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Assessment of the Adaptation Strategies of Farmers at the Mt. Isarog Watershed Area to the Impacts of Extreme Weather Conditions

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Abstract

The study evaluated the various adaptation strategies of farmers at the Mt. Isarog Watershed Area to the impacts of extreme weather conditions. Specifically, it looked into the Identification of the various climatic events that have significant impacts on three dimension of farming like crops, income and soil quality. It also identified the adaptation strategies used by farmers to the impacts of various climatic events and how such adaptation strategies affected the various farming sectors in the upland and lowland areas of the Mt. Isarog watershed. The data were gathered using focused group discussion, direct observation and interview. Results showed that climatic changes have significant and negative impacts on the three dimension of farming and vary in the upland and lowland portion of the Mt. Isarog watershed area. Crop damages resulting in loss of income are the most common effect of climate change. Adaptation strategies of farmers are mostly focused on the preservation of their crops and the use of modern and local farming technologies. Having an alternative source of income, livelihood trainings, and crop insurance are possible win-win solution to help farmers cope in moments of extreme weather condition.

Subject Areas

Agricultural Science

Keywords

Adaptation Strategies, Mt. Isarog Watershed Area, Extreme Weather Conditions, Win-Win Solution, Impacts to Farming

1. Introduction

Climate change is a global phenomenon resulting in extreme climates affecting

human lives and the environment [1]. What is certain now is that climate change is already having an adverse impact on the developing countries and the poorest communities. They are the ones most adversely affected and least able to respond to the effects of climate change and this includes the Philippines. Climate trends in the Philippines [2] include seasonal temperature change and rainfall change, extreme temperature and rainfall events. The trends of tropical cyclone occurrence/passage within the Philippine Area of Responsibility (PAR) have an average of 20 tropical cyclones per year with strong multi-decadal variability and maximum sustained winds greater than 150 kph most exhibited during El Nino years. The analysis of trends of extreme daily temperatures and extreme daily rainfall indicates a significant increase in the number of hot days and a decrease of cool nights.

Climate change is an obstacle to the sustained eradication of poverty but the future impacts on poverty can be determined through pro-poor policies and carbon dioxide emission reduction [3]. Climate change is also triggered by temperature rise and increased variability and pattern of rainfall and super typhoon events including the El Nino. Such phenomena result in a more complex pattern and unpredictable changes in temperature causing threats to the environment and the community particularly the farmers. Without proper scientific guidance, global phenomena on climate change can create confusion among farmers [4] because extreme temperature and precipitation can affect crop production because at high temperature, soils become drier and many weeds, pests, plants and even fungi thrive in extreme temperatures like warmer climate, wetter climate or increased carbon dioxide levels [5]. Likewise, climate change associated with increases in temperature, increases in CO_2, and changing patterns of rainfall may lead to a considerable decline in crop production and this poses a big challenge to farmers as they face the challenge of meeting the demands of increasing population and the threat to increasing climatic changes like drought, extreme heat, heavy rainfall and floods. There is then a need to pay more attention on conducting researches on adaptation and mitigation to climate change [6]. Insect pests become more prolific and prevalent as temperature increases intensifying the occurrence of diseases in crops and spread out in a much wider areas. Such phenomena need to be well understood by the farmers in order to help them cope with every climate change that strikes in their locality. Farmers should learn to adapt to every climatic changes in order to survive.

The impact of climate change affects the entire Philippines including the Bicol region where the Mt. Isarog is located. In this region, the provinces vulnerable to climate change are Albay, Camarines Sur and Sorsogon [7]. The region is frequently visited by typhoons, volcanic eruptions, earthquakes, flooding, drought, La Nina and El Nino phenomena. The threat to livelihood resiliency and productivity is a challenging demand for climate change adaptation. Sustainable adaptation strategies used by the different farming sectors are vital information to ensure feasible farming system and guarantee food security amidst extreme climatic conditions.

According to Stern [8], one way to remove the impact of climate change is to improve energy efficiency, to inform, to educate and to persuade people to positively respond to climate changes. There's a need to identify the barriers that hinders the process of adaptation to climate change [9]. Tropical forests preservation is an effective mitigation option against climate change [10]. In the US farmers used adaptation strategies such as the changes in crop selection, timing in field operations and use of pesticides [11]. Adaptation to climate change can be derived from a variety of factors such as the nature of the impacts on climate change, geographical areas and some adaptation interventions from the government or from non-government organizations. In the Philippines, the strategy on climate change adaptation has been formulated to prepare the farmers on the adverse effect of climate changes by collaborating with government agencies, the academe and the civil society [12]. Agricultural adaptation strategies were developed to maintain domestic agricultural production and to broaden economic growth and structural transformation. Sustaining agricultural production growth is important to achieve poverty reduction [13].

However, farmer's adaptation to climate change could vary based on multiple factors such as their beliefs on climate change, the presence of an heir, geographical location and a variety of other farm characteristics and farmer attributes and farmers' experiences [14]. Understanding how farmers perceive climate change risks and how this affects their willingness to adopt adaptation practices is likewise critical in developing an effective climate change strategy for the agricultural sector [15]. The farmer's experiences and understanding on climate change in the Mt. Isarog watershed area is worth evaluating to learn from their experiences and to look forward into possible assistance that can be provided in mitigating their issues and concerns when various climatic conditions affect their locality. In this study, the interrelationship of the impacts of climate change to the three dimensions of farming was analyzed.

