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Climate Change Adaptation Strategies of Smallholder Agroforestry Farmers in the Philippines

ABSTRACT

This article argues that smallholder agroforestry farmers in the selected provinces in the Philippines have already been experiencing climate change in their respective areas as indicated by the change in the rainfall and temperature patterns. Using direct interviews and focus group discussions, the respondent-farmers highlighted that increased incidence of pests and diseases, stunted growth of crops, low crop productivity, delayed planting, delayed fruiting of some crops particularly perennial species, poor quality of produce, increased cost in farm operations, low income and decreased yield of some crops, are among the general impacts of climate change in their agricultural production systems. On the positive aspect, some crops had increased yield as an impact of climate change. The farmers employ their local knowledge and skills in adapting to the impacts of climate change. Among these include changing cropping patterns, integrating more crops in the farm, engaging in other off-farm and non-farm activities as additional source of income, changing the cultivated crops, mulching, and using organic fertilizers, among others. This article also highlights the benefits that the respondent-farmers derive from agroforestry, a land use management system that is currently being practiced in the study sites.

Key words: *Climate change, agroforestry, local knowledge, agricultural production systems, impacts*

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INTRODUCTION

There has been an increasing recognition of climate change as among the major environmental problems that the world is currently faced with. Climate change is indeed real and evident. It is inevitable, and it has to be appropriately and sustainably addressed.

Climate change is defined by the Intergovernmental Panel for Climate Change (IPCC) as a statistically significant variation that persists for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as slow continuous rise in global mean surface temperature. Climate change 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 a comparable time periods (*UNFCC* as cited by *Lasco et al 2004*). This phenomenon is indeed a fact, as some countries, including the Philippines have been experiencing the impacts of climate change.

The *IPCC TAR* (*2001*) predicts that, precipitation will increase over high latitude regions in both summer and winter seasons. Increases are also projected over northern mid-latitudes, tropical Africa and Antarcticain winter, and in southern and Eastern Asia in summer. Larger year-to-year variations in precipitation are very likely over most areas where an increase in mean precipitation is projected. In addition, the *IPCC TAR* (*2001*) highlights that "yields of some crops in tropical agricultural areas decrease with even minimal increases in temperature because they are near their maximum temperature tolerance. Where there is also a large decrease in rainfall in subtropical and tropical dryland/rainfed systems, crop yields would even be more adversely affected."

These projections point to the fact that the agriculture sector is the most vulnerable to climate change, because of its dependence to water and temperature conditions. Climate change poses threats and risks to agricultural production, in general, and to the poor/marginal farmers, in particular. Ironically, the farmers have the least contribution to gas emissions in the atmosphere, and yet, they are considered to be the most vulnerable to the effects of climate change.

As among the developing countries, the Philippines, is highly vulnerable to climate change impacts. The Philippines was the "world's top climate victim" in terms of damage caused by extreme weather events, and is among the top ten countries on a 'climate risk index' for the years 1998 to 2007, on the basis of average damage from such events during that period (*Raquedan 2010*). El Niño tends to affect agriculture in the Philippines through drought, while La Niña tends to produce greater rainfall and increased flooding. The two strongest El Niño events in the last 35 years occurred in 1982/83 and 1997/98 and both events affected agricultural production, with substantial declines in production of four main crops– rice, corn, coconut, and sugarcane (*Amadore 2005*). Most recently, the El Niño of 2009/10 produced substantial declines in farm production in the first quarter (2.8%) and second quarter (3.5%), evidently as a result of drought (*Felix 2010* as cited by *Lang and Chow 2010*).

There have been some macro-level projections and technical recommendations from experts to the agriculture sector about mitigation and adaptation strategies to the impacts of climate change, as contained in the IPCC Report in 2007. It is hightime to study the micro-level or farmer-level evidences of climate change impacts, and how the agriculture sector, particularly its households or farmers respond and initiate or exhibit adaptation mechanisms and/or activities. It is important to document and review the impacts of climate change to the crop and livestock production, soil fertility level, marketing and other agricultural activities of the farmers, particularly those situated in areas that are classified as vulnerable to climate change impacts. It is for this reason that this research was deemed necessary, as there may be some indigenous or local practices that could help the small-scale agricultural households ensure food security and farm productivity.

