Journal of Developments in Sustainable Agriculture 5: 47–63 (2010)

Enhancing Food Security in the Context of Climate Change and the Role of Higher Education Institutions in the Philippines

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Growing evidence of global climate change, specifically in the Philippines, has forced us to respond to its impacts to ensure the wellbeing of our people.

Scientists are in agreement that, over the last 150 years, the Earth has warmed by 0.7℃. In the Philippines, the projected increase in temperature, based on the trend for the period 1951–2006, is in the range of 0.8–2.4℃ by 2050. Reduced rainfall has also been noted in some areas, particularly during El Niño events, whereas there has been an increase in rainfall over Western Visayas. Also, the number of tropical cyclones appearing in the Western Pacific seems to be increasing, but no individual tropical cyclones can be directly attributed to climate change.

Climate change is expected to have adverse impacts on many sectors. Sea level rise is a threat to coastal communities and island ecosystems. Weather changes and climate variability could severely affect coastal fisheries because of flooding and coral bleaching. Limited rainfall during the growing season and excessive rainfall during wet months are expected to cause a decline in agricultural productivity; coupled with population increases, this could place more people at risk from hunger. Typhoons such as Ondoy and Pepeng have caused extensive damage to life, property, and agriculture in the Philippines. These two typhoons have triggered speculation of food insecurity and have forced the national government to address the challenges brought about by climate change. This challenge is presented here with respect to the potential role of tertiary educational institutions—how do we enhance our people's capacity to adapt to changes in climate?

Key words: climate change and food security, Philippines climate change, higher education and climate change, agriculture and climate change

Introduction

Growing evidence of climate change around the world and in the Philippines in particular has left us with no choice but to act, and act fast, in a coordinated way. The issue of climate change and climate variability is among the top priorities of governments today because of growing recognition of its potential and real threat to our environment as well as to human systems, including agricultural production, biodiversity, health, and other sectors and processes (IPCC, 2007). Extreme climatic events, such as frequent occurrences of strong typhoons, prolonged wet and dry seasons, and increased incidence of disease outbreaks, affect the sustainability of agricultural production systems, thus leading to food and livelihood shortages (IPCC, 2007).

The Philippines has rich and diverse natural resources. However, the rapid growth of population

Received: November 7, 2009, Accepted: December 21, 2009

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and continuous exploitation of natural resources in the country have resulted in increasing environmental degradation. Environmental problems are further aggravated by extreme climatic events, thus putting billions of people at an unimaginable risk. The Philippines is highly vulnerable to climate change and global warming owing to its archipelagic nature and very extensive coastline. The susceptibility of the different regions of our country to temperature increase and changing patterns of rainfall affects our agricultural areas and fisheries.

This paper aims to present some key evidence of climate change, potential and observed climatic change impacts, and adaptation to and mitigation of climate change. It concludes with a commentary on the role of higher education institutions in addressing the challenges posed by climate change in the Philippines.

The Philippines' Climate Is Changing

Global Warming

A consensus among scientists of the world is that over the last 150 years the Earth has warmed by 0.7℃. NASA recorded that 2005 was the warmest year on record since the 1800s. The recorded temperature increase has influenced the melting of polar ice, which has resulted in sea level rise. Climate is now changing under the combined influences of natural and human activities. In some cases human influences (predominantly the enhanced greenhouse affect) have already overwhelmed natural variations. The changes we are now seeing are the most rapid and sustained for at least the last 1000 years. A comparison of surface temperature and solar irradiance (Solanski *et al.*, 2004) shows the human footprint in the increase in the average global temperature.

Observed Temperature Trends in the Philippines

In the Philippines, increasing trends in temperature for the period 1951–2006 are very apparent. The departures from the 1961–1990 normal values are 0.6104℃, 0.3472℃, and 0.8904℃ for the annual mean, maximum, and minimum temperatures, respectively (Manton *et al.*, 1998). Likewise, a significant increase in the frequency of hot days and warm nights and decrease in the number of cold days and cool nights have been noted. Hot days represent the frequency of days on which the maximum temperature is above the 1961–1990 mean 99 th percentile. Cold nights represent the frequency of days with a minimum temperature below the 1961–1990 mean 1st percentile.

Observed Rainfall Trends

In the Philippines, normal rainfall shows reduced rainfall all over the country (Fig. 1a) as we moved from one normal period (1951 to 1975) to another (1975 to 2000), as much as 500 mm over Luzon (latitude ~12 deg N to 18.5 deg N), highlighted in darker red area in Fig. 1a. *Climatologists define* a climatic *normal* as the arithmetic average of a climate element such as rainfall over a prescribed 30-year. Geographical variations in rainfall becomes more pronounced with Luzon drier than normal while Eastern Visayas (longitude ~123 deg E to ~126 deg E) wetter than normal, during El Niño years (Fig. 1b) and even much more during La Niña years (highlighted area in dark green, Fig. 1c), as much as 400 mm more than the previous normal values. Considering all the years, we see Northeastern Luzon tends to be drier (indicated by the grid box in Fig. 1d) than the rest of the country.

Figure 2 shows the high variability of rainfall for individual El Niño years (twelve months total values starting from April to March of the following year). The 1997–1998 El Niño event remains the driest episode on record in the Philippines, as the rest of the world.