Mt. Isarog is a typical volcanic cone mountain with rugged steep slopes cut by narrow gorges, rivers, streams and creeks. It is a network of interlacing streams and numerous springs and these water bodies provide potable water to 571,676 people of the 15 of the 37 municipalities and cities of Camarines Sur and irrigation water to 67,400 hectares of rice land. It is subdivided into seven (7) sub-catchments areas distributed around Mt. Isarog which are the Tinablanan sub-catchment, the Salog-Maalsom Sub-Catchment, Himaao Sub-Catchment, Rangas Sub-Catchment, Tigman Sub-Catchment, Inarihan Sub-Catchment and the Lupi Sub-Catchment [16]. From among the seven sub-catchments, only the Salog-Maalsom Sub-Catchment is covered by the study. This portion is endowed with abundant crops like abaca, coconut, root crops, rice and vegetables. It is exposed to two climatic types which are the type II and type IV. Type II prevails on the eastern part with pronounced rainy season from November to February and Type IV affects the western portion with no pronounced dry season and pronounced rainfall. Humid period starts from June and ends in January and

moist period from May to February [17]. Mt. Isarog has an elevation of 1966 meters and temperature varies with elevation having warmest at sea level (23˚C - 27˚C) and coldest at its peak (12˚C - 15˚C). Precipitation can be moderate (17 mm) to heavy (34 mm) depending on the climatic conditions occurring in the area [18].

The study area is located at a portion of the Salog-Maalsom catchment, one of the seven watershed catchment area of Mt. Isarog (**Figure 1(a)**) and it covers ten barangays of the municipality of Goa, Camarines Sur, Philippines (**Figure 1(b)**) Five of these barangays were chosen to represent the upland area which are the Abucayan, Pinaglabanan, Digdigon, Payatan and Hiwacloy and the other five represented the lower portion of Mt. Isarog which are the Cagaycay, Taytay, Halawigogon, Napawon and Salog. The coordinates and their corresponding elevation are presented in **Table 1** [19] showing the elevation and coordinates of the barangays under study where Hiwacloy has the highest elevation and Salog the lowest. Most of the crops grown in the upland area are abaca, coconuts root crops and vegetables (**Figure 1(c)**). Whereas in the lowland area, most of the farmers are engaged in rice and vegetable farming (**Figure 1(d)**).

Just like the other parts of Mt. Isarog, the study area is vulnerable to climate change such as typhoon, heavy rains, extreme heat, El Nino, La Nina, early and delay onset of rain and all of these had been experienced by the farmers in both the upper and lower Isarog. Most of the farmers in the Mt. Isarog watershed area are between the age of 34 to 82 years and that they had been in the farming industry for more than 3 decades indicating a long-term experience in farming. Their rich experience to farming includes the impacts of various climate changes and had taught them various adaptation strategies to help them survive amidst the challenges brought by the harsh impacts of climate change. Farming in the upland and lowland Isarog are still male dominated and mostly of them are tenants.

Table 1. Elevation and coordinates of barangays under study.

Barangays	Elevation	Coordinates	
		Latitude	Longitude
Hiwacloy	1140 m	13.6674402	123.404711
Payatan	308 m	13.7312375	123.382276
Digdigon	237 m	13.7202368	123.421534
Pinaglabanan	194 m	13.9687913	123.446762
Abucayan	199 m	13.6939538	123.453768
Cagaycay	97m	13.7230932	123.452367
Halawigogogn	65 m	13.7108974	123.482920
Taytay	47 m	13.6997065	123.498598
Napawon	42 m	13.723855	123.480389
Salog	36 m	13.7365502	123.474857

Source: Map, *i.e.* Google Maps.

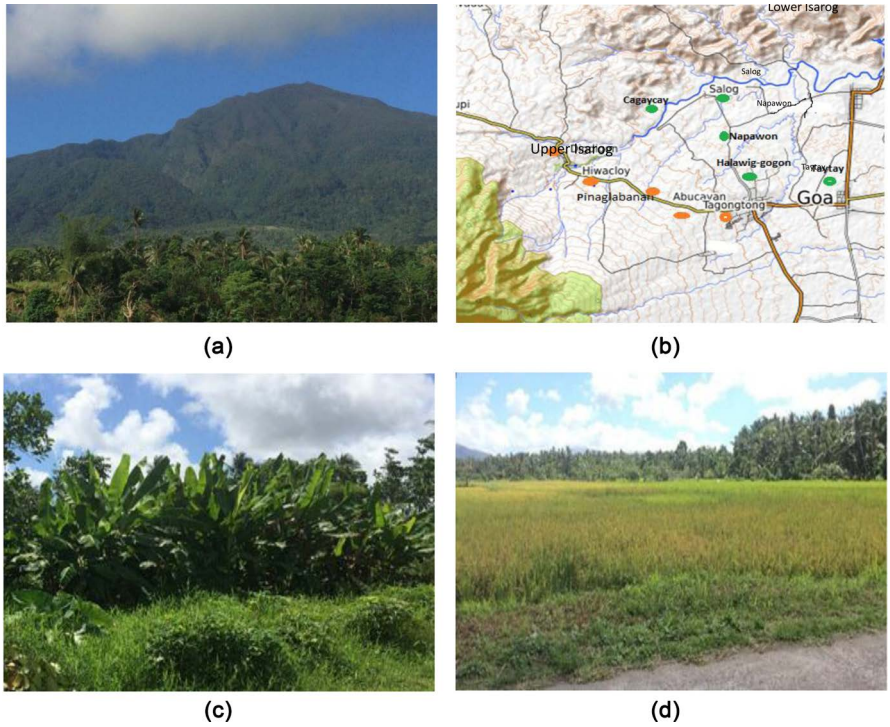

Figure 1. (a) Mt. Isarog is located at Camarines Sur, a province of the Bicol Region, Philippines; (b) The study area showing the 10 braongays in the lower and upper portion of Mt. Isarog; (c) Abaca is one of the major crops grown at the upper portion of MT. Isarog; (d) Rice is one of the major crops grown at the lower portion of Mt. Isarog.

Majority of the farmers are farming a small land area mostly less than 1 hectare. Farmers are engaged in multi-cropping which is combination of either rice or vegetables in the lowland area and abaca and coconut in the upland area. For vegetable farmers, they farm a variety of vegetables but there are also farmers who are engaged in monocropping such as planting rice only, coconut only, corn only or abaca only. Climate change has significant effect to the three dimensions of farming: soil quality, crops and income along the Mt. Isarog watershed area. Thus, this study evaluated the impacts of climate change to farmers and how farmers adapted to the impacts of extreme weather. The impacts of climate change can vary from one dimension to another and from one place to another. The impacts may or may not be favorable to the farmers and the answer can be established through the careful analysis of the various climatic events that occurred in the Mt. Isarog watershed area.