Agroforestry as an adaptation strategy to climate change has been recognized being a land use system that can maintain biodiversity and carbon stocks (*Shibu and Sougata 2012*). Beetz (2002) emphasized that the resulting biological interactions of agroforestry components provide a wide-range of above- and below-ground opportunities and benefits including diversified income sources, increased biological production, better water quality, optimization of capture and use of scarce rainwater, and improved habitat for human beings and wildlife. Agroforestry has been recognized as having the greatest potential for C sequestration of all the land uses for the inclusion of trees in the agricultural landscapes often improves the productivity of systems while providing opportunities to create C sinks (*Albrecht and Khandji 2003).*

The research reported in this paper was implemented in 2010 and 2011 to assess the understanding and awareness of agroforestry practitioners and upland farmers on the issue of climate change and its impacts to agricultural development; identify the indications and evidences ofclimate change based on the experiences and observations of the farmers in their agricultural production; analyze the different mechanisms and strategies that are being employed by the upland farmers in coping with the impacts of climate change; and formulate recommendations to the concerned national and local development organizations as regards to adoption of appropriate and sound climate change mitigation and adaptation strategies.

METHODOLOGY

Selection of the study sites was primarily based on an earlier knowledge about the agroforestry practices and systems that are being employed by the farmers cultivating the farms. The study covered 69 smallholder upland farmers employing agroforestry as their land-use management system. Most of the respondents represent the Luzon island (53), followed by the Visayas (15) and Mindanao having the least number of respondents (2) (**Figure 1**). Selection of respondents was purposive involving the farmers whohave been engaged in agroforestry production for at least five years.

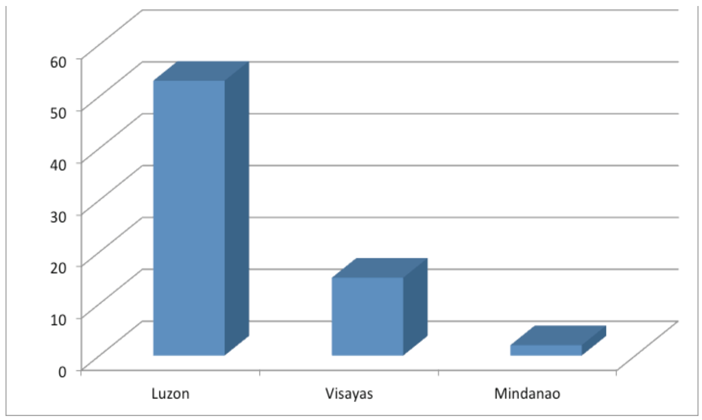

Figure 1. Major island groups represented by the respondents.

Personal interviews of farmers obtained information on the indications and evidences of climate change based on the farmers' observations on the cropping season; effects of climate change to the agricultural production; coping mechanisms of the farmers on the negative effects of climate change; and institutional support with regards to climate change mitigation and adaptation initiatives in the locality. Focus group discussion was conducted in areas with a group of respondents from the people's organizations, particularly in Bicol and Iloilo. Direct observation of the agroforestry farms was also done to validate the information obtained from the interviews.

RESULTS AND DISCUSSION

Study area and climate classifications

The study was conducted in five provinces in the Philippines representing the three major islands of the country. These include Silang, Cavite; Mallig, Isabela; Atok and Tublay, Benguet; and Guinobatan, Albay, representing the Luzon island; Dingle, Iloilo and Tabango, Leyte representing Visayas island; and Trento, Agusan del Sur and Bansalan, Davao del Sur, representing the Mindanao island.

These areas represent the different climatic classifications (**Figure 2**). The provinces of Cavite, Benguet, and Iloilo belong to Type I climate, which is characterized by two pronounced seasons – dry from November to April and wet during the rest of the year. The province of Albay is classified as Type II, having no dry season but with a very pronounced maximum rainfall from November to January. The province of Isabela belongs to Type III climate, whose seasons are not very pronounced; with a dry season from November to April and a wet season during the rest of the year. Davao del Sur, Agusan del Sur and Leyte provinces are classified as Type IV climate, with rainfall more or lessevenly distributed throughout the year.

Agroforestry systems and practices

Based on observation, the study sites were classified as agroforestry farms or integrating agricultural crops, with forest trees and/or livestock. The crop species combination varies in each study site (**Table 1**).