Tropical Cyclone Trends

In terms of geographical tracks, the number of tropical cyclones (TCs) appearing in the Western Pacific seems to be increasing. In the Philippines, the rise in the number of TCs crossing land is most pronounced over Visayas (MO, 2009, Hilario, 2010). Other studies indicate that the peak wind speeds of TCs have also been increasing, magnifying the damage caused. However, no significant trend is apparent in the number of annual tropical cyclone events in the Philippines' area of jurisdiction. An average of 20 TCs still prevails (see Fig. 3), with a large year-to-year variability (from 11 to 33; that is largely attributed to the El Niño-Southern Oscillation phenomenon (PAGASA 2002). The most recent typhoons that hit the country, Ketsana ("Ondoy"), Pharma ("Pepeng"), and Melor ("Quedan"), were manifestations of the changing

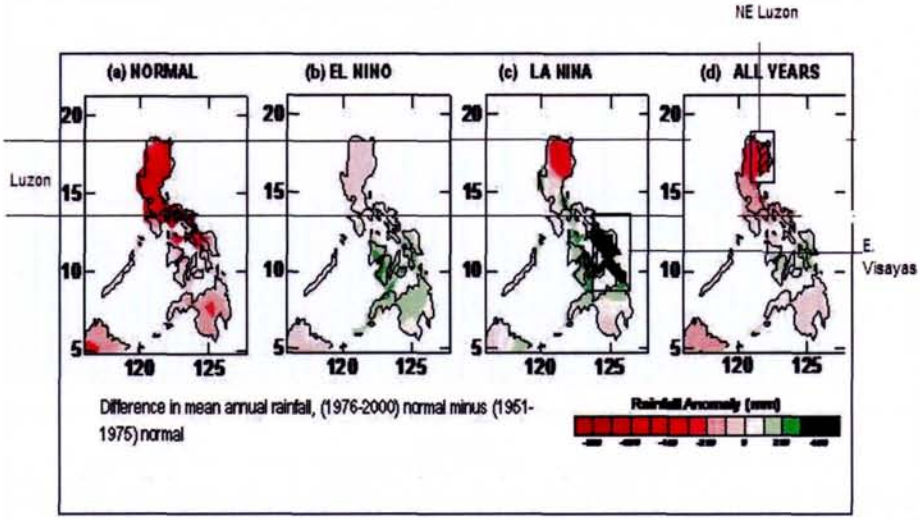

Fig. 1. Changes in mean annual rainfall over the Philippines. Difference between the average rainfall of two 30-year periods. Period is from 1951–1975 and the other period is 1976–2000. ENSO events are based on the Multivariate ENSO Index (Manton *et al.,* 2001).

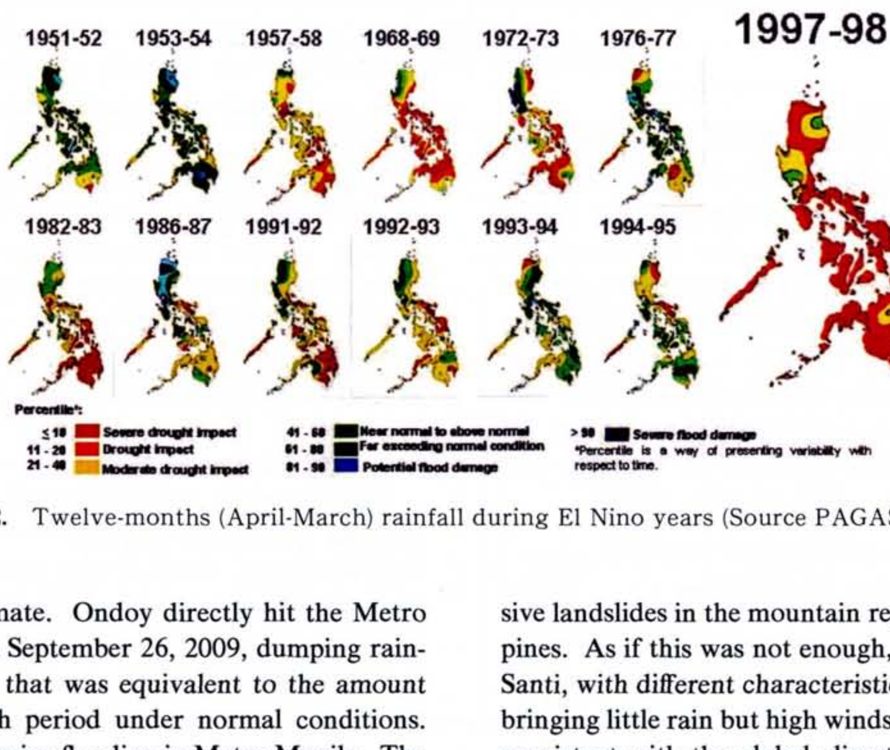

Fig. 2. Twelve-months (April-March) rainfall during El Nino years (Source PAGASA 2000).

