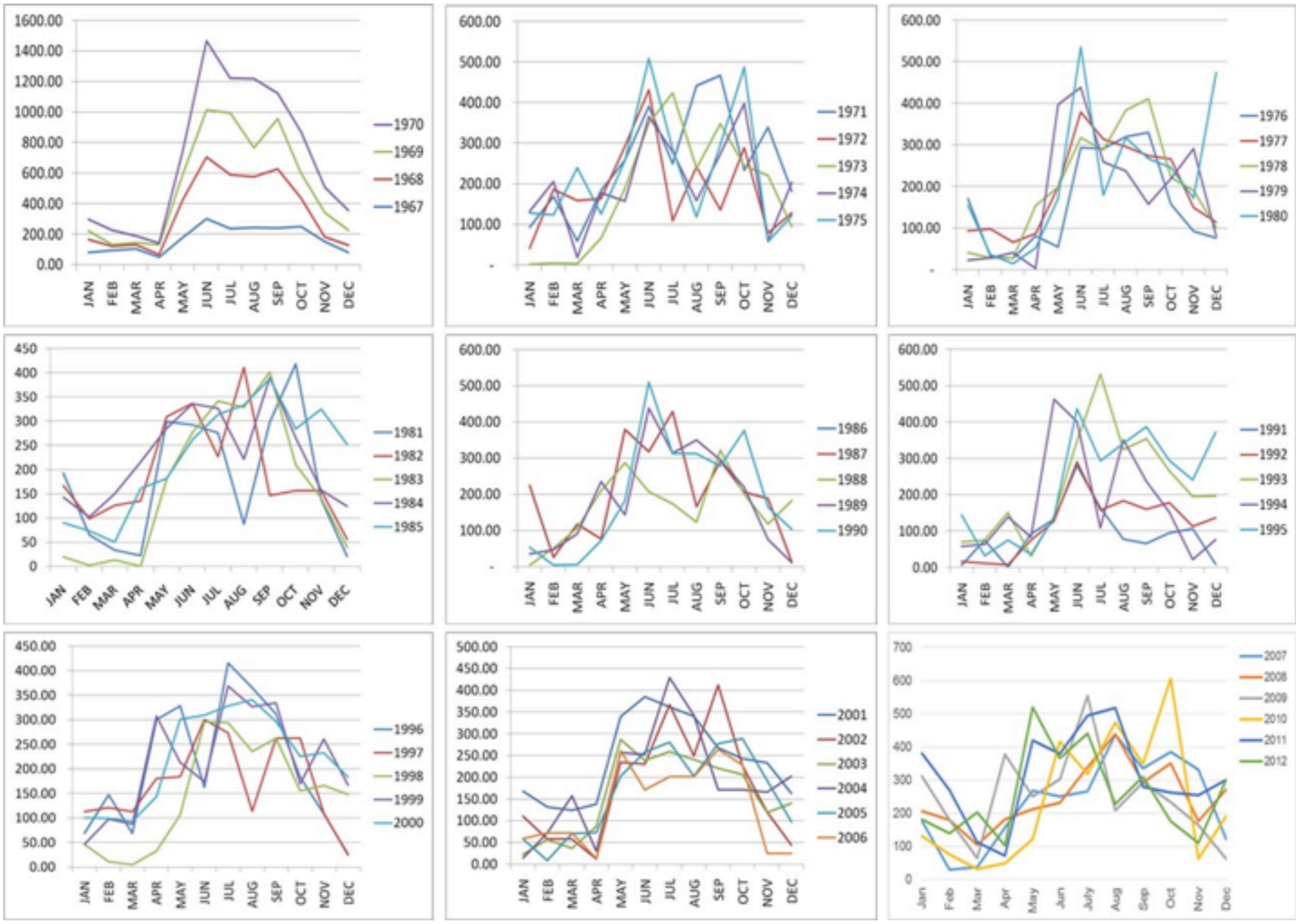

Figure 2. Variation in annual rainfall pattern (1967-2012) based on PAGASA records. (Source: PAGASA Meteorological Database 2015)