Climate change in the study sites

Results indicate that the upland farmers have already

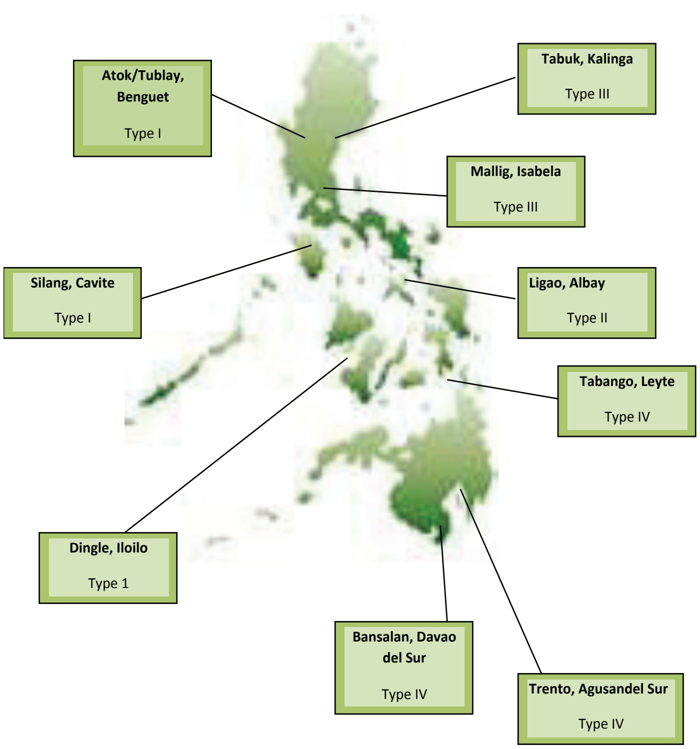

Figure 2. Climate Classifications of the study sites in the Philippines.

been experiencing climate change in all of the study sites. All of them have mentioned that local prevailing climate has changed a lot. They recalled that in the past, they can easily schedule their agricultural production because of the on-time rainy season. But in the recent years, particularly during the onset of year 2000, they have already observed the changing patterns. They have observed that the heat is more intense now, especially in Southern Luzon. There were more rainy days and the rain was heavier especially in 2010 and 2011 (**Figure 3**). In the Type IV climate of Mindanao and Eastern Visayas areas, the standard even distribution of rains throughout the year has altered to include heavy rains during the summer season.

Meanwhile, there was an observed long rainy season in 2009 in Silang, Cavite, which belongs to Type I climate. A number of typhoons have hit the area, which have damaged practically the agricultural crops. In Dingle, Iloilo, on the other hand, the farmer-respondents have observed the long dry season. Normally, it should be dry from November to April and rainy season should start in May. However, in 2010, there was an observed prolonged dry season as it has extended until May 2010. The rains started in June 2010. Similarly in Tabuk, Kalinga, a prolonged dry season was experienced and observed by the farmer-respondents. The usual dry season in the locality is from April to May but prolonged dry/summer season has already been experienced way back in 1995 in Tabuk, Kalinga.

The changing rainfall patterns and degree of the temperature increase were the basic considerations of the farmer-respondents in saying that, indeed, climate change is happening already in their respective areas. The fluctuating dry and wet seasons have also contributed to water/irrigation shortage, occurrence of pests such as brown plant hoppers and black bugs especially for rice, and army worms on the vegetables; damage of fruit crops from too much heat; heat stroke of sows; delayed planting season for water-dependent annual crops like rice and vegetables. The occurrence of pests and noxious weeds, and the delayed planting season were very much apparent in monocropping rice production areas. In Mindanao, the farmer observed a prolonged dry season, which has caused the dropping-off of buds and flowers. This has contributed to reduced yield of various fruits planted.

The inter-island documentation of the evidences of climate change is really an alarming scenario. In fact, the Philippines ranks fifth in the Global Risk Index for 2015 with a Climate Risk index (CRI) score of 19.50 (*Kreft et al. 2015*). This CRI score was based from 1994 to 2013. The Germanwatch Global Climate Risk Index (CRI) identifies those countries most affected by extreme weather events in

Table 1. Agroforestry practices in the study sites.