Philippines climate. Ondoy directly hit the Metro Manila area on September 26, 2009, dumping rainfall in 3 hours that was equivalent to the amount over a 1-month period under normal conditions. This caused massive flooding in Metro Manila. The following typhoon, Pepeng, hit a few days after Ondoy moved on and caused damage to the northern part of Luzon, the main island of the country. Pepeng was an unusual tropical storm because of its redirection. While Pepeng was on its way out of the Philippines, another typhoon, Melor, attracted it back, resulting in submergence of the agricultural areas and urban areas of northern Luzon and massive landslides in the mountain region of the Philippines. As if this was not enough, another typhoon, Santi, with different characteristics, passed quickly, bringing little rain but high winds. These trends are consistent with the global climate change patterns that have been observed by World's Meteorologists Organization or WMO (Hilario, 2010).

Temperature Projections

From analyses based on the work of Hulme and Sheard (1999), two Intergovernmental Panel on Climate Change (IPCC) emission scenarios (B1, low; and A2, high) yielded an increasing tempera-

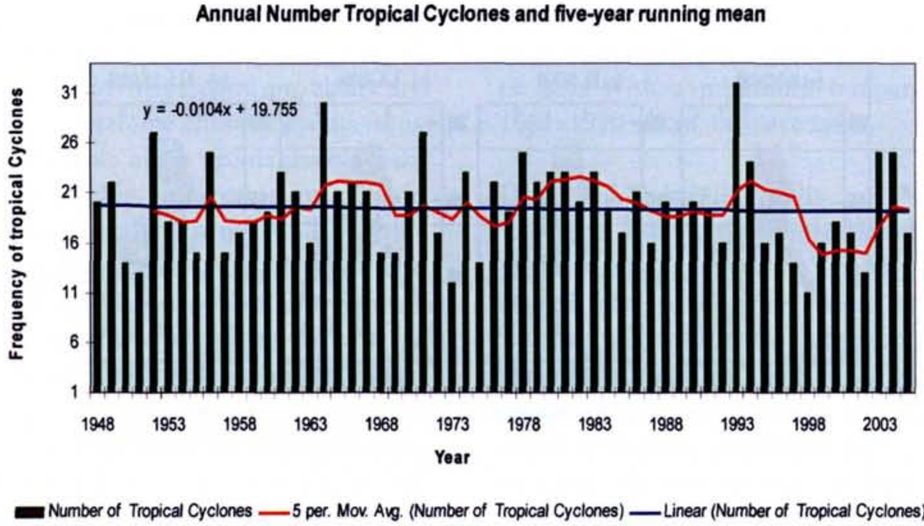

Fig. 3. Annual total number of tropical cyclones inside the Philippine area of responsibility.

ture projection for the Philippines for 2020, 2050, and 2080 (Fig. 4a). The projection for mid-century is within the range of 0.8–2.4℃.

Rainfall Projections

Global climate models predict mixed or weak rainfall trends toward the end of the 21st century for the southeast region, especially in the Philippines (IPCC, 2007). This is also reflected in the projections of Hulme and Sheard (1999) for the middle of this century, which although indicate small changes, tend to show a drier dry period (December-February or Northern Hemisphere winter) and a wetter wet period (June-August or Northern Hemisphere summer) for both low and high IPCC emission scenarios (Fig. 4b).

Impacts of Climate Change in the Philippines

The IPCC (2001) reported that "climate in Tropical Asia is characterized by seasonal weather patterns associated with the two monsoons and the occurrence of tropical cyclones in the two core areas of cyclogenesis." The IPCC also noted that mean surface temperatures across Asia have increased in the range of 0.3–0.8℃ in the last century. Moreover, a decrease in mean rainfall has been experienced by many Asian countries in the past three decades (IPCC, 2001).

Because of its archipelagic nature, the Philippines is very vulnerable to coastal erosion and land loss, flooding, upstream movement of saline water, and seawater intrusion into freshwater basins (Philippine Second National Communication, 2009). Sea-level rise and frequent tropical cyclones will place people and properties in the coastal areas at major risk.

Crops are very sensitive to climate change; however, the net effects of changes in crop yield, production, storage, and distribution due to climate fluctuation may vary in different regions because of several factors, such as varietal and local differences in growing seasons, crop management, regional location and characteristics (BAR, 2009).

Sea-Level Rise and Flooding

The Philippines is an archipelago of 7107 islands and has a coastline that extends over 34,000 km. The 10 largest cities of the country, including Metro Manila and the city of Cebu, lie on the coast.

Sea-level rise is caused by an increase in the Earth's temperature, leading to the rapid melting of glaciers in various parts of the world. The Manila Bay coastal region has a population of over 10 million and serves as a focal point of commercial, industrial, agricultural, and aquacultural activities (Crosby, 2005). A vulnerability assessment study conducted in the Manila Bay coastal area by Perez, Feir, Carandang, and Gonzalez (Crosby, 2005) showed that mean sea level has been increasing since 1965 and in recent years has exhibited a rapid increase of between 20 and 40 cm (Crosby, 2005).

