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Local experiences and coping mechanisms on climate change among smallholder upland farmers in Barobbob Watershed, Nueva Vizcaya, Philippines

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ABSTRACT. This case study analyzed the local experiences and coping mechanisms among smallholder upland farmers within the Barobbob Watershed in Bayombong, Nueva Vizcaya, Philippines, amidst the impacts of climate change. In-depth key informant interviews and secondary data collection were administered to 30 smallholder upland farmers from three communities (Barangay Ipil-Cuneg, Magsaysay, and Masoc) within the watershed. Results showed that smallholder upland farmers in Barobbob Watershed are implementing various strategies to cope with local climate change variability. These coping mechanisms included establishing diversion canals and rain-based sprinklers, continuing farm experiments with fertilizers and watering devices, and contour farming. They also used shorter-cycle and drought-resistant crops instead of cultivating rice, especially during the drought season. However, smallholder upland farmers' ability to cope is affected by inadequate technical and financial support from the local government. Thus, local interventions and strategies could be extended to enhance further chances of successful climate change adaptation, particularly in agricultural activities.

Keywords: agriculture, innovations, strategies, weather variability

INTRODUCTION

Climate change is a global phenomenon that requires urgent action from all sectors of society. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) released in 2013, the globe is warming due to increasing greenhouse gases (GHG) in the atmosphere. If present trends continue beyond 2020, the leading causes of climate change would undoubtedly be attributed to human-produced GHG as opposed to natural variability. Among the most important climate change impacts include rising sea levels causing flooding events on vulnerable low-lying islands, coast, and communities (NOAA 2016; IPCC 2019a); melting of the polar ice caps (NASA 2020); changing ecosystems threatening vulnerable plants and animals to extinction (Richter *et al*. 2007; KIT 2020); heatwaves and droughts (Benzie *et al*. 2011; Miralles *et al*. 2018); torrential downpours and powerful storms (Mendelsohn *et al*. 2012; Chen *et al*. 2020); significant changes in crop productivity leading to reduced food security (Godfray 2010; IPCC 2019b); increased occurrences of pests and diseases due to rising temperatures (Lindner *et al*. 2010; Fouque & Reeder 2019); and ocean acidification affecting the food-producing potential of the oceans (Orr *et al*. 2005; Kibria 2015).

In the Philippines, climate change impacts are evident, especially in the agriculture and forestry sectors. The country experiences extreme climatic events such as severe droughts, El Niño/La Niña occurrences, changes in rainfall patterns, a rise of surface air temperature, and frequent typhoons (Resurreccion *et al*. 2008; Frame *et al*. 2020). These occurrences led to reduced food crop production in the agricultural sector, resulting in food insecurity and a decline in health and nutritional status among local people. These aggravate the existing socio-economic and ecological challenges in the country. For instance, smallholder upland farmers are further marginalized in coping with climate change because most are poor rural people who rely on fewer assets and vulnerable natural resources (Abawi *et al*. 2013; Gatzweiler & van Braun 2016).

In its 2007 report, IPCC highlighted macro-level projections and technical recommendations to the agricultural sector regarding potential mitigation and adaptation strategies towards climate change. As a result, a growing literature on the mitigation and adaptation strategies for forestry and agricultural sectors in the Philippines develops (*e.g.* Cruz *et al*. 2007; Landicho *et al*. 2014; Lasco *et al*. 2011; Malabayabas & Baconguis 2020). This paper aims to add to local literature on climate change by analyzing the local experiences and coping mechanisms of smallholder upland farmers within a watershed amidst the impacts of climate change.

While this case study captures the experiences and coping mechanisms of smallholder upland farmers residing within the Barobbob Watershed, the results obtained might solely apply to these groups of people and those living in similar conditions and/or ecosystems. Nonetheless, this study presented a set of narratives about upland farmers who live in poor socio-economic conditions within a protected watershed, which, by law, should be devoid of people.

METHODOLOGY

The site was selected as it provided a context where upland farmers dependent on forestlands for daily subsistence and livelihood survive through small-scale agricultural production despite extreme weather and climatic variability.