2. Objectives of the Study

The study aims to assess and describe the various adaptation strategies of upland and lowland farmers in Mt. Isarog watershed area to the impacts of extreme weather conditions as input in developing a win-win adaptation options to various farming sectors. Specifically, the study was conducted to:

1) Identify climatic events in the area and their corresponding impacts on three dimension of farming like crops, income and soil quality.

2) Identify the adaptation strategies used or developed by the key farming sectors on the impacts along the dimension of crops, farm income and soil quality by the key farming sectors.

3) Compare the impacts of climate change to various farming sectors in the upland and lowland Mt. Isarog watershed area.

4) Propose a win-win adaptation options for the various farming sectors.

3. Methodology

The focus group discussion was conducted among the key farming sectors to 18 - 35 participants classified as the abaca farmers, root crop farmers, rice farmers, coconut farmers and vegetable farmers in the upland and lowland communities of the Mt. Isarog watershed area to identify the different impacts of extreme weather to various farming sectors to the three dimensions of farming which include the soil quality, crops and income. They were also asked questions on their adaptation strategies whenever an extreme weather occurs in their locality and the effects of their adaptation strategies to the three dimensions of farming. The effects of the adaptation strategies done by farmers in different climatic conditions were then analyzed as favorable or not favorable to the farmers or whether these adaptation strategies have positive or negative impacts to the three dimensions of farming. The impact of extreme weather to the farmers and their adaptation strategies in the upland and lowland areas were also compared. Results of the focus group discussion were then validated by field visit to their farms and interview with the key informant farmers, the local officials of the barangays and the experts in agriculture.

4. Impact of Climate Change to the Three Dimensions of Farming

Impact of climate change to soil quality. The impact of climate change to soil quality, crops and income to the different framing sectors is presented in Table 2. During extreme heat, the quality of soil becomes dry, cracked and dusty. This is caused by the rapid evaporation of moisture from the soil. Dryness of soil is an indication the lack of moisture needed for plant growth and development. At this climate, root crops, coconut and abaca are not affected but rice and vegetable farmers find difficulty in growing their crops since these crops need substantial amount of moisture in order to survive. Contrary to the extreme heat, extreme rainfall provides excessive water making the soil wet, muddy and slippery. This kind of soil condition is not favorable to root crops, vegetables and even rice because over supply of water loosens the soil and vegetables can be readily washed away. This also happens to root crops planted along the sloping side and rice on the lowland area. When there is strong typhoon and heavy precipitation of rain, soil is loosened and eroded. Whereas, the early onset of rain maintains the soil quality and this gives favorable growth for all kinds of crops. On the contrary, the delay onset of rain makes the soil dry and dusty and La

Table 2. The impact of different climatic events to the three dimensions of farming: soil quality, crops and income sectors in the lowland and upland Isarog.

Climatic Condition	Impacts to Soil Quality	Impacts to Crops					Impacts to Income
		Abaca	Coconut	Rice	Root Crops	Vegetables	
Extreme Heat	Dryness of soil Cracking of soil Soil becomes dusty	Good or better yield Good income	No effect Normal yield Normal income	Dryness, early maturation, stunted growth, No yield No incomes	No effect Normal yield Normal income	Dryness, early maturation, stunted growth, No yield No incomes	Good or better income to abaca farmers Normal income for coconut and root crop farmers No income to vegetables and rice farmers
Extreme Rainfall	Soil is very wet and muddy Soil becomes loose and cannot hold vegetables	No impact and good growth Good yield	Virus attack (*cadang-cadang*) Early falling of fruits and flowers Rat infestation Poor yield	Pest infestation Poor growth and development Poor yield	Stunted growth, molds infestation, Decaying of crops Poor yield	Washing out of vegetables Poor growth and development Poor yield Molds and fungal infection	Low to no income for root crops, vegetables, rice and coconut farmers Good income to abaca farmers
Typhoon	Wet and loosened soil, some parts are eroded and becomes infertile	Uprooting and destruction of crops Partial to no yield	Falling down and decay of crops Destruction of crops Partial yield	Partial to total destruction of crops Partial to no yield	Toppling down of crops Smaller sizes of root crops Partial to no yields	Toppling or washing away of crops Partial to total destruction of crops Partial to no yield	Low income for abaca, root crops, coconut farmers No income to rice and vegetable farmers
Early Onset of Rainy Days	Moisture of soil is favorable to crops	Healthy growth of plants Favorable for planting	Healthy growth of plants but fruits are smaller in size Favorable for planting crops	Crops grow healthy	Crops grow healthy	Crops grow better	Better yield or good income for abaca, coconut and root crops Low income for vegetables and rice farmers
Delay Onset of Rainy Days	Soil is dried	No impact	No impact	Unable to plant on time	No impact	Low crop yield	Income not affected
Prolonged Heat (El Nino)	Cracking and dusty soil	Drying of crops	Pest and viral attack	Reddening of leaves Plants don't mature	Drying of crops	Drying of crops Pest infestation Poor growth	Low to poor income
Prolonged Rain (La Nina)	Soil is muddy, nutrients are washed out result to poor soil quality	Good and favorable growth	Falling of fruits	Plants do not mature	Decaying of crops No tubers production	Decaying of crops Poor growth Attack of molds	Good income for abaca farmers. Poor to no income for coconut, root crops, vegetables and rice

Nina, or prolonged rain, makes the soil muddy, soft and infertile. The effect of climate change depends on the kind of soil texture. Sandy loam soil does not crack but it becomes dryer. Sandy soils retain little water at high water potentials and water content decreases rapidly with the water potential [20]. The clay loam soil cracks due to excessive heat.