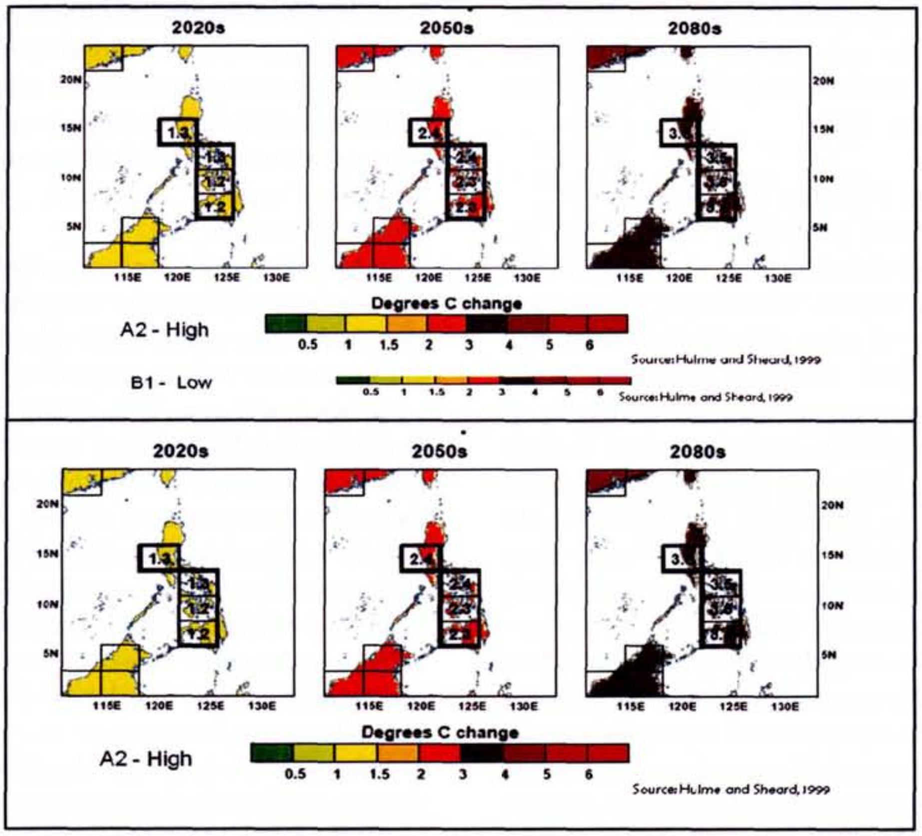

Fig. 4a. Temperature projections for 2020, 2050 and 2080 with low and high IPCC emission scenarios (from Hulme and Sheard, 1999).

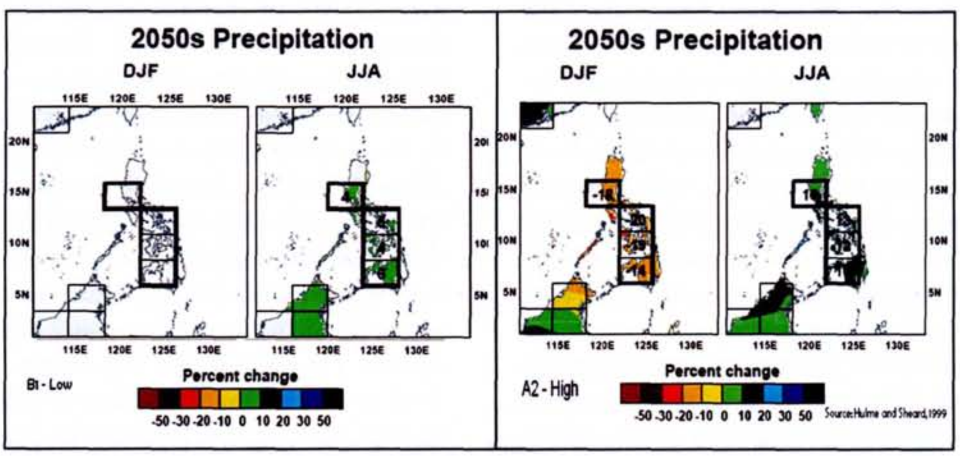

Fig. 4b. Rainfall projections for the middle of this century (from Hulme and Sheard, 1999).

Industrialization, urbanization, and human migration in coastal areas over the past 10 years have intensified significantly, thus making these areas more susceptible to flooding.

As the country's population grows, ecosystems are continuously degraded. This situation will worsen the occurrence of flooding and inundation in low-lying coastal areas. Seventy percent of the country's infrastructure is located in the low-lying areas of Metro Manila, Cebu, and Davao; therefore, if sea level continues to rise, about 50 million people will be at risk (Espaldon, 2007). This peril may be further aggravated if storm activities increase. Fisherfolks and informal settlers in coastal cities are expected to be severely affected by climate change (Espaldon, 2007).

Agricultural and Fisheries Production

Crops are directly affected by weather and climate. Thus, crop production is at risk during extreme weather events. Substantial weather and climate changes will affect the growth of crops and may result in yield decreases (Lansigan *et al.*, 2000). However, crop production risks due to typhoons may vary from one location to another (Lansigan *et al.*, 2007). On the basis of the spatial distribution of the occurrence of typhoons in the Philippines, typhoons are expected to occur more frequently in the central and northern parts of the country (Lansigan *et al.*, 2007).