Study Site	Agroforestry System	Farm Components		
		Agricultural crops	Woody perennials	Livestock
Silang, Cavite	Multistorey system	Ubi/yam (*Dioscorea elata*) Ginger (*Zingiber officinale*), Pineapple (*Ananas comosus*), Peanut (*Arachis hypogeae*, Pole sitao (*Vigna unguiculata*), Papaya (*Carica papaya*)	Mahogany (*Swietenia macrophylla*), Native forest trees	Hogs (*Sus domesticus*) Poultry
Dingle, Iloilo	Alley cropping system	Sugarcane (*Saccharum officinarum*), Rice (*Oryza sativa*), corn (*Zea mays*), vegetables, banana (*Musa sapientum*),	Rambutan (*Nephellium lapacceum*) ,mango (*Mangifera indica*), Mahogany (*Swietenia macrophylla*), Gmelina (*Gmelina arborea*)	Carabao (*Bubalus bubalis*) Hogs
Tabuk, Kalinga	Silvipastoral system	Pole sitao (*Vigna unguiculata*), Pineapple (*Ananas comosus*), Rice (*Oryza sativa*)	guyabano (*Annona muricata* L.)., ipil-ipil (*Leucaena leucocephala*), gmelina (*Gmelina arborea*), Eucalyptus (*Eucalyptus* sp), Mahogany (*Swietenia macrophylla*)	Cattle
	Multistorey system	banana	Lanzones (*Lansium domesticum*), Mango (*Mangifera indica*), Narra (*Pterocarpus indicus*)	
Mallig, Isabela	Silvipastoral	Rice	Mango	Turkey (*Melleagris galiopavo*)
Trento, Agusan del Sur	Multistorey system	string beans (*Phaseolus vulgaris*), okra (*Abelmoschus esculentus* L.), squash (*Cucurbita maxima*), banana	calamansi (*Citrus microcarpa*), coconut (*Cocos nucifera*), durian (*Durio zibethinus*), lanzones (*Lansium domesticum*), mangosteem (*Garcinia mangostana L*), mango, abiu (*Pouteria caimito*) rubber (*Hevea brasiliensis*), falcata (*Paraserianthes falcataria* (L.) Nielsen)	
Tabango, Leyte	Alley cropping	Corn, peanut, mungbean, cassava (*Cucurbita maxima*), sweet potato, gabi	Mango, coconut and native forest trees	
Ligao, Albay	Alley cropping	Cassava, sweet potato (*Ipomea batatas*), corn, ube, peanut	Rambutan, coconut, kakawate, rensonii	
Davao City	Multistorey system	Cassava, corn	Durian, lanzones, mangosteen, rambutan, coconut	Goat (*Capra hircus*) Hogs

specific time periods, based on four indicators, namely total number of deaths, deaths per 100,000 inhabitants, absolute losses in million US$ purchasing power parities (PPP) and losses per unit Gross Domestic Product in %. It is also important to note that in 2013, the Philippines ranked first among the most ten affected countries due to Typhoon Haiyan, which struck the country in November 2013, inflicting over US$ 13 billion in economic losses and 6,000 deaths.

Effects of climate change in the agroforestry production

Rao et al. (*2007*) as cited by *Tolentino et al* (*2010*) highlight that soil, water, carbon and nitrogen cycles, crop growth and development, and incidence of weeds, pests and diseases are among the major agricultural processes and factors that are directly influenced by climate change.

There has been a decline in the crop production of the respondent-farmers (40%) (**Figure 4**). This has been brought about by the low crop yield, which was caused by the higher incidence of pests and diseases (43%), delayed fruiting of crops (19%), stunted growth or vegetative growth is encouraged because of too much rain (39%), particularly in the case of corn, higher incidence of weeds because of the continuous rains, and the increase in the labor costs (12%). Other observed effects of climate change among the farmers in Southern Luzon are the pest infestation at theonset of the first rain after a long drought. This occurred in 2010 when black bug and army worm (*Spodoptera exigua*) infestation was experienced in rice production.

In Dingle, Iloilo, the farmers had to delay the planting of crops that are too much dependent on water/irrigation, particularly rice, because of the prolonged dry season. In addition, Farmer A in Dingle, Iloilo who has about 700 heads of chickens (*Gallus domesticus*) and 38 sows need to exert extra effort in sourcing for the water needed to maintain the livestock, because the immediate water sources (e.g. creeks) have also dried up. The labor cost has likewise increased. Normally, the farm laborers would start planting