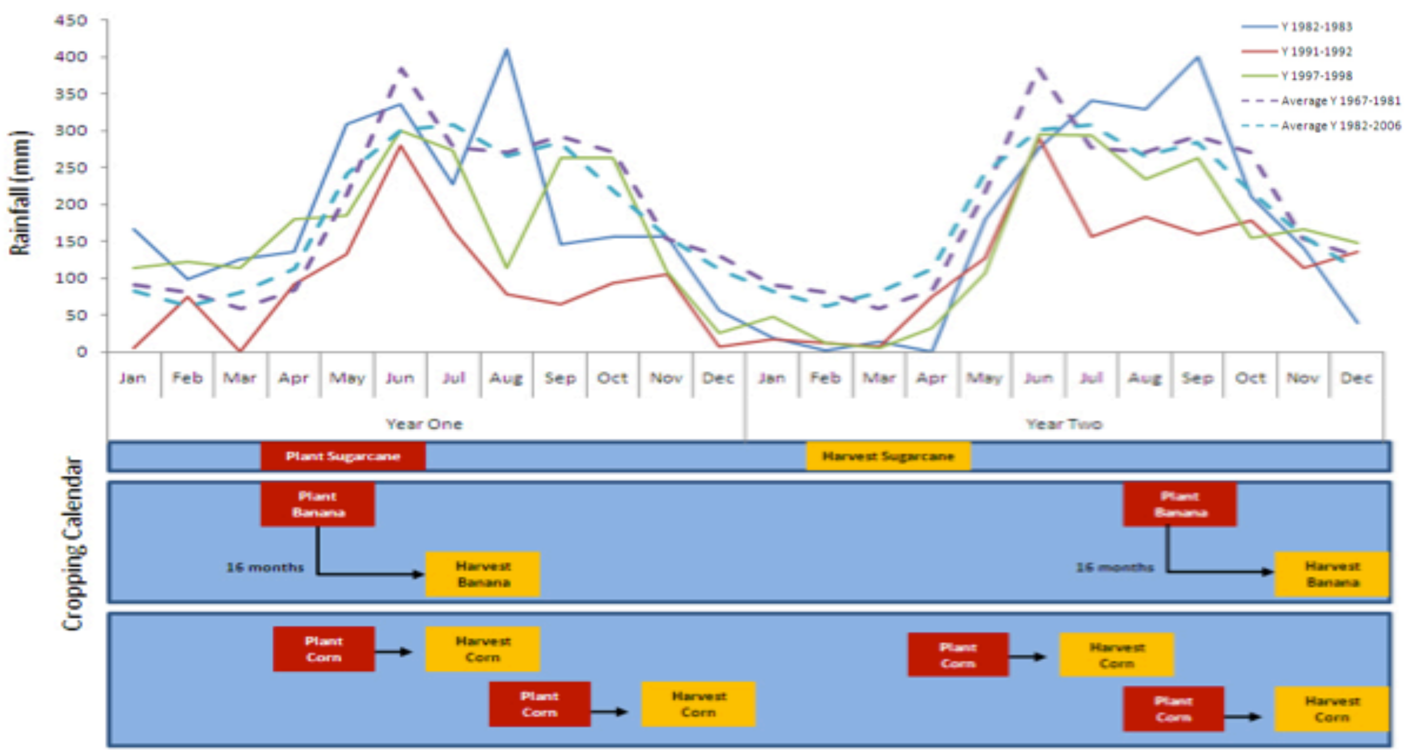

Figure 3. Rainfall patterns and cropping calendar during major El Niño events.

recall how climatic variabilities and extremes had affected their crops especially considering the 1982-1983 severe drought brought about by El Niño as a reference point. From 1982 up to 2012, the amount of rainfall had apparently declined to around 900 mm for the period of May to July. These are the specific months that are vital for producing the commercial crops such as sugarcane, banana and corn.

Figure 3 combined the average rainfall pattern per month over the last four (4) decades with the cropping calendar of banana, sugarcane and corn. This showed that farming activities are greatly affected by the amount of rains available especially during the planting season. To better understand the degree of impacts of climatic variations on the agricultural production, available statistics on rice and corn yield during the fourth quarter cropping months (September to December) were examined (**Figure 4**). The more variable rainfall had been, the greater the difference in production was observed. By estimate, corn harvest on the second quarter of 2005 has tremendously decreased by more than 30,000 mt as a result of drought. A similar story was observed during the fourth quarter of 1999 when corn harvest has dropped by more than 150,000 mt. However, the occurrence of La Niña and prolonged rain were seen to be beneficial in corn and rice production as seen in the positive differences in their harvest from 1994 to 2008.