Location of the study

This case study was conducted within the Barobbob Watershed in Bayombong, Nueva Vizcaya, Philippines. The watershed supplies potable water and irrigation to upland and lowland farmers in the municipalities of Bayombong and Solano in Nueva Vizcaya. It is also a sub-watershed of the Magat Watershed project, declared as a forest reservation under Proclamation No. 573, s. 1969 to preserve existing forests of the public domain in Nueva Vizcaya and other provinces around the country. The watershed is located in three barangays (*i.e.*, smallest political unit in the country), namely Magsaysay, Ipil-Cuneg, and Masoc. These barangays are within the first-class municipality of Bayombong in Nueva Vizcaya (**Figure 1**). Barobbob Watershed is situated approximately between 16° 29' 29" and 16° 31' 03" North latitude and between 121° 04' 55" and 121°07' 31" East longitude, and has an elevation of 435 meters above sea level (masl) with an average discharge rate of 2,700,000 gal^{-1} day (Combalicer *et al*. 2007). As of 2016, the three barangays have a total population of 8,864, with 572 households located at Barangay Masoc, 1,300 households in Barangay Magsaysay, and 108 households in Barangay Ipil-Cuneg. The 2015 census, as cited in PhilAtlast (2016), indicated a positive growth rate in the three barangays with Barangay Ipil-Cuneg having the highest growth rate of 4.58% or an increase of 112 people from the previous population of 460 in 2010. It was followed by Barangay Masoc with 4.57%, or an increase of 565 people, from the previous population of 2,792 in 2010. Barangay Magsaysay has the lowest increase with 0.98% or additional 236 people from the previous year of 4,485 in 2010. In general, the male-female ratio is almost 1:1 of the combined populations (**Table 1**) during the study period.

Table 1. Population and household size of the study site.

Barangay	No. of household	Male	Female	Population
Masoc	572	1,432	1,367	2,799
Magsaysay	1,300	2,831	2,768	5,599
Ipil-Cuneg	108	178	288	466
Total	1,980	4,441	4,443	8,864

Sources: Province of Nueva Vizcaya website 2016; PhilAtlas 2016.

Barobbob watershed has a total land area of 868.79 ha. It includes the watershed management project of the Provincial Government of Nueva Vizcaya and the Barobbob Watershed Occupants Association, Inc. (BWOA) under a Memorandum of Agreement (MOA) (Combalicer *et al*. 2007). Other land tenures and management instruments covering the Barobbob Watershed area include the following: 1) Boy Scouts of the Philippines (BSP) – Girl Scout of the Philippines (GSP) jamboree site, 2) Certificates of Ancestral Domain Title (CADT) of the Ayangan and Kalanguya tribes, and 3) Land Grant of the Philippine Science High School (PSHS) Cagayan Valley campus. Of these tenure instruments, the Barobbob co-management agreement (*i.e.*, BWOA–MOA) occupies the largest area with 439 ha (or 48.95%), followed by the BSP/GSP jamboree site (12.49%), CADT Kalanguya Tribe (5.40%), CADT Ayangan Tribe (0.79%), and the land grant of the PSHS Cagayan Valley campus (0.62%). Open access land (*i.e.*, with no existing land tenure instrument) covers about 31.76% of the Barobbob Watershed area (**Table 2**).

Data collection

Three methods of data collection were employed namely: a) field observations; b) archival research; and c) in-depth interview. From 5–7 January 2017, a field visit was done for on-site interviews and photo-documentation of biophysical and socio-economic conditions. Secondary data on Barobbob

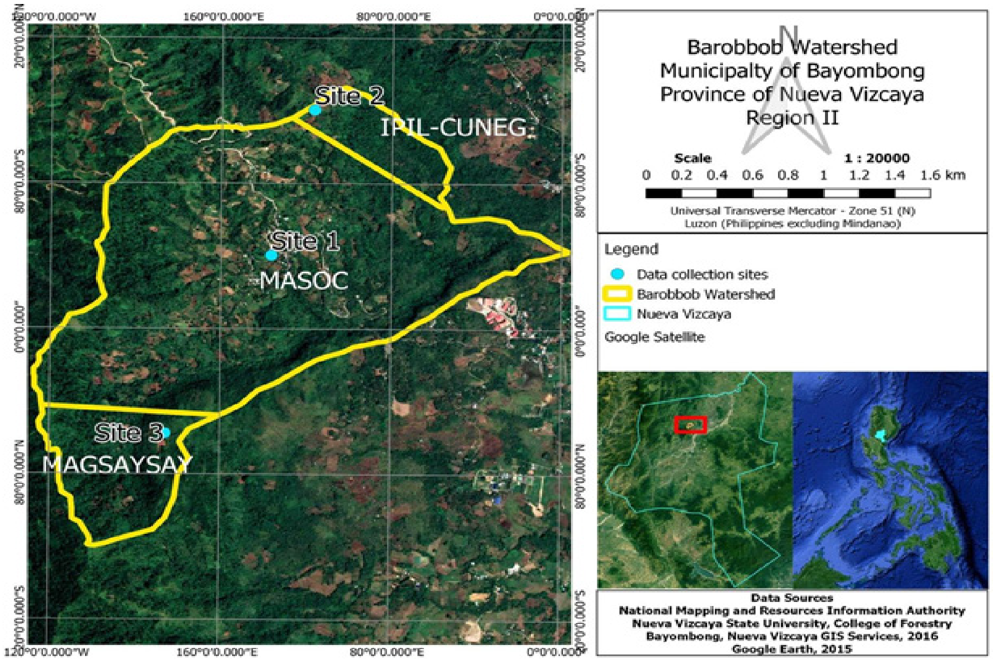

Figure 1. Location map of Barobbob Watershed, Bayombong, Nueva Vizcaya.