The impacts of climate change to crops. The impact of extreme weather to the different farming sectors varies with the kind of crops. Rice and vegetables are the most affected because they needed water the most. The scarcity of water during extreme heat results to the changes in the physical appearance of the crops such as the reddening of the leaves, poor and stunted growth, early maturation and drying of crops. Crops are also attacked by pests like insects, worm, molds and fungi. The effect of it is more evident to rice followed by vegetables, coconuts and abaca but not to root crops. This unusual growth of plants caused by pest infestation and water deficiency gives low quality crops and poor yield. Data also shows that extreme heat does not affect the root crops indicating its resiliency to heat. In fact, *camote* grows better and produce more tubers on this condition. However, peanuts exhibit less rooting system and produce less or no nuts at all. Abaca also grows well during extreme heat with some pest and infestation resulting to poor and stunted growth. Likewise, coconut is not much affected by extreme heat but when it does, it is infected by fungi and viruses as indicated by the reddening or blackening of its leaves. Often, if not treated at once, coconuts do not survive.

Extreme rainfall leads to stunted growth, decay and rat infestation of crops. For the root crops, the plants may grow healthy but no tubers are formed. This is due to the insufficiency of sunlight needed for the photosynthetic reaction to produce more starch in tubers. Abaca grows well on extreme rainfall but they are infested by rats and molds at the roots destroying the abaca. Coconuts can also thrive in extreme rainfall but *cadang-cadang*, a kind of coconut virus, infect the crop. There is also the tendency for the coconut flowers and young coconut fruits to fall due to the pressures of heavy rain. Vegetables do not thrive on heavy rainfall because of excessive water and they are washed away by the strong force of water. Pests like golden snails and worms, fungi and molds also attacked the vegetables on this season. Rice can thrive on extreme rainfall because basically rice needs more irrigation in order to grow healthy and productive. But the oversupply of water negatively affects plant growth due to excessive water and pest infestations

Typhoon can destroy all kinds of crops and properties in a very short period of time in varying degree depending on the strength of typhoon. In this climatic condition, the root crops are the ones that are least affected but the other crops like abaca, coconuts, vegetables and rice suffer from partial to total destruction. Crops are either uprooted in the case of abaca, washed away in the case of vegetables and fruits fell down and decay in the case of coconuts. This happens because during typhoon, water softens the soil and the strong wind can pull down the soft and weak body of abaca. Root crops are not much affected because most of them are resilient to strong winds and heavy rains. Only the upper part of the crop is destroyed but the tubers are spared from the destruction. The early onset of rainfall is favorable to all kinds of crops because precipitation provides water at an early time and the early provision of water allows the crops to grow healthier and better. According to the farmers, it is in this climatic condition that

farming is favorable and they take this opportunity to plant their crops as soon as there is abundant supply of water. The delay onset of rains has also no impact to coconuts, abaca and root crops but negative impact is more evident to rice and vegetables which are water dependent. Prolonged heat deteriorates the quality of crops and lowers crop yield due to the lack of water in soil and pest infestation. Whereas the prolonged rain is favorable to abaca but not to other crops because crops decay due to oversupply of rain. Molds and other insects also thrive at this climate degrading the quality of crops.

The impact of climate change to income. The impact of climate change to the income of farmers is also presented in Table 2. The impact of extreme heat to income is either favorable or not. Root crops for example provide a better income when grown in extreme heat particularly sweet potato (*camote*) because it produce more and better tubers at this season. This means greater yield for *camote* farmers and therefore better income. Some root crops however cannot thrive to the high temperature such as the peanuts, *cassava* and *gabi* so they produce less tubers and empty nuts in the case of peanuts giving less or no yield at all negatively affecting the farmer's income. Abaca farming is also not a promising activity at this season because abaca does not grow well at high temperature. Some abaca farmers would even experience losses, thus the decrease in their income. The same is true to coconut and vegetable farmers because the quality of their product is poor incurring less to no income. Rice farmers said that their income increased due to high demand of the product as explained by the law of supply and demand. The income of root crop and abaca farmers during extreme rainfall is better. However, farmers in other farming sectors experience problems on post-harvest due to the absence of postharvest facility that will help dry up their wet products. Wet *palay*, for example, cannot demand higher price and often experience price deduction because the product is wet. Abaca farmers during typhoon experience steady income but coconut, rice, and vegetable farmers suffered from losses and the outcome is debt and poverty.

The early onset of rain is promising to farmers in all sectors especially to the root crop farmers, followed by vegetable farmers, abaca farmers and the least to rice farmers. Due to the early advent of rain, the farmers were able to plant their crops earlier giving them a better yield and a better income. The early onset of rain is also favorable to root crop farmers because of the better quality of their crops giving them higher income. In particular, *gabi* and cassava grows better and planting this kind of crop at this climate is highly recommended. During the delay onset of rain, the income of farmers is the same as the normal condition or better particularly to abaca farmers and vegetable farmers. The variability of the impact of El Nino (prolonged heat) is observed among farmers in different farming sectors. In particular, abaca and coconuts are not much affected by the El Nino and the resiliency of the crops gives the farmers quality products and better income.

The foregoing data suggests that the different climatic events affect the income of farmers favorably and not favorably. There is an observed variability on

the effect of extreme weather to the income of farmers. Some crops could give farmers security of income while the others do not and made the farmers suffer from losses, debt and poverty. The income of farmers is dependent on the weather conditions affecting them and the resiliency of the crops also depend on extreme climatic events. Farmer's income in the Mt. Isarog watershed area varies in extreme weather conditions. They only need to adapt to the existing climatic events in order to survive. The impacts of climate change to the three dimension of farming are interconnected making the soil quality as the baseline cause of the effect. The low quality of soil as evidenced by dryness or wetness of the soil results to poor crop production and poor income affecting the quality of life of the farmers. From the seven climatic events, the early onset of rainfall is favorable to the three dimension of farming which sustains the quality of the soil resulting to better crop yield and better income. Some crops like abaca, root crops and coconut are resilient to climate change.

5. Adaptation Strategies of Farmers against Extreme Weather

Adaptation strategies of farmers to soil quality and their effects to farming sectors. The adaptation strategies of farmers to soil quality during climate changes and their effects to farming sectors in the upland and lowland watershed is presented in Table 3.