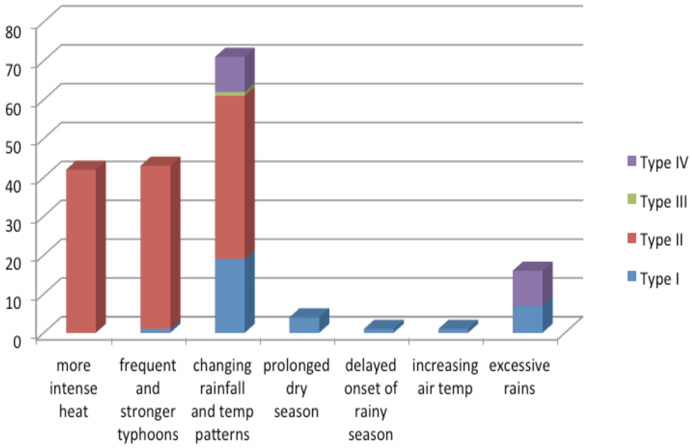

Figure 3. Farmer-level indications of climate change.

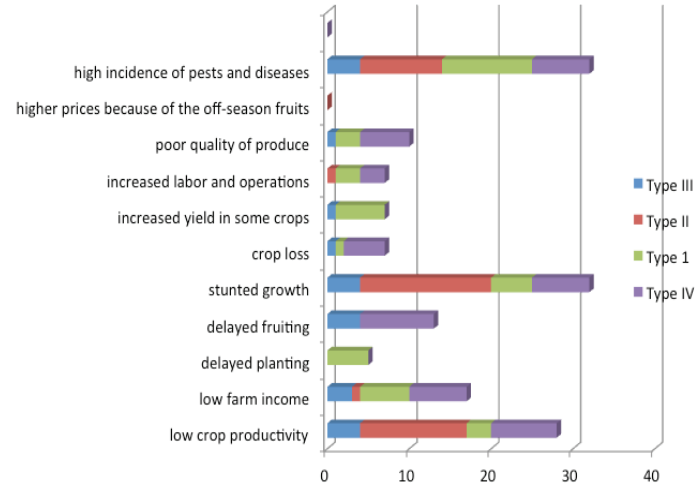

Figure 4. Effects of climate change on the agricultural/ agroforestry production of the respondent-farmers.

or weeding the farms from early morning until 12:00 noon and then from 2:00 to 4:00 in the afternoon. However, in the last cropping season, the laborers usually cease to work at 10:00 in the morning and resume at 4:00 in the afternoon because of too much heat. Farmer A also experienced increased electricity cost, because he had to put electric fans to the pigpens in order to prevent heat stroke. Meanwhile, Farmer B in Iloilo had observed the distorted growth of banana and the fruits as well. The farmer used to harvest good quality banana, but this year, most of the bananas were small and distorted. Finally, Farmer C who is engaged only in rice production has to invest so much on chemical fertilizers and pesticides to control the spread of brown plant hoppers and weeds in his rice production areas. Fortunately, Farmer C has the capital to establish water pumps and impounding dams which serve as the water source during the long dry season.

While his farm has withstood the climatic inconsistencies in the last four or five years, the 1:9 agroforestry farmer in Silang, Cavite has also experienced crop losses. For instance a significant number of papaya, vegetables and other short-term crops of the 1:9 system did not achieve the desired yield/production due to strong rains brought about by the typhoons that have hit the area in 2009. In addition, maintenance cost such as weeding has increased because of the faster growth of grasses and weeds brought about by frequent rains.

The prolonged dry season in Tabuk, Kalinga specifically during the period of January to June 2010, resulted to the mortality of cacao (*Theobroma cacao*) trees leaving only 1,000 resistant standing trees. There was also an observed high mortality of banana, considering that this crop is susceptible to drought. During El Niño, it was also observed that calamansi did not bear fruit, while corn did not grow well. However, El Niño was apparently beneficial to the growth of mango as indicated by the increase in yield from 7 tons in 2009 to 12 tons during the drought season of 2010.

In Mindanao, the fruiting of major fruit trees such as rambutan, lanzones and durian is hampered by prolonged dry season, in some instances, and heavy rains.

Most of the documented farms had been affected in terms of production yield. Some researchers have indicated the effect of temperature and vapor pressure deficit on crop yield. (*Kang et al. 2009; Ziska et al. 2010*). Increased temperature leads to faster crop development resulting to shorter crop duration or growing period, which in most cases is associated with lower yields (*Kang et al. 2009*). Moreover, rising temperature compounded with higher atmospheric carbon dioxide, may favor the growth and survival of many pests and diseases specific to agricultural crops which in turn causes losses to agricultural production.