(Source: National Mapping and Resources Information Authority (NAMRIA); Nueva Vizcaya State University, College of Forestry Bayombong, Nueva Vizcaya GIS Services, 2016, Google Earth, 2015).

Table 2. Land tenure instruments issued within the Barobbob Watershed.

Land tenure	Area (ha)	%
BWOA-MOA	439.00	48.95
BSP/GSPJamboree site	111.97	12.49
CADT of Kalanguya Tribe	48.39	5.40
CADT of Ayangan Tribe	7.06	0.79
Land Grant of the PSHS Cagayan Valley campus	5.59	0.62
Open access	284.78	31.76
Total	896.79	100.00

Source: Nueva Vizcaya State University (NVSU) 2016.

Watershed were obtained through the assistance of the Provincial Environment Natural Resources Office (ENRO–Bayombong), Municipal Environment Natural Resources Office (MENRO), and the NVSU. These documents included the Barobbob Watershed Management Plan, the status of lots awarded through BWOA–MOA as of October 2015, population profiles of the barangays, and other research outputs conducted in the study site. Thirty participants were selected from a list of upland farmers provided by ENRO–Bayombong, based on the following criteria: 1) occupation (upland farmers with farm lots within Barobbob Watershed), 2) farm size (with less than 5 ha of farm lots), and 3) duly recognized farmers (included in the municipal government's official list of farmers).

Data analysis

Qualitative data analysis (Sutton & Austin 2015) was employed in this case study. It involved thematic analysis of smallholder upland farmers' experiences, through sharing and recounting, on the impacts of climate change on their farms in particular and locality in general. The audio recordings of these in-depth interviews were transcribed and coded into categories and themes. Emerging themes were constructed as qualitative data were summarized and categorized. Frequencies and percentage of responses were computed by analyzing word repetitions and keywords-in-context during the in-depth interviews. These emerging themes included the following: agricultural production system and practices, knowledge and understanding of climate change, effects of climate change on agricultural production, farm strategies to cope with climate change, and presence of strategic interventions on climate change. This study also used descriptive statistics such as frequency counts, percentages, and ranking.

RESULTS AND DISCUSSION

This section analyzed the emerging themes based on the local experiences and coping mechanisms of smallholder upland farmers in Barobbob Watershed. It also discussed the socio-demographic profile of the participants using descriptive statistics.

Socio-demographic characteristics of the participants

The smallholder upland farmers (n=30) as study participants provided information on age, gender, educational attainment, years of residence, household size, land ownership, farm size, and monthly income (**Table 3**). The age range was from 17 to 70 years old. Seven (23.33%) of the smallholder upland farmers belonged to the 17 – 30-year-old age group, while half (50%) were middle-aged (*i.e.*, 31 – 40-year-old age group), and eight (26.67%) were above 50 years old. Of these 30 smallholder upland farmers, 60% were male, and 40% were female.

Table 3. Socio-demographic characteristics of smallholder upland farmers.

Socio demographic characteristics	F (n=30)	%	Average
Age			
Young (17-30 yr old)	7	23.33	
Middle-age (31-50 yr old)	15	50.00	
Old (>50 yr old)	8	26.67	
Gender			
Male	18	60.00	
Female	12	40.00	
Educational attainment			
No formal schooling	4	13.33	
Elementary	4	13.33	
High school	11	36.67	
Vocational	4	13.33	
College	7	23.33	
Years of residence			
7-19	11	36.67	
20-32	13	43.33	
33 and above	6	20.00	
Household size			
Small (up to 4 members)	12	40.00	
Medium (5 – 7 members)	8	26.67	
Large (8 and more members)	10	33.33	
Land ownership (household)			
Land tenure (*i.e.*, CADT, MOA,	22	73.33	
Titled (*i.e.*, A&D)	3	10.00	
Informal settlers and tenants	5	16.67	
Farm size (in ha)			1.68 ha
0.08 – 2	24	80.00	
2.1 – 4	2	6.67	
> 4.1	4	13.33	
Monthly income (in PhP)			9,190.00
0 – 5,000	5	16.67	
5,100 – 10,000	18	60.00	
> 10,100	7	23.33	

In terms of educational attainment, 11 (36.67%) smallholder upland farmers obtained high school education and 4 (13.33%) attended elementary school. Four (13.33%) smallholder upland farmers did not receive any formal schooling, 4 (13.33%) took vocational courses, and 7 (23.33%) went to college. In terms of years of residence, almost half of the total smallholder upland farmers (43.33%) lived in the area from 20 to 32 years while 6 (20%) resides in the area for more than 33 years. In terms of farm holdings, 11 (36.67%) smallholder upland farmers lived and cultivated their farms from 7 to 19 years. Some of them (40%) have small-sized households with at most 4 members, 10 (33.33%) smallholder upland farmers have large-sized households, and 8 (26.67%) have medium-sized households.