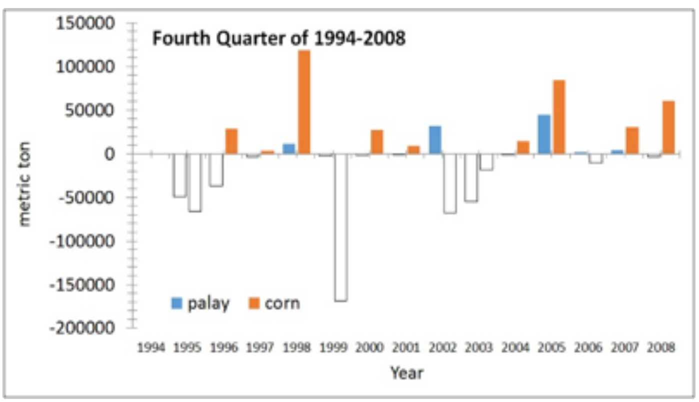

Figure 4. Difference in volume harvested for rice and corn in Bukidnon during the 2nd and 4th quarter from 1994-2009 (BAS 2010; http://countrystat.bas.gov.ph).

Variables examined

A number of variables were examined to describe the impact of climatic variability, namely: crop yield, household income, domestic water, health and livelihood. Crop yield refers to the amount of crop production in a year. Household income is the summation of income accruing from all sources coming from all working members of the family. Domestic water is an estimated amount of water used for domestic consumption such as cooking, washing and cleaning while farm water is the amount of water used for farming purposes. Health refers to diseases or health-related problems that a member of the family had during different climate phenomena. Livelihood refers to the different sources of income each family had during variable and extreme climates. The impacts of climate variability and extremes were determined in these areas.

Generally, the impacts of the different climate phenomena are negative to the upland farmers (**Table 4**). Health was viewed to be negatively affected by climatic variability and children were mentioned to be the most vulnerable. Crop yield and livelihood on the other hand, both have positive and negative effect for the early onset of rains and negative for the delayed onset of rains, prolonged rains, La Niña and El Niño. Domestic and farm water gained positive impact during early onset of rains where farmers were able to prepare ahead for their crops, thereby maximizing the amount of rains as well as the production/profit that could be derived thereof. Most adversely affected areas by climate variability and extremes are crop yield, farm water, and domestic water, respectively.

The impacts of early rain on different areas examined are both positive and negative. There are cases when early rain facilitated good crop yield thereby also increasing the income for the household but there are also instances when early rain brought bad crop yield, reducing household income. Delayed onset of rains normally brought negative impacts to all areas examined. Farmers were accustomed to planting their crops during the months of May to June; the

Table 4. Impacts of rainfall variability and El Niño to upland farmers.

Area Examined	General impacts				
	Early Rain	Delayed Rain	Prolonged Rain	La Nina	El Nino
Crop yield	+ -	-	-	-	-
Household income	+ -	-	+ -	-	+ -
Domestic water	+	-	+ -	+ -	-
Farm water	+	-	+ -	+ -	-
Health	-	-	-	-	-
Livelihood	+ -	-	-	-	-

(+) positive impact
(-) negative impact

Table 5. Adaptation strategies currently applied by farming households in different climatic events.