Farmers have very limited adaptation strategies to the impacts of climate change to soil quality. Cleaning or removing weeds in abaca plantation is the most observed adaption strategy of farmers during extreme heat and plowing is used by the root crop farmers to soften the soil but such methods may not be favorable to farming because it allows rapid evaporation of moisture in the soil creating more dusts and polluting the air. During extreme rainfall, soils and its nutrients are carried away by the rain reducing the quality of the soil in the upper Mt. Isarog watershed area. Quality of soils on root crops, abaca, coconut and rice are maintained so the farmers practice no adaptation strategy. In the case of prolonged heat, farmers just wait for the rain to come.

Adaptation strategies of farmers to soil quality and their effects to farming sectors. One of the notable adaptation strategies of farmers during extreme heat is to allow the weeds to grow with their crops. According to farmers, this practice is beneficial because it prevents the moisture from rapid evaporation but the weeds compete with the nutrients and water from the soil resulting to low productivity of the crops. Competition between the crop and the weeds is not a healthy relationship. Farmers also plant crops resistant to heat like peanuts, beans, *upo*, mongo and squash Vegetable farmers adopt crop rotation depending on the climatic condition. They also use in between cropping by planting vegetables in between coconuts, abaca and root crops. This diversification maximizes land use and security of income. During extreme heat and prolonged heat, rice farmers don't farm their crops and just wait for the advent of rain. Other alternative strategies used by farmers are the replacement of the infected

Table 3. Farmers' adaptation strategies to the three dimension of farming and their effects to farming sectors.

Climatic Conditions	Crops	Income	Soil Quality
Extreme Heat	Weeds are not removed to prevent soil from drying Plant other crops resistant to heat like peanuts, beans, upo, mongo and squash Use crop rotation Proper farm management In between cropping Farrowing Manual irrigation of crops Replacement of crops affected by heat and pests Spray with pesticides Manual removal of pests and molds No planting until the rain comes Plant again	Take loans or credits Buy and sell other crops to augment income	Prepare the area for the upcoming rain Plow the field to soften the soil
Extreme Rainfall	Plant crops resistant to rain Improve the irrigation system Proper timing of crops based on planting season Manual removal of pests and sucklings Spray crops with pesticides	Look for alternative livelihood Buy and sell other goods a or products	Just allow the soil to get carried away by the rain
Typhoon	Plant creeping or low growing crops during typhoon season Prayer so that typhoon will not come and change its way Early harvest of crops that are already matured Plant crops that can be harvested for a shorter period of time Ask for assistance from the Department of Agriculture Provide a stronger support to crops planted with trellis Replace the destroyed crops Trimming of leaves	Harvest the fallen or destroyed crops Plant alternative crops like root crops	None
Early Onset of Rainy Days	Choose seedlings resistant to rain Use intercropping Allow the crops to sprout again (*saringsing*) Farrowing	None because of good yield or income	None
Delay Onset of Rainy Days	Choose a variety of crops resilient to heat Use intercropping technology Wait for the rainy days to come Manually water the crops morning and afternoon Replace destroyed crops	Diversion to other livelihood activities	None
La Nina	Provide a wider space for the excess water to come out of the field Select a variety of crops suited to the climate Harvest the crops early so that it will not get rotten Intercropping Plant again	None	Allow the plants to decay
El Nino	Plant crops resilient to heat Use crop rotation Grow livestock as alternative source of income Manually water the crops Remove the suckling Clean up the area before replanting	None	None

or dried crops and the manual irrigation of crops. Such strategies are costly because additional labor and material cost is required. When extreme heat is intolerable, farmers would just let their crops dry and wait for the next cropping season. This kind of strategy makes farmers helpless and the impact of this is income loss.

Pest infestation is one of the biggest problems of farmers in all farming sectors during extreme weather. Insects, molds, fungi, rats and many other pests attack the crops at this season. Farmers fight with them by spraying pesticide while some remove the pests manually. Plants infected by mold are removed and then replaced by a new one. These adaptation strategies are traditional and not favorable because this entails high labor cost, poor yield and low income. The strategies of farmers to the impacts of the early onset of rainfall are favorable to all farming sectors because crops grow favorably. Crop rotation, selection of resilient crops, in between cropping, and proper farm management are some of the adaptation strategies used by farmers during extreme weather and these are favorable to farming because crops grow healthy and robustly. On the other hand, traditional adaptation strategies such as the delaying of the schedule of farming, manual irrigation, crop replacement of dried and infected crops and use of pesticides are not favorable because of the demand for more labor cost and materials.

During the extreme rainfall, irrigation management system is done by filling up soil to rice paddies to minimize the flow of water in the rice field or making a wider opening in the paddies when water supply is low. Such method regulates the amount of water coming in or out of the field. Some farmers plant crops that are resistant to extreme rainfall such as the submarine rice rather than the ordinary variety of rice. This rice variety can survive even if they had been submerged in water for a long period of time. Pesticide sprays are often used to eradicate pests but in extreme rainfall, this method is not feasible since pesticides can be washed away by the rain. Other farmers manually remove pests and infected suckling to prevent the pests from spreading. These activities are labor and time consuming which are not advantageous.

During the typhoon season, farmers offer prayers for Divine intervention to change the typhoon path. The strategy may be extraordinary but many farmers believe in Divine powerful intervention. Listening to the early forecast of typhoon is important information to farmers in decision making. In the advent of typhoon, vegetables and rice farmers harvest their mature crops before the expected typhoon arrival and convert them into cash before they are totally damaged. The abaca and the coconut farmers do their post-harvest by gathering all fallen coconut fruits and convert them into copra and to cash and by stripping the fallen abaca to make fibers and sell them for cash. As a preparation against typhoon, abaca farmers trim the leaves to prevent the crops from toppling. In this way, they do not experience total loss because they were still able to recover a partial of the crops damaged by typhoon. But farmers have to wait for another year or two before they can recover fully from losses. Other beneficial strategies

used by farmers during typhoon are the planting of creeping or low growing crops, providing stronger support to trellis and harvesting mature crops before the advent of typhoon. These strategies prevent farmers from incurring total crop damage and losses. Vegetable farmers plant crops that can be harvested for a shorter period of time and harvest them prior to the advent of typhoon.