As the Barobbob Watershed is of public domain in the uplands, these smallholder upland farmers had to secure land tenure instruments or management agreements for their farm lots to maintain occupancy (Hliang *et al*. 2013). Twenty-two smallholder upland farmers (73.33%) possessed land tenure instruments or management agreements such as the CADT and BWOA–MOA (**Table 2**). Three of them (10%) secured land titles, while 5 (16.67%) remained as tenants and farm laborers and thus, did not have rights to the lands they till. Participants who were recipients of the BWOA–MOA hailed from Barangay Masoc, while those who were CADT holders came from Barangay Ipil-Cuneg, an area adjacent to the Ayangan and Kalanguya ancestral domains. Moreover, most of the smallholder upland farmers (80%) worked on farm lots with areas ranging from 0.08 to 2 ha, while 2 (or 6.67%) cultivated farm lots with 2 to 4 ha. Four (13.33%) smallholder upland farmers tilled more than 4 ha of farm lots. In terms of income, about 60% of the smallholder upland farmers earned monthly income ranging from PhP 5,000 to 10,000, 5 (16.67%) had a monthly income of less than PhP 5,000, while 7 (23.33%) earned more than PhP 10,000 per month. All these income levels are below the poverty threshold set in the Philippines, which is PhP 10,481 based on the 2018 Food and Poverty Threshold of the Philippine Statistics Authority (PSA).

Agricultural production system and practices

In describing the agricultural production system and practices, the following themes emerged: 1) sources of water for farm irrigation, 2) crop rotation and components, and 3) off-farm livelihood sources. For these smallholder upland farmers, water was the most sought-after farm input. The availability of water in the upland dictates the planting schedule (Carig *et al*. 2016). Based on in-depth interviews, farms near the water sources benefited more from rice farming since the crop requires plenty of water. Farm lots located far from water sources relied primarily on rain to sustain farming activities. According to the participants, any delay in the rainy season or shortage of water throughout the year directly affects their farm operations.

Given this scenario, the majority of participants (90%) relied on Barobbob Watershed for irrigation. However, smallholder farmers whose farm lots are located away from the Barobbob spring have to adjust to cope with water scarcity. Some of these adjustments involved shifting to sahod-ulan or rainfed farming, use of portable polyvinyl chloride (PVC) pipes to channel water from the Barobbob watershed to their farms, and devising a water impounding system to store rainwater. While only one farmer used the water impounding system, other smallholder upland farmers noted that it is an effective mechanism in storing water for the dry season. Such water-impounding system also served as soil and water conservation as well as a flood control measure in the farm lot (**Table 4**). Although the water impounding system was an effective mechanism in extreme events such as drought, smallholder upland farmers preferred to use rainfed and PVC pipes in watering the plants because these mechanisms made water readily available and supply the right amount at a shorter distance to their farm lots.

Table 4. Agricultural production system of smallholder upland farmers in Barobbob Watershed.

Production system	F (n=30)	%
Sources of water for irrigation*		
Barobbob spring	27	90.00
Rainfed	11	36.67
PVC pipe	2	6.66
Water impounding system	1	3.33
Agricultural production system*		
Crop rotation	29	96.67
Monoculture	11	36.67
Agroforestry	6	23.33
Crop components*		
Corn	14	46.67
Rice	12	40.00
Vegetables and root crops	24	80.00

**Multiple responses*

In terms of agricultural practices, a majority (96.67%) of smallholder farmers preferred crop rotation, while the rest practiced agroforestry and favored monoculture whenever water was abundant (**Table 4**). Rice and corn were the primary crops planted in the small upland farms. Those who preferred monoculture over crop rotation maintained that the former was cost-effective as it does not require intensive farm management. Monocropping required fewer farm inputs, which cut farm expenses significantly. Moreover, the smallholder farmers pointed out that soil compaction seemed to decrease in monoculture. However, according to four smallholder farmers, these benefits of monoculture were short-termed, compared to crop rotation benefits.