A survey of rice farmers in Nueva Ecija in 1995 revealed that the occurrence of strong typhoons during the wet and dry seasons caused 28.9% and 34% damage to crop yield, respectively (Lansigan, 2007). Damage to crop yields due to typhoons may cause an 80% to 100% yield loss in corn (Lansigan *et al.*, 2007). Avanzado-Cuevas in 2003 (in Catacutan, 2004) noted in a study a significant increase in runoff and soil erosion within the Manupali watershed in Mt. Kitanglad, Bukidnon during the 1999 La Niña event. A net income loss of PhP 912.06 ha^{-1} in corn production was also experienced.

The Philippines' Department of Agriculture (DA) reported that the country's production of major crops dropped by at least 14.36% due to El Niño and intense typhoons in 1998 (Monsalud and Montesur, 2003a). Two of the most important crops in the Philippines are rice and corn. Rice serves as the major staple food, whereas corn is the main source of feeds for the livestock industry (Lansigan *et al.*, 2007). Compared with crop production of the 1997-1998 with crop production in 2002, rice and corn yields decreased by 24.1 and 11.7%, respectively. Coconut production dwindled by almost 13% and sugarcane production by 17.3 %; mango, banana, and coffee production also declined. An extended drought that spanned 1997-1998 caused sugarcane and banana production to decrease, but pineapple production diminished because of crop shifting and late planting. In contrast, tobacco and abaca or Manila hemp production improved during the 1997-1998 dry season. The National Tobacco Administration helped to increase tobacco production by providing financial assistance and implementing various programs, whereas abaca production increased because of favorable weather conditions (Monsalud and Montesur, 2003a).

In Nueva Ecija, extreme climatic events due to El Niño greatly affected the cropping calendars for rice and other crops and also income yields (Monsalud and Montesur, 2003b).

In terms of livestock, the Food and Agriculture Organization (2007) noted that livestock production may decrease because of a reduction in the output of feed grains as a result of drought and unfavorable foreign exchange. DA reports in 1998 (Monsalud and Montesur, 2003a) showed that carabao and cattle production increased by 6.5% and 3.7%, respectively. However, chicken production decreased by 1.1%, and broiler production dwindled later in the same year.

Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development or PCARRD (Monsalud and Montesur, 2003a) reported that farming is the major source of income in selected municipalities of Pampanga, Camarines Sur, Catanduanes, Bulacan, and Zambales. However, 50.6% of the respondents experienced food shortages due to El Niño. Drying of crops and fishpond areas, reduced fish catches and absence of fish in the usual catch areas, as well as an increase in the price of food commodities, were the causes of food scarcity, as cited by local respondents (Monsalud and Montesur, 2003a).

This experience also demonstrates that fisheries can be severely affected. Degradation of water resources may reduce the water supply for aquaculture (Monsalud and Montesur, 2003a). The 1999 report of the Philippine Council on Marine and Aquatic Resources Development estimated PhP 6.2 billion economic loss in aquaculture production in the 1998 El Niño event (Monsalud and Montesur, 2003a). Regions III and VI, which are devoted to aquaculture and marine fisheries, were seriously damaged. In the Autonomous Region of Muslim Mindanao (ARMM), seaweed production dwindled, causing high economic losses there (Monsalud and Montesur, 2003a). The extent to which the El Niño or similar events contributed to the losses, however, needs further examination because of the possibility of other causes of production decline, such as water quality degradation. Weather changes and climate variability could also seriously affect coastal fisheries because of coral bleaching.

Water Shortage

The IPCC 4th Assessment Report (2001) indicated that water shortage is expected with climate change. The El Niño events that the country has experienced, of which 1997 was the worst, have provided a preview of the extent of water shortage that could be expected with climate change. Analyses of seasonal rainfall conducted from October 1997 to March 1998 by the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) revealed that almost 90% of the country experienced a decrease in rainfall (PAGASA-DOST, 1998, in Monsalud and Montesur, 2003a). Likewise, the provinces of Aurora, Batanes, Bicol, Davao Oriental, Leyte, Misamis Occidental, Quezon, Samar, and Surigao had negative seasonal rainfall departures of more than 800 mm, whereas in Iloilo, Batangas, Cebu, and some parts of Mindanao 32% of the water sources, including rivers and springs, were dry (Librero *et al.,* 1999, in Monsalud and Montesur, 2003a).

The occurrence of a potable water shortage in the city of General Santos and Davao del Sur forced the local residents to cut down banana trees and boil their trunks for an alternative source of water (Monsalud and Montesur, 2003a). In addition, various trees and grasses in the mountains of Regions II and III died from water depletion, thus affecting air quality in Region II (Acoba-Battad *et al.,* 1999, in Monsalud and Montesur, 2003a).

Social and Economic Impacts

Monsalud and Montesur (2003a) noted that El Niño affected 267 barangays in Negros Occidental alone in 1997–1998. Widespread hunger among the farming communities, resulting from the fact that almost 8000 ha of sugarland was unfit for production, was attributed to the El Niño event. Damage to crops and livestock was estimated to be more than PhP 140 million. Luzon was greatly affected by the 1997–1998 El Niño as shown in Table 1. Farmers' income was also badly affected, forcing them to adopt alternative strategies to survive.