The early onset of rain is favorable to farmers because of better soil quality, better crop productivity and better income. Planting root crops at this season is advisable particularly in the upland area when rain is readily available. Farmers in all farming sectors adopt intercropping as a strategy to cope with the early onset or rain or plant rain resistant crops. Some farmers use *saringsing or* rationing to rice. *Saringsing* is allowing the rice to grow again without replanting. The practice may be economical in terms of labor cost but the yield is not the same as in the first stage farming. The process is beneficial to soil because it conditions the soil to become more fertile.

Proper irrigation management is adopted by rice farmers to regulate the amount of water in the farm while vegetable farmers choose crops suitable to the climate like the water melon, tomatoes and beans during the dry season. Other farmers harvest their crops early so that they will not be rotten or they use intercropping. These strategies are favorable to farmers and help them cope with the adverse impact of La Nina. Somehow, the farmers do not suffer financially because they can still have income to ensure food security and survival amidst weather adversity. For crops that were not saved from heavy and prolonged rainfall, farmers plant again, which is not beneficial because this entails another capital for labor and planting materials. During El Nino, farmers plant crops resilient to heat such as mongo, squash peanuts and root crops. These crops need less water and grow well under extreme heat. They are also engaged in crop rotation, and intercropping. These methods are sustainable cropping technologies while weeding, crop replanting and suckling removal, manual irrigation system and replanting are not sustainable cropping technologies because they are adversely affecting the farmers due to higher labor cost demand.

Farmers can evade the disastrous effect of climate change when they are aware of the impacts of extreme weather conditions. Farmers should have wide understanding of the nature of every climate variability particularly its impact, its nature and frequency of occurrence and how farmers should learn how to deal with them. Farmer's education and training on climate change can be of great help to farmers vulnerable to all kinds of extreme weather. Many of the farmers' adaptation strategies are technologically advanced but some are still traditional. Traditional methods may not be favorable among farmers but the lack of technological knowledge and financial support makes them vulnerable to climate variability. The need to train farmers to a more advanced farming technology is relevant to help farmers cope with the adverse effect of extreme weather conditions.

Adaptation strategies of farmers to income and their effects to farming

sectors. The adaptation strategies of farmers during extreme heat to income include taking loans and credits to *compradors* or the middle men who buy and sell agricultural products. Usually, farmers go to *comprador* for credits in exchange for the crops they harvest. The crops that farmers grow served as the collateral of the loans they availed from the *comprador*. This practice is disadvantageous on the part of the farmers because during the harvest time, the farmer would bring their products to the comprador, keep value of cost of the product and deduct from the cost the amount of the loans accorded to them with interest and at lower cost. Farmers are not protected in this case and they are helpless when they are affected by the extreme weather conditions. Abaca farmers wait for the replaced crops to grow and the waiting would last for 6 months to one year depending on the crops grown. During the waiting time, farmers engage in buy and sell and others migrate to other places in search for alternative jobs. Some farmers would send their children in the cities to work as household helpers and the salary is the one that sustains their daily needs. Schooling children are made to quit affecting the children's education.

The experience of farmers during extreme rainfall is far better than during extreme heat because the presence of more rain in the field means good or better growth for all kinds of crops. Thus, the production of their crops is better and their income is better. Although, in some cases, some farmers still experience losses but they manage to engage in buy and sell as alternative source of income. The income of coconut farmers are not much affected by the extreme rainfall because these crops can grow robustly. During typhoon, farmers can still find some ways to recover their income by converting damaged crops to cash such as the fallen coconuts into copra and the fallen abaca to fibers. The root crops are not affected so the root crop farmers can still find a steady income after the typhoon but the rice and vegetables when totally damaged by the typhoon means a total loss of income and need for new capital or investments. Farmers in this case go again to compradors, loan sharks or lease up their property.

The early onset of the rainfall is promising to the income of farmers. According to the farmers, the harvest of all crops in this climatic condition is good and this means a good income to all farmers. Farmers do take the opportunity of farming early as soon as the rain started pouring so they can harvest early and the return of the investment is also earlier. But what they plant are alternative or seasonal crops that are resilient to this kind of weather. Most farmers in different farming sectors have no adaptation strategies during the delay onset of rain fall. It means that the farmers were not affected by the delay onset of rainfall particularly the root crops, abaca, and the coconut farmers. Vegetable farmers resort to finding other means of livelihood while they waited for the advent of the rain. La Nina also have no significant impact on the income of the farmers in all sectors so they have no adaptation strategies During la Nina, crops grow favorably and has also no adaptation strategy. Likewise, El Nino does not affect the income of farmers so they also have no adaptation strategy to augment their income.

From the seven extreme weather conditions that had been affecting a portion of Mt. Isarog watershed area, the most devastating to the farmer's income is the extreme heat followed by the typhoon, extreme rainfall, delay and early onset of rainfall, La Nina and El Nino. The early onset of rain favors farming activities.

6. Comparison of the Impacts of Climate Change to the Three Dimensions of Farming in the Upper and Lower Portion of Mt. Isarog Watershed Area

The adaptation strategies of the farmers in the lower and upper portion of Mt. Isarog depend on the impacts of climate change to the three dimensions of farming. The strategies of the farmers in the upper and lower portion of the Mt. Isarog watershed area have similarities and differences and these are presented in Table 4.

Soil Quality. The soil quality in the upper portion is loosened and infertile during prolonged heat, extreme rainfall and La Nino while it becomes dusty and cracked during extreme heat. During extreme rainfall and prolonged rainfall, the soil becomes wetter and loosened and in the upper portion of the Mt. Isarog watershed area, the soil are carried away making the soil less fertile in the upper portion and more fertile in the lower portion of the watershed area. The effect of extreme heat to soil quality is similar to the upper and lower portion of Mt. Isarog giving similar impacts to crops particularly to vegetables and rice. Abaca, coconuts and root crops which are more abundant in the upper portion are not affected by the cracking of soil because their roots are deep and they can still absorb water from the underground. The early onset of rain improves soil quality in the upper Isarog and favors the planting for all kinds of crops but the soil in the lower portion is muddy making the soil unfavorable for planting. During La Nina, lots of soil are washed out in the upper portion but soil quality in the lower portion of the watershed area is better.