Crop rotation was practiced by almost all smallholder upland farmers (96.67%) because it promoted pest resistance. Planting different crop varieties decreased pest attacks (Lamichhane *et al*. 2015), promotes soil fertility, produces more biomass, and yields more than the monoculture system (Macandog & Ocampo 2005; Nevens & Reheul 2001). According to the smallholder upland farmers, yield varied depending on the type and number of crops rotated.

Agroforestry was also practiced in the area. One of the pioneer practitioners of agroforestry in Barobbob Watershed was the BWOA president, who shared that:

> *"I have learned about agroforestry from the training, seminars, and model-site visitation I have attended. When I started planting fruit-bearing trees, like 320 rambutan, I noticed the improvement of yield and productivity of my harvest on our farm. Therefore, I started encouraging my fellow farmers to adopt this kind of practice here."*

He claimed that while he chose to plant rambutan (*Nephelium lappaceum* L.) and other fruit-bearing trees along farm boundaries, his co-farmers only grew vegetables. He mentioned that just as he learned from the seminars, practicing agroforestry created more productive and profitable farms than his co-farmers' monocropping system. He tried to convince them to practice agroforestry because of its potential economic and ecological benefits. However, some smallholder farmers noted that climate change and the ensuing water shortage made agroforestry trees less productive.

In terms of crop components, a majority (80%) of the smallholder farmers were vegetable growers. Fourteen (46.67%) were maize cultivators, while 12 (40%) were rice cultivators. Vegetable crops cultivated included Baguio beans [*Phaseolus compressus* (DC.)], monggo [*Vigna radiate* (L.) R. Wilczek], squash (*Cucurbita maxima* Duchesne), tomatoes (*Solanum lycopersicum* L.), pepper (*Capsicum frutescens* L.), pepper bell (*Capsicum annuum* L.), bitter gourd (*Momordica charantia* Linn.), cucumber (*Cucumis sativus* L.), cabbage (*Brassica oleracea* var. *capitata* Linn.), eggplant (*Solanum melongena* L.), green pepper [*Capsicum annuum* var. *longum* (DC.) Sendtn.], okra [*Abelmoschus esculentus* (Linn.) Moench.], radish [*Raphanus raphanistrum* subsp. *sativus* (L.) Domin], pechay (*Brassica rapa* L.), string beans [*Vigna unguiculata* (L.) Walpers subsp. *sesquipedalis* (L.) Verdc.], and bottle gourd [*Lagenaria siceraria* (Mol.) Standley]. On one hand, root crops included sweet potato [*Ipomea batatas* (L.) Lam.], ginger (*Zingiber officinale* Roscoe), peanut (*Arachis hypogaea* Linn.), and gabi (*Colocasia esculenta* Linn). On the other hand, there were also fruit trees grown such as cacao (*Theobroma cacao* L.), guyabano (*Annona muricata* L.), mango (*Mangifera indica* L.), jackfruit (*Artocarpus heterophyllus* Lam.), and pomelo [*Citrus maxima* (Burm.) Merr].

In terms of off-farm livelihood sources, both male and female smallholder farmers secured alternative sources of income. Male farmers took other jobs such as 1) laborer (*i.e.*, carpenter, mason, gardener, and livestock raiser); 2) tricycle driver; and security guard. For female smallholder farmers, the top three off-farm livelihood sources were: 1) laborer (gardener and livestock-raiser), 2) teacher, and 3) seamstress.

Knowledge and understanding of climate change

Definitions of climate change as provided by the smallholder upland farmers in Barobbob Watershed can be seen in **Table 5** In general, they defined climate change as the drastic change and increased uncertainties in the normal climatic pattern they had in the past. Such definition included observations of climatic variabilities during the wet and dry seasons in the area for the past 20 years (**Table 6**). During the dry season, they observed drought, shortage of water, as well as occasional rains and typhoons. During the wet season, there was drought and a lack of rain. The smallholder farmers also mentioned the unpredictable climatic patterns, and that for the past 20 years there were instances of early or delayed onset of both dry and rainy seasons.

Moreover, these smallholder upland farmers coped with climate variability during rainy or dry seasons by modifying farm practices. During the rainy season and when flooding occurs, farmers constructed diversion canals to control the flow of water into their respective fields and avert possible damages to the crops. During the dry season with high temperatures, farmers established rain burst sprinkles to provide adequate water to the crops.

The smallholder upland farmers defined climate change based on personal and communal experiences on the impacts of climate variabilities in the locality. Twelve (40%) smallholder upland farmers gained knowledge and understanding of climate change through personal field experiences, sharings from the academe and other educational institutions, and observing each other's farm activities. About one-fourth of the smallholder upland farmers claimed that they gained knowledge about climate change from the academic community. Other primary sources of climate information were radio (16.67%) and TV news (16.67%). One participant (3.33%) learned about climate change through relatives and friends.