Climate Change Adaptation Strategies of the Respondent-Farmers

IPCC TAR (*2001*) defines adaptive capacity as the ability of a system to adjust to climate change and to moderate potential damages, to take advantage of opportunities or to cope with the consequences. The goal of any adaptation measure should be to increase the capacity of a system to survive external shocks or changes.*FPRI* (*2007*) as cited by *Bradshaw et al.* (*2004*), highlighted that important adaptation options in the agricultural sector include crop diversification, mixed crop-livestock farming systems using different crop varieties, changing planting and harvesting dates and mixing less productive, drought-resistant and high-yield water sensitive crops.

This study revealed that farmers make use of their local knowledge in addressing the effects of climate change to their agricultural production. Most of them have changed their crops to suit the changing rainfall patterns (54%), integrated more crops to maximize production (40%), used organic fertilizers (13%), engaged in some off-farm and non-farm activities (23%), while a few practiced their rituals to prevent their crops from being attacked by the pests (1%), and others would not plant the crops (2%) (**Figure 5**). Most of these interventions do not require substantial capital investments which is typical of smallholders. *Tillman et al.* (*2002*) highlighted that many smallholder farmers have few other livelihood sources giving them little financial capital to invest on expensive adaptation strategies.

Farmer A in Tabuk, Kalinga, for instance, was able to install water pumps within the 100-ha agroforestry farm just to supply water to the different crops. This was possible because she had the financial capacity to install such facility. However, in the case of Farmer B in Dingle, Iloilo, he had to dig holes in the creek in order to get enough water for the crops and livestock, because the former had already dried up brought about by the long dry season. Unlike Farmer A, Farmer B has limited financial capacity to install water pumps.

Farmer C of Dingle, Iloilo employed mulching in all of the fruit trees planted in his farm. He has also intensified vermiculture for the production of organic fertilizer. Meanwhile, the farmer in Agusan del Sur gave up some crops and changed them with more drought tolerant varieties or species. In the case of fruit trees, pruning of some branches to minimize the canopy being supported by the plant is done prior to the flowering of the trees. Also, the farmer would cut grasses before the onset of rainy season and again during the end of the rainy season. In this way, the available soil moisture is conserved providing for the needed moisture during the dry season. According to *Selvaraju* (*2014*) the adoption of alternative management practices is crucial in the event of water scarcity, drought or flood, when the practices used under normal conditions are no longer appropriate. In Nepal, measures promoted to reduce the risks of crop failure include the adoption of suitable crop varieties, proper spacing, application of fertilizers based on the number of rainfall, and needs-based pest control.

During the rainy season when water is abundant, water impounding structures are constructed and the water can be used to water the plants or for drinking by the farm animals. Farmer A in Trento, Agusan del Sur constructed a number of impounding dams, strategically located within the farm. The construction of conservation ponds or water impounding structures is a traditional coping strategy for addressing water shortages at the household and community levels. *Selvaraju* (*2007*) as cited by *Lasco et al.* (*2011*) reported that through small-scale water harvesting structures in the form of mini-ponds, farmers in Northwest Bangladesh are able to store rainwater for supplemental irrigation during drought periods. In addition to improved water water availability for crops, other benefits of conservation ponds include supporting livestock, manure generation from dredged silt, replenishment of groundwater, and fish farming opportunites (*Selvaraju,2014*).

The 1:9 agroforestry farmer highly attributes the resilience of his farm to climate stresses to the high degree of mixtures of both perennial and short-term crops in the system. Such is a typical multistorey cropping system where farmers grow nine or more crops simultaneously in one parcel of land in order to maximize the productivity, while protecting against climate risks. This practice conserve soil