Table 1. Cost of production inputs lost for rice and corn

Region	Rice (PhP)	Corn (PhP)
Region I	11,467,923	42,682
Region II	271,201,305	406,761,927
Region III	134,196,676	478,200
Region IV	249,776,968	0

Source: Acoba-Battad *et al.* (1999), in Monsalud and Montesur (2003a).

Risk Reduction through Adaptation and Coping Mechanisms

The combined effects of temperature increase, continuous heavy rain, strong typhoons, outbreak of diseases, and prolonged wet and dry seasons have resulted in negative impacts on agricultural production in the country. As conditions under climate change worsen through the years, people need to adjust and employ various adaptive strategies to cope with the situations brought by climate fluctuation. Here, we can easily be trapped into simply identifying the climatic risks or exposure and determining adaptation and mitigation strategies that we can employ. Some environmental scholars, however, caution that adaptation and mitigation in response to any environmental change, such as climate change, need to be understood as a socio-natural or ecological process (the "coupled ecosystem"). A coupled ecosystem refers to the human and ecological systems intricately twined and becomes one unit. Hence, if our objective is to reduce social vulnerability to risks associated with climate change, then we could view vulnerability as having two sides: external vulnerability, which is the exposure to climate risks, and the internal side, which is the coping and adaptation mechanisms. Studies have shown that coping is a "highly complex, contextual and dynamic issue, especially in times of crisis" (Bohle, 2001).

Coping is closely linked to the concept of access, particularly to resources or assets—economic, socio-political, infrastructural, ecological, and personal. It is important to consider that the assets that people control help to mitigate people's vulnerability and strengthen their resilience toward climate risks. The more assets they control, the less vulnerable they are. "Social assets" play a significant role for the most vulnerable populations and sectors. Social assets include social networks of mutual trusts, shared norms, and reciprocity. Among Filipinos, this is the very core of our community. The other issue of significance in coping strategies is the conflict and crisis theory, which notes that the capacity to manage crisis situations and solve conflicts successfully will be a determinant of how well the communities can cope with climate risks.

Coping and adaptation measures as part of adaptive management can reduce the vulnerability of different stakeholders, especially farmers (Lansigan *et al.,* 2000), fishermen, urban centers, and coastal regions (Sales, 2005). These can be classified as anticipatory and reactive, autonomous and planned, and public and private adaptations (IPCC, 2007b; Klein and Smith, 2003; Adger, 2003; Smit and Pilifosova, 2003):

1. Anticipatory adaptation occurs before the impacts of climate change are observed (also referred to as proactive adaptation).
2. Reactive adaptation takes place after the effects of climate change have been observed.
3. Autonomous adaptation is triggered by ecological changes in natural systems and market or welfare changes in human systems (also referred to as spontaneous adaptation).
4. Planned adaptation is the result of a deliberate policy decision.
5. Private adaptation is usually initiated by individuals, households, or private companies and is commonly done in the actor's rational self-interest.
6. Public adaptation is directed at collective needs and is implemented at all government levels (also called societal adaptation).

A Review of Adaptive Measures in the Philippines

The IPCC (2001) proposed two general strategies on adaptation that can be used: macrostrategy and microstrategy. Macrostrategy involves rapid development. The IPCC has highlighted the need for the elusive goal of rapid economic growth and development along a sustainable development path:

Sustainable and equitable development will increase income levels, education, and technical skills and improve public food distribution, disaster preparedness and management, and health care systems in developing countries of Asia. All of these changes could substantially enhance social capital and reduce the vulnerability of these countries to climate change.

Meanwhile, microstrategy aims to modify the management of sectors that are highly susceptible to climate change such as institutions and infrastructures that can incorporate risks of climate change (IPCC, 2001).

Although the IPCC has recommended different adaptive measures for various sectors, such as adjusting the cropping calendar and crop rotation for the agri-sector, the country already has a number of different types of adaptive measures that are related to environmental sustainability, if not directly associated with climate change adaptations. Today, these technologies can serve as adaptation strategies. These strategies capture both the indigenous and local wisdom and technical and scientific knowledge of local communities, but there is a need to fully document these so that we do not duplicate effort. At the moment, technologies and approaches can be categorized into two types: "soft" approaches and technological or technical solutions. Soft approaches refer to the mode of arrangements among stakeholders, which are more process- than technology-based. The farmer-scientist approach and landcare are examples of soft approaches; these are inclined toward strengthening the capacities of individual farmers/sectors to enable them to build strong partnerships with others (local government units, non-government organizations, government agencies and international research agencies). The technological approaches focus on the simple transfer of technologies from source to communities. Technologies that can be relevant for climate change risk reduction include crop management (including varietal selection); biomass and nutrient management (including composting); water management; and efficient energy use. Indigenous technologies such as natural pest management, drought resistant crops and water capture systems are also available for further promotion and dissemination to other similar localities.