In terms of climate change causes, the smallholder farmers referred mostly to anthropogenic causes. Majority (73.33%) attributed the causes of climate change to unregulated kaingin or shifting cultivation. They claimed that unregulated kaingin could be destructive since more carbon dioxide are released into the atmosphere, and could further degrade soil fertility and forest cover in the area. Moreover, half of the smallholder upland farmers indicated that conventional farming could also be one of the anthropogenic causes of climate change since

Table 5. Climate change definitions of smallholder upland farmers in Barobbob Watershed.

Technical definition of climate change (IPCC 2007)	Local definition of climate change (by smallholder upland farmers)
"Change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods."	"Drastic changes and uncertainties of climatic pat terns in the local climate for the past 20 years" "Changes related mostly to the state of rainfall and temperature in the area" "Changes in climate directly attributed to human activities" "Effects of climate change were observed in their farms which included infestations, low adaptability of crops, water shortage, flooding, drought, soil erosion, and delayed harvesting of crops"

Table 6. Indicators of climate change and effects on crops as defined by the smallholder upland farmers in Barobbob Watershed.

Indicators of climate change	Local impacts	Coping mechanisms
Rainy season		
• Strong and heavy raining • Frequent typhoon • Freezing temperature • Strong river current and flooding • Lack of the availability of sunlight	• Damaged crops • Decline in crop yield • Pest infestation • Soil degradation • Decrease in income	• Shifting to off-farm sources of income • Continuous farming and experimentation • Contour farming, agroforestry • Establishment of diversion canals • Conventional farming using organic fertilizers and adapting to new farming technologies
Dry season		
• High temperature • El Niño • Early-onset of dry season • Water shortage	• Damage and wilting of crops, low production • Farmers cannot plant crops especially rice • Presence of crop diseases and infestation • Soil degradation • High competition • Migration to a water source • Decrease in income	• Shifting to off-farm sources of income • Continuous farming and experimentation • Establishment of rain burst sprinkle to provide water • Increase in the application of fertilizers • Frequent watering • Temporary planting of drought-resistant crops

farm inputs were made of synthetic chemicals. A farmer explained that even though conventional farming could secure a good harvest, the overall quality of the farm lots could be affected since chemical inputs contribute to an increase in soil acidity and could be ingested by humans from eating contaminated crops or vegetables. However, smallholder farmers also claimed that they could not stop practicing this type of farming because it would lessen crop yield if they shift to organic farming, especially due to climate change.

Lastly, some (13.33%) smallholder upland farmers claimed that cutting trees also weakened the overall quality of the Barobbob watershed. Such practice degrades the forest cover of the watershed and releases carbon dioxide into the atmosphere.

Impacts of climate change on agricultural production

In analyzing the climate change impacts on agricultural production, emerging themes were examined. These themes focused on the environmental, economic, and socio-political dimensions of climate change as observed and experienced by smallholder upland farmers in their localities (**Table 7**).

Table 7. Impacts of climate change in Barobbob Watershed.

Impacts on	F (n=30)	%
Environment*		
Infestation	19	63.33
Crop damage	13	43.33
Soil degradation	4	13.33
Economy*		
Decrease in income	22	73.33
Decrease in the market value of crops	20	66.67
Market loss	6	20.00
Socio-political conditions*		
Poor farm maintenance and management	20	66.67
Feud and competition	12	40.00
Lack of institutional support and leadership	3	10.00

**Multiple responses*

In terms of environmental impacts, the smallholder upland farmers encountered increased pest infestations, diseases, and viruses in their farm crops. Pests included insects, animals such as rodents, and worms resulted in irregular and low yields. Identified plant diseases were wilting (*Erwinia* sp.), curling (*Taprina* sp.), blight (*Phytophthora* sp.), yellowing and powdery mildew (*Podosphaera* sp.), as well as rice tungro bacilliform viruses. According to almost half (43.44%) of smallholder upland farmers, these pests and diseases caused the plants to have a low resistance to extreme climate variabilities, or die from cumulative effects of these biological agents.

In terms of economic impacts, a majority (73.33%) of smallholder upland farmers noted that a decrease in household income due to impacts of climate change was the primary economic challenge. Less than 20% of respondents pointed at the delayed farm activities, especially market deliveries due to extreme weather and climate variability, to have caused negative impacts on their financial capacity. They believed that profit relied heavily on the market value of crops and farm inputs. They would suffer losses if crops were stunted or did not bear enough yields.