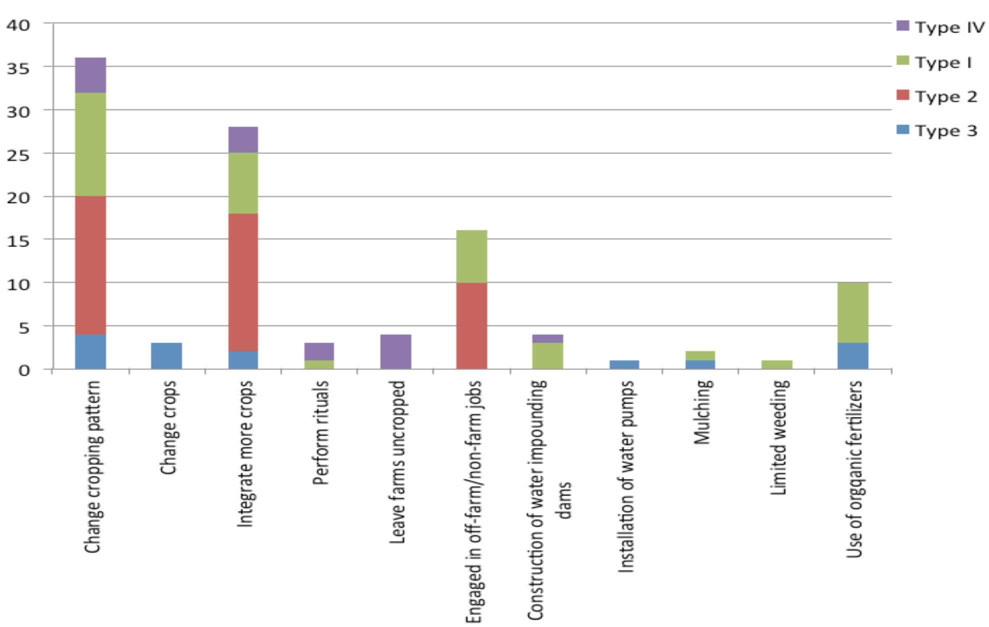

Figure 5. Climate change adaptation strategies of the respondent-farmers.

moisture and porosity, lessens soil erosion, runoff and fertilizer requirement, and allows for more diverse production and income sources for farmers (*Lasco et. al, 2011*). As an adaptation to climate change, the 1:9 agroforestry system allows the farmer to have a readily available option of crop or crop combinations both for biophysical/environmental and economic (marketing-related) benefits/reasons. The best species combinations for the farm, climate and culture ended up to be: mahogany + coffee (*Coffea* sp) + banana + papaya (*Carica papaya*) + pepper (*Piper nigrum*) + pineapple + guyabano (or other fruit trees like mangosteen) + ube and its variations of short-term high value crops such as peanut, pepper, among others are integrated in the system. One of the unique characteristics of the farmer in Pooc, Silang, Cavite is his being an entrepreneur, such that he has a strong link to the market for his produce. Moreover, the farmer in Silang, Cavite is intuitively a researcher by himself, such that he has the initiative to try combining other crops in his farm, to the extent of producing his own planting materials of papaya (from hybrids) and to continuously practice cultural management practices such as mulching, weeding, thinning, pruning and organic fertilizer application, among others.

A number of usual silvicultural and cultural farming practices are being implemented by the farmers in Kalinga and Isabela to cope with the impacts of climate change. Infrastructure facilities are also constructed to adapt to the changing climate like installation of irrigation facilities: water pump, water tank and water catchment among others. However, this scheme is limited to the farmers having financial capital. Most of the strategies implemented by the farmer-respondents coincided with the published crop production adaptation strategies like the modification in the management practices such as shifting planting dates, increasing fertilizer use, introduction of new plant varieties and use of irrigation systems to minimize the adverse effects of reduced precipitation and higher temperatures (*Callaway 2003; Schipper 2007*). It is also notable that said adaptation options are bounded with financial constraints. In relation, the farmers adopt strategies that are within their economic capabilities such as switching crops, crop rotation, minimum tillage and drought resistant varieties. According to *Shongwe et al.* (*2014*), households should adopt strategies that are cost-effective.

Climate change issue is being debated and advocated worldwide. A number of policy options and institutional support systems have been recommended by the experts and scientists that would help mitigate and/or adapt to the impacts of climate change. Surprisingly, however, most of the farmer-respondents mentioned that not a single technical assistance, except those in Ligao, Albay with existing project collaboration with a state university and local government unit. In most areas/study sites, however, information campaign or IEC about climate change issues, impacts and adaptation strategies have yet to be provided by the local development organizations (**Figure 6**). Thus, the farmers are left only with their own strategies, with no other basket of options which they could select from with regards to climate change adaptation strategies.

Recognizing the Value of Agroforestry in Climate Change Adaptation

IFPRI (*2006*) mentioned that one of the ways for upland farmers to cope and to mitigate the adverse consequences of climate change is through agroforestry. Agroforestry is a dynamic, ecologically-based natural resource management system that deliberately combines woody perennials with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence on the same land, with the aim of diversifying and sustaining production for increased social, economic and environmental benefits (*World Agroforestry Centre 2007; Lundgren and Raintree 1983*).