Area Examined	Adaptation Strategies				
	Early Rain	**Delayed Rain**	**Prolonged Rain**	**La Nina**	**El Nino**
Crop yield	1. Fertilizer and chemical application 2. Early preparation for cropping 3. Crop diversification 4. Construction of temporary drainage/canal 5. Affected but do nothing	1. Supplemental watering 2. Wait for rainy season to come 3. Fertilizer and chemical application 4. Off-farm work 5. Crop diversification 6. Praying 7. Wait for next cropping season	1. Construction of temporary drainage/canal 2. Fertilizer application 3. Crop diversification 4. Prepare for next cropping	1. Fertilizer application 2. Government assistance 3. Off-farm work	1. Off-farm work 2. Get water from other source 3. Disposal of assets 4. Credit 5. Crop diversification 6. Fertilizer application 7. Do not harvest to save expenses 8. Government assistance 9. Farming in other place 10. Praying 11. Affected but do nothing
Household income	1. Off-farm work 2. Crop diversification 3. Income from other source 4. Plant again 5. Credit 6. Affected but do nothing	1. Off-farm work 2. Income from other source 3. Credit 4. Wait for rainy season 5. Plant again 6. Alternative food 7. Affected but do nothing	1. Off-farm work 2. Reduced food consumption 3. Crop diversification 4. Kinship ties 5. Income from other source 6. Credit 7. Plant again 8. Praying 9. Fertilizer application	1. Off-farm work 2. Credit 3. Assets disposal	1. Off-farm work 2. Assets disposal 3. Reduced food consumption 4. Credit 5. Fertilizer application 6. Wait for rainy season 7. Alternative food 8. Kinship ties 9. Plant again 10. Praying 11. Change location of farming 12. Get water from other source 13. Government assistance 14. Affected but do nothing
Domestic water		1. Conserve water 2. Get water from other source	1. Repair water facilities 2. Construction temporary drainage/canal 3. Get water from other source 4. Stock rain water	1. Repair water facilities 2. Construction temporary drainage/canal 3. Get water from other source 4. Stock rain water	1. Get water from other source 2. Conserve water 3. Buy drinking water
Farm water		1. Get water from other source 2. Wait for rainy season	1. Wait for rainy season	1. Get water from other source	1. Repair water facilities 2. Get water from other source
Health	1. Commercial medicines 2. Herbal medicines 3. Go to health center 4. Do precautionary measures 5. Praying 6. Consult quack doctor	1. Commercial medicines 2. Herbal medicines 3. Go to health center 4. Do precautionary measures 5. Praying 6. Consult quack doctor	1. Commercial medicines 2. Herbal medicines 3. Go to health center 4. Do precautionary measures 5. Praying 6. Consult quack doctor	1. Commercial medicines 2. Herbal medicines 3. Go to health center 4. Do precautionary measures 5. Praying 6. Consult quack doctor	1. Commercial medicines 2. Herbal medicines 3. Go to health center 4. Do precautionary measures 5. Praying 6. Consult quack doctor

delay in its onset had big impact on the planted crops that was starting to grow. Once the growing stage was hampered by lack of water, the plants wilt and dry out, thereby losing the farmer's potential to earn.

Current Adaptation Practices

Lantapan farmers applied different strategies to negate the adverse impacts of climatic variability. **Table 5** highlights these strategies which mostly focused on crop production and income generation during the time of El Niño. This was followed by the strategies to augment crop yield and farm water during delayed rains, and improving household income and domestic water during prolonged rains. Through time, farmers have devised ways to augment the need for water for the crops' planting regime. Increasing crop yield also implies increase in income, thereby making them more adaptive to climate variabilities.

Effectiveness of Adaptation Practices

Despite that a number of strategies have been implemented, it does not necessarily imply that each of the strategy was effective. Each respondent was asked to rate the effectiveness of the adaptation strategies applied. Effectiveness of a strategy is a function of how it was able to increase crop yield and income or even negate adverse impact of a climatic event on the different areas examined. To assess the effectiveness of adaptation strategies applied, only the two major climatic phenomenon were taken into account i.e. prolonged rains (changing climatic pattern) in December 2007 and El Niño (1982-1983 and 2006).The average of effectiveness scores of all the respondents was obtained for each adaptation strategy (**Table 6**). Filipinos' religious inclination is indicative of a belief system that any mishap can be changed by a strong faith in the almighty God. This is the reason why prayer was perceived as the most effective strategy used for negating adverse impacts of rainfall variability and El Niño to household income, crop yield and health. Water sourcing in other places has a score of 4.27 since water was perceived as a critical resource for farming and domestic use. Manual (carabao carriage) and diesel-powered water pump are being done to facilitate water sourcing. Asset disposal ranked third which aimed to augment crop yield, household income, and livelihood. To support the need of the family, especially for school-related expenses, livestock such as pigs and chickens were disposed even at a lower price. Off-farm work and irrigation canal construction were the least scored. Off-farm work (e.g. carpentry, vending, providing other services) aimed to compensate the income forgone from not doing farming due to extreme climatic events. Lastly, the construction of irrigation canal was done by some farmers to contribute on improving farm water distribution hence generate some income even during the event of El Niño or drought.

Motivation for adaptation to climate variability and extremes

Perception of adaptation effectiveness depends on the availability and absence of barriers for implementation

Table 5. Adaptation strategies currently applied by farming households in different climatic events. (Cont.)