In terms of socio-political impacts, about 40 percent of the smallholder farmers claimed to have experienced the following climate change-related concerns: (a) health problems, (b) undue competition among farmers brought about by water scarcity, (c) migration to a place near or adjacent to a water source, (d) difficulty in budgeting household income, (e) enviousness as a negative attitude, and (f) being forced to take out loans to augment household incomes. Based on the narratives, health was affected by the unpredicted rainy season. For example, a 36-year-old female farmer from Barangay Magsaysay complained that "when farmers were caught in the rain, and then followed suddenly by extreme heat, the farmers would get sick and could not do any farming activities anymore." Moreover, both 62-year-old and 24-year-old male farmers from Barangay Masoc claimed that the intensive application of chemical fertilizers and pesticides on crops as a coping mechanism to drought and infestation would eventually affect the health of the consumers once crops are ingested.

As upland farmers in the Barobbob watershed struggled to keep up with the shifting weather patterns and climate change-induced scarcity of water resources, undue competition and tensions ensued. Such "undue competition" would be experienced during drought seasons particularly when farm lots located near the Barobbob spring access water for irrigation, while those farm lots located far from the spring would have to delay planting. According to a 53-year-old farmer from Barangay Magsaysay, "farmers do not cooperate to cope and adapt to climate change; instead, they blame and compete with each other."

Moreover, the majority of smallholder farmers (66.67%) identified low farm maintenance and management as one of the root causes of the socio-political problems in agricultural production. They believed that the lack of institutional support and leadership in the barangays, as well as the inadequate financial, institutional, and leadership support to sustain farming activities, exacerbates the already burdensome impacts of climate change. It adds to the fact that they are already losing the drive to continue farming. These factors significantly affected the decision-making processes among smallholder upland farmers, especially in sustaining farming activities. Some farmers were selling farm assets such as machines and equipment to cope.

Farm strategies to cope up with climate change

Because of the gravity of the impacts of climate change as perceived by the smallholder upland farmers, they innovated some coping mechanisms to adapt to what they defined as climate change situations. These coping mechanisms are listed in **Table 8**.

Table 8. Coping mechanisms of smallholder upland farmers in Barobbob Watershed.

Coping mechanisms of smallholder upland farmers	F (n=30)	%
Coping mechanisms		
Technical farming strategies	24	80.00
Strategic interventions from other stake holders	5	16.67
Alternative off-farm livelihood sources	1	3.33
Importance of the coping mechanisms		
Knowledge dissemination and adoption	20	66.67
Improvement and creation of innovative farm strategies	12	40.00
Endorsement of adaptive, high tolerant, and high yielding varieties crops	8	26.67
Effectiveness of the coping mechanisms		
Effective	20	66.67
Not effective	3	10.00
Not all are effective	7	23.33

Based on **Table 8**, most smallholder upland farmers could cope with climate change by implementing some technical farming strategies (80%) and participating in strategic interventions devised by other stakeholders (16.67%). In comparison, one respondent shifted to alternative off-farm livelihood sources. Farming strategies included the use of external inputs such as organic fertilizers to enhance soil fertility, shifting to or combining two different farming systems, applying innovative farming technologies (*e.g.*, rain burst sprinkler and water impounding system), and planting highly adaptive and higher-yielding crop varieties such as eggplant (*S. melongena*), tomatoes (*S. lycopersicum*), and Baguio beans (*P. compressus*). Strategic interventions included non-technical farming aspects such as increasing financial capital, availing loans and negotiating with farm input suppliers, seeking assistance from concerned agencies, participating in capacity-building activities, training and seminars, and cooperating with other upland farmers. Alternative off-farm livelihood strategies included small-scale businesses like sari-sari stores and engagement in other blue-collared jobs such as laborers, construction workers, security guards, gardeners, seamstress, livestock raisers, and tricycle drivers. In terms of the importance of these coping mechanisms, almost half of the smallholder upland farmers perceived that these mechanisms are vital because it could improve and create more innovative farm strategies.

More than half of the respondents (66.67%) confirmed the importance of coping mechanisms in further disseminating knowledge on climate change adaptation among other upland farmers. On the other hand, more than one-fourth (26.67%) of the smallholder upland farmers indicated that these coping mechanisms were important because they could identify adaptive, high tolerant, and high-yielding varieties of crops and share with co-farmers.

More than half (66.67%) of the smallholder upland farmers opined that their coping mechanisms were effective. For example, the practice of contour farming controls some minor crop damages. During the long dry season, they experienced crop damage due to drought. Even if they applied fertilizers and insecticides but with prevalent water scarcity, they have to give up a few crops with low adaptability to extreme weather and climate variability. However, close to one-fourth of the smallholder upland farmers (23.33%) indicated that not all coping mechanisms were effective. Accordingly, coping mechanisms on climate change are primarily affected by some political and socio-economic problems.