All of the respondent-farmers practice agroforestry, with diverse crops and/or animals. While some crops may have been negatively affected by the impacts of climate change, there were also some crops whose performance were favoured by the changing climatic patterns as shown in **Figure 4**. According to *Cunningham et al* (*2008*), the range and rotation of high-performing annual crops provide income and reduce disease incidence. When one crop fails because of pests and disease infestation, strong rains and winds or drought, the farmers still have other crops that would compensate for the losses.

Agroforestry involves the combination of trees, crops and livestock that are intentionally designed and managed as a whole production unit. With agroforestry, production

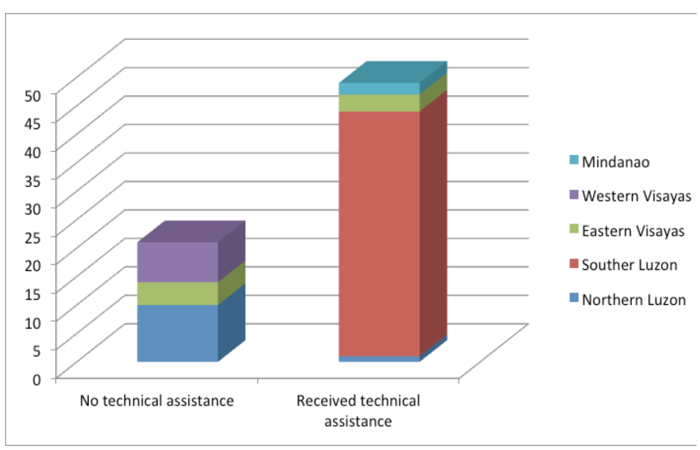

Figure 6. Technical assistance received by the respondent-farmers as regards climate change adaptation.

is optimized given that crops are combined with perennial and short-term crops, coupled with its animal/livestock component. In addition to the production aspect, the protective role of agroforestry is equally most relevant. Among the benefits are the following: increased crop yields, improved soil and water quality, increased biodiversity, lower greenhouse gas emissions and increased carbon sequestration.

Indeed, there has been a significant increase in the recognition of agroforestry as a climate change adaptation strategy. The smallholder agroforestry farmers themselves who are most vulnerable to the effects of climate change realized and experienced the importance of having various crop or component combinations in the system to have an alternative source of food or livelihood, or even for their overall environmental protection, should they experience extremes of rainfall and temperature regimes. With agroforestry, the different crop and even animal components exhibit different growth and production characteristics that make them resilient to adverse effects of climatic conditions.

The study validated earlier claims that agroforestry is an effective climate change adaptation strategy. Because of the direct (e.g. fodder, food, livestock, fuelwood, poles, etc) and indirect (e.g. soil amelioration, soil fertility improvement, live fencing, etc) solutions that agroforestry systems provide, the agroforestry farmers were able to cope with the effects of climate change. Agroforestryas an adaptation strategy to climate change based on the documentation of the study sites had resulted into enhanced resilience and reduced vulnerability of communities as the farmers diversity their production system to meet their livelihood needs (*Burton 2002*).

Among the benefits that agroforestry bring to the farmer-respondents during the period of climate change are as follows:

1. The declining production/yield of one crop is compensated by the other crops. The diversity of crop components provides lesser risk on the farmers because there are other crops that could substitute for the loss or failure of the other crops.

2. Interaction of the diverse crop components provide opportunities to get away with the costly farm inputs. The integration of nitrogen-fixing species such as *Rensonii* and kakawate provide soil amelioration benefits. Dried leaves and litterfall of woody perennials and agricultural crops are used as mulch for soil and water conservation. The presence of woody perennials, particularly the forest trees provide ecological services.

CONCLUSION AND IMPLICATIONS

This study captured the perceptions and direct experiences of smallholder agroforestry farmers with regards to climate change. Results indicate that these farmers have been experiencing the impacts of climate change, and try to devise strategies that will help cope or adapt to climate change impacts. While the local knowledge of farmers in climate change adaptation are highly recognized, the concerned research and extension institutions shall design a climate change communication program that will enhance the awareness of farmers and other sectors concerned about climate change and the site-specific climate change adaptation strategies. Communicating climate change issues and knowledge is therefore necessary, not only to warn farmers and other concerned sectors about the effects of climate change, but more importantly to come up with innovative way of adapting to climate change impacts.

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