Farmer-Scientist Training Program using the farmer-scientist partnership

The Farmer-Scientist Training Program (FSTP) for sustainable development, an extension program of the University of the Philippines Los Baños (UPLB) College of Agriculture through the Agricultural Systems Cluster, started in Cebu in 1994 and aims to help farmers develop their technical and scientific skills in growing corn and other crops with the use of sustainable technologies. This is done through direct contact with agricultural experts (Seminiano *et al.,* 2005). FSTP teaches farmers to develop a modern approach and openness to innovations. As part of the outcome, the Cebuano farmers have adapted diversified agricultural practices and technologies that could reduce their vulnerability to changing rainfall conditions. The partnership has also improved the farmers' access to assets, such as information, political influence, and the capacity to deal with new conditions.

Landcare approach

Landcare began in Claveria, Misamis Oriental, in 1996 and is an approach for developing collective actions to address the problem of land degradation (Espaldon *et al.,* 2006). At the center of this approach is the community landcare group in partnership with local government units and nongovernment agencies. Villanueva (2006) showed the potential of this approach to promote soil and water conservation technologies and at the same time enhance the resilience of communities to drought and heavy rainfall. Contour farming, also promoted through landcare, has contributed to the resilience of upland farms in Bukidnon to heavy rainfall in terms of protecting the fertile but thin soils of upland farms (Pulhin *et al.,* 2009). Although the landcare approach promotes particular soil and water conservation techniques, such as natural vegetative strips and agroforestry, the approach is more inclined toward enhancing the capacity of farmers to modify technologies to fit their farm conditions and assets. The contribution of a research institution in partnership with the LGU can be a very critical aspect of Landcare. One of the major lessons learned here is that there is a leveling off of the various roles of partners and the open communication line between and among players. In this case, PCARRD, an agency under the Department of Science and Technology, has assisted the local government units in establishing the Farmers Information Technology System, which serves as an information bank for local communities.

The formation of autonomous farmer organizations with good institutional linkage and institutional support from credible local organizations can help farmers to cope with the impacts of climate change (Pulhin *et al.,* 2009). Farmer-leaders are the best trainers on soil conservation and upland crop production; and farmer-scientists can be of great help, as they carry out crop variety selection on their own farms. Micro financing and a dependable and honest linkage of farmer organizations with the market are also suggested to be part of the social adaptation mechanism.

Cropping Patterns and Management

Some possible coping strategies for rice production, such as the use of early-maturing rice varieties in unstable production areas, can be used in the face of climatic variability (O'Toole and Chang, 1978, in Lansigan *et al.,* 2000). Ratooning for shorter growing periods; planting lodge-resistant, nonshattering, and waterlogging-resistant varieties; establishing windbreaks in strategic areas; developing methods to conserve rainwater to extend cropping period; and developing simple implements for rapid harvesting and postharvesting handling are also possible coping strategies (Pantastico and Cardenas, 1980, in Lansigan *et al.,* 2000).

The Organic Rice Farming and Bio-Diverse, Integrated, Organic (BIO) Farm System is a technology that is particularly relevant to climate change issues in terms of its overall impact in reducing the energy consumption of the rice production system. Mendoza (2004) indicated that the cash capital expense of organic rice farming was 33% (USD 39 ha^{-1}) of that of conventional farming (USD 118 ha^{-1}). Mendoza also noted that organic farming improved soil quality, and despite the slightly lower yields on organic farms (3.25 t ha^{-1}) than on conventional farms (3.52 t ha^{-1}), organic farming yielded higher net revenue (USD 332 ha^{-1}) than conventional farming (USD 290 ha^{-1}). Moreover, organic farms consumed less energy than conventional farms (1 t of paddy rice used only 170 Mcal fossil fuel-based energy inputs but used 884 Mcal in conventional farms) (Mendoza, 2004).

Another agri-system being tested is the BIO farm system that aims to produce food for the households given a limited resource (land, labor, capital) and to develop a farming practice that uses water efficiently (Mendoza, 2007).

The resilience and adaptability of the BIO farm was proven after the occurrence of typhoon *Milenyo* in September of 2006 (Mendoza, 2007). Many of the crops of the BIO farm survived, including okra (*Abelmoschus escuclentus*), saluyot (*Corchorus capsularus*), camote (*Ipomoea batatas*), gabi (*Colocasia esculenta*), cassava (*Manihot esculenta*), kangkong (*Ipomoea aquatica*), Jatropha (*Jatropha curcas*) seedlings, and calamansi (*Citrofortunella microcarpa*). In addition, the plants became drought tolerant during the dry months and became water logging resistant during the wet season. Mendoza surmised that this could be attributed to the combination of mulching and organic fertilizer application to the plants.

Biomass and Nutrient Management

Vermicomposting, which produces compost worms and vermicompost (Adorada, 2007), can be a good alternative source of income (Binahon, 2007). Aside from being economically viable, vermicomposting affects water, air, and land resources in positive ways: through organic waste management, air pollution control, and reduction in the application of fertilizers and pesticides.

Solid Waste Management

Proper practice of solid waste management can play a vital role in mitigating the effects of climate variability. Zamora (2001) listed solid waste management strategies as waste reduction, recycling, solid waste collection management, enhancing waste management education, establishment of a waste information network, and disposal and residual management. Materials such as plastics bags, plastic containers, polystyrene foam, and tin cans release certain types of greenhouse gases when burned. Hence, reuse of these materials will help trim down the amounts of waste and greenhouse gases released to the atmosphere.