Presence of strategic interventions

Strategic interventions (technical, institutional, and educational) were limited in the area (**Table 9**). Technical interventions included agroforestry, conventional farming using organic fertilizers, and new farming technologies such as solar dyer, rain burst sprinkler, and water impounding system. Institutional interventions include the introduction of new rice varieties, distribution of seeds, and discounted farm inputs by the Department of Agriculture (DA), distribution of fruit-bearing trees by the ENRO and Ecological Park, and distribution of livestock to Indigenous People through the Modified Conditional Cash Transfer (MCCT) program of the Department of Social Welfare and Development (DSWD) or otherwise known as the 4Ps or the Pantawid Pamilyang Pilipino Program.

On the other hand, the DILG spearheaded the PAMANA program and framework or the "Payapa at Masaganang Pamayanan" to secure peace and development. It implemented development interventions in line with the Millennium Development Goals (MDG) in isolated, hard-to-reach, and conflict-affected communities. This program includes training on food processing. Also, academe such as the NVSU conducted seminars and trainings on mushroom production. It also distributed exotic and indigenous seedlings such as the small leaf mahogany [*Swietenia mahogany* (L.) Jacq.], big-leaf mahogany (S*wietenia macrophylla* King), himbabao (*Broussonetia luzonica* (Blanco) Bur.), and betel nut (*Areca catechu* L.).

Table 9. Strategic interventions in Barobbob Watershed.

Strategic interventions	Activities
Technical intervention	Agroforestry, conventional farming using organic fertilizers new farming technologies such as solar dyer, rain burst sprinkler and water impounding system
Institutional intervention	Introduction of new rice varieties, distribution of seeds and discounted farm inputs by DA, distribution of fruit-bearing trees by ENRO and Ecological Park, distribution of livestock through MCCT program of DSWD, seminars, and trainings about climate change by ENRO and DILG, training of food processing and PAMANA Program by LGU
Educational intervention	Seminars and trainings, and distribution of exotic and indigenous trees by NVSU

CONCLUSION AND RECOMMENDATIONS

Smallholder upland farmers in Barobbob Watershed were already using various strategies to cope and adapt to the changes and variability of the local climate. Their farming experiences facilitated the use of shorter cycle crop varieties to maximize the possibility of harvesting amidst decreasing rainfall conditions. They shifted to drought-tolerant crops and crop varieties instead of cultivating rice crops and crop varieties. The coping mechanisms practiced by smallholder upland farmers varied among the different barangays within the boundary of the watershed because of the biophysical environment and the socio-political conditions of the area.

The changes and variability in the local climate of Barobbob Watershed, which motivated the smallholder upland farmers to cope, had many socio-economic implications at both household and community levels. These implications included threats to food insecurity, increased water shortage, decreased income, increased competition, and conflicts over scarce resources, as well as deforestation and degradation of forests as an avenue for an alternative source of household income amidst climate change variability.

Evidence of environmental degradation through deforestation showed that these could be traced back to the unregulated kaingin and cutting of trees. These practices could also be associated with the lack of alternative sources of income apart from farm-intensive crop production livelihood activities. Findings of this case study also point to the ability of smallholder upland farmers to cope with immediate and short-term coping mechanisms despite challenges such as inadequate technical and financial support from the local government. Thus, these smallholder upland farmers hoped for the local government to extend effective interventions and strategies to enhance the climate change adaptation in their locality.

Specifically, the following recommended strategies are geared towards strengthening the adaptability of smallholder upland farmers as they might provide a framework to improve collaborative efforts. Technical strategies include a) identification and promotion of heat and drought-tolerant crop varieties; b) scaling up of sustainable land management practices to the farm level to increase agricultural production, replenish soil nutrients, moderate microclimates, and reduce pest infestations; c) implementation of integrated water resource management of Barobbob Watershed to maintain and improve the healthy functioning of the watershed; and d) combination of watershed management with climate-resilient land-use planning and climate-compatible infrastructures such as efficient irrigation systems and communal rainwater harvesting.

On the other hand, institutional strategies include: a) capacity development among local institutions to plan and adopt sustainable farming models; b) provision of access to improved seed varieties of crops that are resilient to climatic stresses; c) analysis of the water use and distribution of the watershed to design sustainable agricultural production; and, d) strengthening of the food security systems by improving crop storage and marketing facilities.

Lastly, educational strategies may include a) provision of accessible climate information to the smallholder upland farmers to help monitor and respond to climate change impacts; b) documentation of effective traditional farming knowledge and farmer-generated innovations; and c) enhancement of information and communication technologies to disseminate climate information among smallholder upland farmers.

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