Area Examined	Adaptation Strategies				
	Early Rain	Delayed Rain	Prolonged Rain	La Nina	El Nino
Livelihood	1. Farm labor in co-farmers 2. Work in other place 3. Selling of livestock 4. Mortgage farm land to plantation companies	1. Farm labor in co-farmers 2. Work in other place 3. Selling of livestock 4. Mortgage farm land to plantation companies	1. Farm labor in co-farmers 2. Look for work in other places 3. Selling of livestock 4. Mortgage farm land to plantation companies	1. Farm labor in co-farmers 2. Work in other place 3. Selling of livestock 4. Mortgage farm land to plantation companies	1. Farm labor in co-farmers 2. Work in other place 3. Selling of livestock 4. Mortgage farm land to plantation companies

Table 6. Top five effective adaptation strategies applied at the community level that cut across the areas examined based on Focus Group Discussions.

Adaptation strategies	Average Rate of Effectiveness	Areas amined
Praying	4.90	Household income (RV&EN), Crop yield (EN), Health (RV&EN)
Get water from other source	4.27	Domestic water (RV&EN), Crop yield (EN), Farm water (EN)
Asset disposal	4.22	Crop yield (EN), Household income (EN), Livelihood (RV&EN)
Off-farm work	4.19	Household income (RV&EN), Crop yield (RV&EN), Livelihood (RV&EN)
Construction of irrigation canal	4.19	Farm water (RV), Crop yield (RV), Domestic water (RV)

(**Table 7**). Farmers' avoidance of risk associated with the adaptation strategies proved to be a wise decision to make. Strategies that entail costs, though seen effective, appear not attractive, unless it will be subsidized by the government. Among small farmers, low or no cost adaptation strategy is the most important criterion. Likewise, cost and effectiveness of adaptation to agricultural production were important factors considered by farmers such as the adoption of water saving irrigation techniques (*Zoua et al. 2013*).

Prayingwasregardedtobeveryeffectiveespeciallywhen done with hard work and believing that God will find a way to save them from the problem. This strategy is well accepted since Lantapan farmers are known for being religious. FGD participants also noted that prayer is a very practical strategy since it can be done anywhere and anytime, and does not involve any costs. Similarly, water sourcing in nearby streams or creeks using pipes was viewed to be effective but labour-intensive and costly. Asset disposal wais commonly practiced since many would be interested to buy them at cheaper prices. If the farmer was in dire need of money, assets were usually disposed or pawned for a very low price. Farmers also tend to look for off-farm work than to stay in the locality because of the opportunities to earn more income than farming. Lastly, irrigation and drainage canal construction were seen effective because it prevents soil erosion and does not involve much cost, except for a fact that it is labour-intensive and time-consuming.

Overall, the perceived level of effectiveness of current adaptation strategies is generally high. This is evident in the information gathered at the household level with the top five adaptation strategies (**Table 8**). A total of 15 strategies were identified as effective, five were health-related while crop yield and income both have three, and livelihood and domestic water have two. The practice of adaptation was mainly influenced by the potential for immediate solution to the problem and low cost of adaptation strategies. Cost, non-availability and difficulty of adaptation strategies arethe major barriers.

All the strategies from each category examined underwent a stepwise regression analysis to determine the factors associated which might have influenced the use of adaptation strategies seen as effective by the households (**Table 9**). The different predictors categorized as demographic, socio-economic, geographic, climate change-related awareness, adaptation strategies and presence/ absence of barriers were considered in the analysis. Only three strategies were found to have a coefficient of determination (R^2) greater than 30%. These are off-farm work, looking for alternative food sources and getting water from other sources. These strategies are under the crop yield, household income and farm water category, respectively. All possible predictors (41 in all) were taken into consideration but the result only accounted for at most seven variables that were significantly associated with adaptation effectiveness.

Looking for off-farm work is a very effective strategy used by farmers in negating the impacts of El Niño on crop yield. The presence of barriers for farmers leads one to seek job opportunities outside farming. Off-farm work was commonly cited important in providing the needed income for the family and for his farm especially when there was scarcity in water supply that affects the overall productivity of his farm.

Household income was likewise negatively affected during El Niño, to supplement the need for cash to buy food for the family. Farmers end up looking for alternative food sources such as sweet potato, corn and banana instead of the staple rice. The variables that influenced the application of this strategy were: availability of planting materials, accessibility to road system and municipal office, inaccessibility of farm to house, high level of awareness on climate variability, membership in different organizations, presence of socio-cultural barriers and absence of other barriers such as loss of farm land, infertile soil, soil erosion, etc. Good road network is important to access the government assistance on food and planting

Table 7. Reasons for adapting to CV&E and the identified barriers at the community level based on focus group discussions.