Farmers have the upland and the lowland area experience the cracking and dryness of the soil. A few of them also grow root crops but just the same root crops are also affected by the cracking and dryness of the land. This poor soil quality affects production for the inability of the crops to absorb water and the nutrients. The upland area is likewise affected by the cracking and drying of the soil particularly the root crops grown in Abucayan, Tagongtong, and Pinaglabanan, The coconuts and abaca grown in Hiwacloy and Digidgon are also affected by the extreme heat but because they have deep rooting system, they can survive at this season. Coconuts, abaca and root crops can survive and are resilient to extreme rainfall so farmers of this kind are not affected.

The upland farmers favor the advent of extreme rainfall because most of their crops are rain dependent and excessive water is not actually felt is the area because water flows freely downhill. Only the vegetables and rice farmers in the lowland area are the most affected by the oversupply of water. Vegetables and

rice farmers in the upland area still favors the extreme rainfall. As observed, farmers in both the upland and lowland watershed area lack the farming technologies and innovations to help them cope with extreme weather like the use of mulching, aquaculture, hydroponics, micro-irrigation system, rainwater harvester and similar modern agriculture practices. Farmers may be provided with technical knowledge on soil quality to help them understand better soil quality and how to deal with them in moments of climate variability.

Crops. The impact of extreme heat is more felt in the upland area than in the lowland area. Root crops, abaca and coconuts which are mostly grown in the upland area are favorable to upland famers because of better production indicating a better income to upland farmers. But for the lowland farmers, vegetable farming is not advisable at this climatic condition because of poor yield and low income. Rice farming has no income at all. This impact is true to both the lowland and upland farmers but the greater negative impact is experienced in the upland areas. The negative impact of the typhoon is observed in both the lowland and upland area. But the upland farmers are more vulnerable. Whereas, the delay onset of rainy days has no effect on all kinds of crops in both the upland and lowland area. The income of the farmers in the upper portion of Mt. Isarog is affected both positively and negatively. While some farmers like the abaca, coconut and vegetable farmers are earning good income from their crops, the root crop farmers are losing their income due to the poor growth and quality product of the crops. During El Nino, the same effect is true to vegetables and upland rice farmers. The lowland rice farmers still enjoy the benefit of good harvest and good income at this climate condition.

The impact of extreme heat is more observed in the upper portion of Mt. Isarog affecting abaca, coconuts and vegetables but not to root crops like *camote*. In the lowland area, the negative impact of extreme heat is more evident to vegetables and rice due to pest infestation and scarcity of water. In the lower portion of Mt Isarog, the most affected crops are the vegetables and rice and these are caused by both pest infestations and scarcity of water. Both rice and vegetables are water dependent and would dry up when the water is scarce. In the upland area, rice decay because the variety of rice planted those that do not need much water which the farmers generally call "*hasok*" (planting rice in *kaingin* areas). The negative impact of heavy rainfall is observed both in the upland and lowland area of Mt. Isarog which include the infestation of pests, fungi and viruses and the oversupply of water. In the lowland area, rice grows better than in the upland area but abaca, coconut and root crops are not much affected by the presence of extreme rainfall. Vegetables are seen to have negative impacts in both the upland and lowland Isarog. At this climatic condition, it is not good to plant vegetables especially they are not water resistant. Upland variety of rice does not thrive at this season but when irrigation is abundant, farmers can plant a variety of rice resistant to water. Better yield for abaca, coconuts and root crops is also expected and this is beneficial to the farmers engaged in this kind of farming.

Table 4. Comparison of the impacts of climate change in the upper and lower portion of Mt. Isarog watershed area.

Dimensions of Farming	Climatic Events	Impacts to Upper Isarog Only	Impacts to Both the Upper and Lower Isarog	Impacts to Lower Isarog Only
Soil Quality	Extreme Heat		Dryness and cracking of soil	
	Extreme Rainfall	Soil is very loose Loss of nutrients	Soil is very wet and muddy	Improved quality of the soil
	Typhoon	Loosened soil, not fertile	Soil is wet	Good quality
	Early Onset of Rainy Days	Moisture of soil is good	None	Soil is muddy
	Delay Onset of Rainy Days	None	None	none
	La Nina (Prolonged Rain)	Lots of nutrients are washed out	Soil is wet and muddy	Improved quality of the soil
	El Nino (Prolonged Heat)	None	Cracking and dusty soil	none
CROPS	Extreme heat	Good growth for abaca More tuber production for root crops	Pest infestation (Worms, insects and pests) Drying of Crops Low crop production	Low quality of fruits Early maturation of crops
	Extreme Rainfall	Virus, Rat and fungal infestation Insufficient fruit and tubers production	Washing out of vegetables Worm Infestation Drying of crops	Golden snails infestation Reddening of leaves (Tagustos)
	Typhoon	None	Partial to total destruction of crops	None
	Early Onset of Rainy Days	None	Healthy growth of crops Good crops yield Favorable to planting	None
	Delay Onset of Rainy Days	Inability to plant crops Poor and stunted growth Favorable to root crops	Drying of crops Low crop yield	No manifested impact in lower portion of Mt. Isarog
	La Nina (Prolonged Rain)	Favorable to abaca crops No tubers for root crops	Poor fruiting system	Poor maturation of crops Low crop yield
	El Nino (Prolonged Heat)	Pest infestation like cocolisap, tungro and cadang-cadang Drying of crops	None	Reddening of leaves Poor maturation of crops
INCOME	Extreme Heat	Decrease of income due to debt and less yield production of crops	Income increased due to higher demand for crops but farmers sometimes incur losses due to poor yield resulting to debt and poverty	Less yield and low income
	Extreme Rainfall	Increase in income for abaca and coconut farmers	Low income due to the low buying price of the crops.	Loss of income for rice and vegetable farmers
	Typhoon		Low to no income depending on the strength of typhoon	
	Early Onset of Rainy Days	Good income	None	Increase of income
	Delay onset of rainy days	No change of income	None	Low to loss of income
	La Nina (Prolonged Rain)	The same or increase of income	None	Low income
	El Nino (Prolonged Heat)	The same income for abaca and vegetable farmers	None	Low income due to poor quality of crops

The negative impact of typhoon is not spared to all kinds of crops but it is more evident in the upland Isarog compared to that in the lowland area. Total destruction of crops means no yield and the farmers has to plant all over again or wait for the crops to recover and bear fruits as in the case of coconut.