Adaptation	Reasons	Barriers
Praying	Very effective, normal habit, done in combination with hard work	None, no cost involved
Get water from other source	Available in the nearby streams/ creeks, continuous supply of water especially for vegetables	Costly, labor intensive, pipes are prone to theft
Asset disposal	Depends on needs, easily disposed, easy income source	No control over price; assers sold at a very low price
Off-farm work	Additional income for the family although may be limited, no/ low cost involved	Skills dependent, limited opportunities, costly because of the need to commute if far from the house
Construction of irrigation/ drainage canal	Prevent soil erosion, conserve soil, no/ low costs involved	Laborious, time consuming, capital intensive

Table 8. Reasons, Rate of Effectiveness and Barriers of adaptation at the household level based on the household survey.

Strategy (Area examined)	Reasons	Effectiveness	Barriers
1. Take commercial medicines (health)	1 (98%)1 and 2	5 (59%)	Costs (82%)
Do precautionary measure (health)	(98%)1 and 2	4 (58%)	Complicated (45%)
2. Take herbal medicines (health)	(97%)	5 (70%)	Not available (77%)
Go to health center (health)	1 (97%)	5 (49%)	Limited (82%)
Selling of livestock (livelihood)	1 (97%)	4 (85%)	Difficult to sell at a good/competitive price (66%)
3. Construction of temporary drainage/ canal (crop yield)	1 (96%)	4 (71%)	Laborious (67%)
Praying (health)	1 (96%)	5 (53%)	Forgot to pray (11%)
4. Credit (income)	1 (96%)	4 (89%)	High interest rate (78%)
Stock water from rain (domestic water)	1 (95%)	4 (90%)	Not safe (15%)
Contour farming (crop yield)	1 (96%)	4 (82%)	Complicated (82%)
5. Prepare for next cropping (crop yield)	1 (95%)	4 (89%)	Exhausted capital (63%)
Income from other source (income)	1 (95%)	4 (89%)	Limited sources (60%)
Kinship ties (income)	1 (95%)	4 (90%)	Poor kin (38%)
Get water from other source (domestic water)	1 (95%)	4 (79%)	Laborious (39%)
Mortgage / rent farm land to plantation companies (livelihood)	1 (95%)	4 (92%)	Long duration of contract (66%)

Reasons: 1 – immediate solution; 2 – low cost; 3 – applicability; 4 – laborious
Effectiveness : 1- very ineffective; 2 – ineffective; 3 – neutral; 4 – effective; 5- very effective

Table 9. Coefficient of determination (R^2) values showing the different factors affecting effectiveness of adaptation strategies during El Niño.

Predictors	Crop Yield[1]	Household Income[2]	Farm Water[3]
Access to hospital	-0.21		
Access to road	-0.83	1.55	1.64
Access to Municipal Office		0.34	0.69
Farm access to house		-0.86	
Farm access to market			
Awareness on climate variability		6.52	2.81
Ownership of land	8.36		
Number of coping mechanisms			5.07
Organizational membership	5.87	10.83	
Financial barrier	49.75		
Socio-cultural barrier	7.04	38.65	
Technological barrier	12.9		24.04
Institutional barrier			-14.4
Other barriers		-11.9	
R Square	0.52	0.39	0.34
R	0.72	0.63	0.58
(Constant)	22.21	40.80	30.03

[1]Off-farm work; [2]Look for alternative food sources; [3]Get from other sources

materials. The Department of Agriculture is encouraging every household to plant nutritious food such as vegetables and root crops to suffice the family's need. High level of awareness of households on possible implication of variable climate (particularly rainfall) will more likely motivate them to get alternative food. Joining organizations build networks as well as advises on how to source for alternative food. Socio-cultural barriers households to add up to the equation for households look for alternative food. These factors reflect the 39% of the variation while 61% was still unaccounted indicating the presence of other equally important variables that were not included in the analysis.

Lastly, getting water from other available sources with an R^2 of 34% implies that the remaining 66% is still unexplained. During El Niño the drying farmland pressures farmers to look for nearby available water. When capital is limited, all available resources either from own household members or the farm animals such as carabao and horse are explored. To facilitate farm water collection, road accessibility, access to local government services, high level of awareness on climate variability, high number of coping mechanisms, presence of technological barriers and absence of institutional barriers, served as key determinants of effectiveness. Road accessibility made water sourcing easier for farmers. Local government units played an important role in extending assistance to farmers especially on rationing collected water to farms, due to the costs and fuel required to transport water. Thus, individual farmers complement this effort by collecting water on their own, using water buffalo to pull a carriage full of water.

High level of awareness of farmers on climate variability appeared to be an advantage in designing local adaptation options (*Maung et al. 2016*). The greater the number of adaptation strategies applied, the more likely they are able to get water for their farms. Further, if technologies serve as a hindrance to make water available, the more likely they will get water from the river manually. Finally, the regression analysis implies that the absence of institutional barriers such as water access policies facilitates water sourcing from nearby rivers.

Barriers to Adaptation

Adaptation effectiveness is also determined by the barriers that either constraints or facilitates its application. Adaptation effectiveness is a marriage of the different barriers combined with other set of factors like demographic, socioeconomic, etc. The above discussion on effectiveness also highlighted some important findings on barriers. These barriers can be categorized into: financial, socio-cultural, technological, institutional and others (*Adger et al. 2007*).

Recent study has assumed that the fewer barriers the farmer face, the better is the adaptation measure (*Nambi et al. 2015*). Findings of the study indicate, however, that to a certain extent, the presence of financial, socio-cultural and technological barriers may not necessarily limit the effectiveness of adaptation strategies. This is presumably because the farmers of Lantapan, despite the climate extremes and variability that they have experienced so far, has not yet achieved their adaptation threshold (*Adger et al. 2009*). Under present situation local farmers tend to see these barriers as a challenge to do better or change the old strategy and devise new ones that will suit the current conditions and resources available. Moreover, the absence or reduced institutional barriers, unlike those normally experienced by farmers in other developing countries, tends to facilitate a more effective implementation of adaptation strategies (*Agyei et al. 2015*).

CONCLUSIONS

Despite the global importance associated to climate change adaptation particularly in developing countries, there remains a limited understanding in assessing their effectiveness and the barriers that constrain their successful implementation especially among farming households in the upland communities of Southeast Asia. This study was therefore conducted to assess the effectiveness of and barriers to adaptation among the upland farming households in Bukidnon Province, Southern Philippines to climate variability particularly the changing rainfall pattern and strong drought brought about by El Niño event.

The study provided a glimpse on the experience of Lantapan upland farmers in addressing the impacts of climate variability on crop yield, household income, domestic water, farm water, health and livelihood, and the adaptation strategies applied on these areas. Changes in rainfall patterns have greatly affected even areas such as Bukidnon province which was traditionally noted to have fertile soil and favorable climate. It negatively affected the crop production (particularly corn), household income, water quantity and quality, health, and livelihood of the upland farmers. Majority of the farmers applied various adaptation strategies to minimize or negate these effects. In general, the farmer's choice of specific or a combination of adaptation strategies is mainly associated with the potential to provide immediate solution to the problem and the financial affordability of the adaptation option.

Perceptions of adaptation effectiveness are dependent on the availability of adaptation strategies and absence of, or limited barriers to implementation. Cost, limited availability of strategies, and difficulty in implementation were also identified as important barriers. Effectiveness of adaptation strategies are also influenced by geographic factors, knowledge on climate variability, organizational membership, and presence/absence of adaptation barriers. To certain extent, the presence of financial, socio-cultural, and technological barriers may not necessarily limit the effectiveness of current adaptation strategies not unless the adaptation threshold has been reached.

It is difficult to identify a "best bet" adaptation strategy that can cut across the different areas of concern since households have very diverse socio-economic and biophysical circumstances which affect their choice of adaptation strategies and since most of them employ adaptation strategies in bundle to increase effectiveness. Despite the perceived effectiveness of many of the current adaptation strategies, there is uncertainty as to their future value considering that climate variability is likely to worsen which threatens future health, food, and livelihood security. There is high agreement in the literature that the anticipated climate change will impose new risks outside the range of current experiences (*Adger et al. 2007; Kassie et al. 2013; IPCC 2014*). Planned adaptation founded on robust current and future vulnerability assessments is therefore necessary to address the future risks associated with the changing climate. To enable farmers to adapt to future climate change impacts, critical financial, socio-cultural, technological, and institutional barriers need to be anticipated and effectively managed.

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