The impact of the delay onset of rainfall to crops is the upland and lowland area is lesser compared to the extreme heat. This climate imbalance results to the decaying of crops as in the case of vegetables or drying of crops as in the case of root crops. The delay supply of rainwater results in destruction of leaves, poor or slow growth of crops as in the case of vegetables. It can be noted that cassava grows healthy and therefore resilient at this climatic condition. Other root crops are not resilient particularly the "*camote*" which exhibit drying, decaying and defective tubers. Crops like abaca and coconut are not affected by this climate change. Vegetables are negatively affected by the delay onset of rainfall.

Generally, the upland Isarog is affected during the delay onset of rainfall but the negative impact is more felt in the lowland area because of the inability of the farmers to plant. Farmers in the upland area are less affected but waiting for the crops to recover is something that they should be prepared of and root crops and vegetable farming is an alternative source of income. The lowland farmers are more favorably affected than the upland farmers because rain is available. Growing crops in the upland Isarog watershed area is favorable during the early onset of rain because this allows the farmers to plant their crops earlier. Coconuts and abaca are not also adversely affected. Farmers adapt to this climate change by planting crops that are resilient to heat or they can use intercropping.

7. Win-Win Solution

Win-win solution is mitigation measures that will address the adverse effect of climate change to farmers in the Mt. Isarog watershed area. Following are some of win-win solutions to sustain farmer quality of life in times of extreme weather conditions:

1) Climate change education of farmers. On Climate Change through trainings and similar activities, education provides the farmers basic understanding of various climatic events that strikes in their locality and develop their knowledge on climate variability. Farmers' education can also help farmers on proper crop selection and use of various agri-technological approaches suitable to extreme weather conditions. Farmers can also be given some alternative livelihood trainings so that while they wait for the next cropping season, they have other sources of income. Farmers can also be taught with proper pest and farm management in different climatic conditions.

2) Financial support. Farmers always experience losses whenever a calamity strikes and it is at this moment that farmers needed the support of the government through crop insurance, micro-financing and the like so that they will not be indebted so much to the middlemen who charges a large percentage of their produce and who have no choice but to sell their products to these middlemen at

a much lower cost. To encourage farmers to avail of crop insurance, it can be given at lower cost and micro-financing at lower interest.

3) Farmers empowerment. Farmers should be given the give costing to their products not the middlemen who buys their products. Direct selling of their product is a better option because they can demand a higher profit and higher income. The farmers can be protected by buying the crops of the farmers during calamities at higher price. The farmers can also be protected through local ordinances offsetting up fixed prices of farm produce during calamities and that.

4) Postharvest facility. Provision of post-harvest facility is recommended because farmers cannot demand a higher price of their products when they harvest their crops after the typhoon, during heavy rainfall, and prolonged rainfall when they could not dry their crops and sell them at very low cost. They have no choice because they have no place where they can dry their harvested crops. Selling their crops at lower cost is better than having them decay and earn nothing at all.

5) Agricultural innovations and technologies. Provision of new and modern technologies to farmers. These technologies can be in the form of facilities, equipment, irrigation system or cropping system appropriate to each kind of climatic condition.

6) Farmers' organization. Encourage farmers to organize and work as one and cooperatively especially in moments of disaster. A more and solid voice from the farming sector can be heard for the government to understand their needs especially during climate change.

7) Research and development capacity building. Conduct of studies on climates change through the support of various government agencies and academic institutions and later create a center of studies on climate change along the Mt. Isarog Watershed area. Heavy investment on research and development is the most appropriate intervention [21] to help farmers cope with climate change. It can spur innovations in sustainable climate-friendly and climate-proof productivity [22].

8) Policies on climate change mitigation. Formulate policies on climate change mitigation through the local government to ensure the protection of the farmers against extreme weather conditions.

8. Conclusion

The degree of the abundance of rain affects soil quality, crops and income of farmers. Extreme heat, prolonged heat and El Nino degrade soil quality because of lack of moisture while extreme rainfall and prolonged rain degrade soil quality by the oversupply of water. Soil quality degradation is caused by the deficiency and oversupply of water resulting in poor growth and development of crops, poor yield and low income. Pest infestation also contributes to crop productivity which is also prevalent in extreme weather particularly during the lack and the oversupply of rain and the kind of pests that attack the crops also varies with the

extreme weather. Typhoon also caused partial to total destruction of crops while the early onset of rain improves soil quality and favours crop productivity and income. Abaca, coconuts and root crops are resilient to climate change but not rice and vegetables. Adaptation strategies of farmers vary with the kind of extreme weather affecting their crops. Adaptation strategies favourable to the farming sectors are crop selection, intercropping, crop rotation and irrigation pest management. Some traditional adaptation strategies like *saringsing* (ratooning), allowing weeds to grow with crops and manual irrigation may not be favourable to farmers' income but favourable to soil quality. The poor crop productivity negatively affects the income farmers in all sectors forcing them to engage in loans or debts with middlemen. There is an observed similarity on the impact of extreme heat and early onset of rain to the upland and lowland Mt. Isarog watershed area while there is an observed variation on the impact of the other climatic events in the upper and lower Mt. Isarog watershed to the three dimensions of farming. Adaptation strategies are more focused on crop and pest management to sustain productivity and income.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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