Indigenous Technologies

Indigenous crops and livestock practices to lessen the effects of El Niño are still widely used in some provinces, such as Bulacan, Pampanga, Catanduanes, and Camarines Sur (Monsalud and Montesur, 2003 a). Indigenous technologies, such as use of smoke from burning agricultural residues within pest infected farm plots or *pausok,* use of herbal pesticides, lighting of lamps at night to keep insects away, and placing poison frogs in the field, are being practiced in Pampanga as plant pest control measures. Farmers from Catanduanes and Camarines Sur use smudging technology, soapy water spray or water mixed with small pepper juice extract to control pests. Animal manure is being used as soil fertilizer in all four provinces, but Pampanga is the only province of the four that uses composting and guano as fertilizers. Diagonal planting, soil cultivation, covering of young plants during intense heat, and no weeding are some of the other methods used in planting to mitigate the effects of climate change. Although some of these technologies have been proven effective over time, other practices need further study.

Some farmers in Camarines Sur do not weed around their plants (Monsalud and Montesur, 2003 a). However, weeds are known to compete with plants for nutrients, leading to decreases in crop yield. Weeds can reduce grain yields of upland rice in the Philippines by about 80% (Mercado, 1979, in Legaspi *et al.,* 1989). In a field experiment at UPLB to determine the effects of handweeding on grain yields in upland rice, Legaspi *et al.* (1989) showed that the absence of weed control produced only 50 kg ha^{-1} of grain, whereas a single weeding increased yields to 2000 kg ha^{-1} and two weedings increased yields to about 2500 kg ha^{-1}. Complete weed control produced 3000 kg ha^{-1} of grain. Thus, they concluded that weeding increases grain yields in upland rice.

In livestock production, corn and sugarcane stalk trash, vegetable rejects, and leaves of crops are used as alternative animal feeds and feed supply (Monsalud and Montesur, 2003a). *Darak* (rice bran) is mixed with commercial feeds to serve as filler. In addition, the *supak* method of feeding and *kumpay,* a kind of grass or coarse food fed to horses or cattle, are used. The *supak* method is "a force-feeding method for animals using bamboo tubes containing rice bran. The bamboo tube is placed inside the animal's mouth to feed the animal" (Monsalud and Montesur, 2003a).

To prevent the spread of diseases in animals during El Niño, Catanduanes use *huag,* a ring made of rattan that is placed around the animal's neck to ward off insects (Monsalud and Montesur, 2003a), whereas residents of Pampanga use *pausok sa gabi* (smoking). Strict quarantine is practiced in Camarines Sur to avoid contamination and the spread of diseases (Monsalud and Montesur, 2003a).

Risk and Management Strategies among Farmers and Indigenous People

Upland households cope with the problem of El Niño by selling their livestock or their farm lands, planting root crops, consuming less, changing their social activities, or selling a smaller proportion of their production. Others transfer to areas where cropping is favorable or work as hired laborers or food vendors (Peras, 2005). Another group vulnerable to climate change is the indigenous peoples. Bornales (2004) noted that Subanens of Mt. Malindang in the province of Misamis Occidental practice land and crop rotation, a shift in agricultural crops, expansion of cultivation areas, out-migration, family planning, formation of organizations, and a change in food consumption. However, the Subanen people have remained vulnerable to the impacts of adverse environmental conditions because of a lack of skills to shift to other livelihoods and a lack of assistance from the relevant institutions and agencies. Other strategies adopted by households during El Niño crises have been reallocation of the household budget, borrowing money, availment of credit, sale of assets, praying, and seeking support from community and kin (Peras, 2005). Again, social capital remains central to enhancing the capacity of poor households to deal with climatic risks.

For the fisherfolk, engaging in upland farming is encouraged. The integration of upland development with coastal resource management will help fisherfolk to cope with climate change-induced abnormal weather, especially when the seas are not favorable for fishing (Peras, 2005).

Water Management

Small water impounding projects have been introduced to help farmers mitigate their vulnerabilities to drought conditions. These can serve the upland portions of agricultural areas and are designed as flood mitigation measures, as well as to provide water for crop diversification and intensification, livestock production, and fish production (Monsalud and Montesur, 2003a).

Shallow tube wells have the potential to irrigate more than 5 million ha in the country. Some of the advantages of these wells include cost effectiveness, openness to privatization, rapid installation, high water efficiency, and simplicity of operation and maintenance (David, 2003). However, the its promotion has been hindered by the lack of support services from some agencies, deficiency of baseline information on aquifers, lack of benchmark information on suitable well development and well drilling techniques, lack of affordable and suitable drilling rigs, and unavailability of pump sets (David, 2003). Furthermore, expansion in the number of shallow tube wells could also lower groundwater levels in the vicinity of the pump wells. This could result in a decrease in the dry season flows of natural waterways, reduced groundwater flow toward mangroves and other coastal area ecosystems, and increased salt-water intrusion in coastal areas. Hence, these should be used with caution.

A small farm reservoir is a water-impounding earth dam structure used to collect rainfall and runoff. It is designed for use on a single farm (Monsalud and Montesur, 2003a). Construction of a small farm reservoir corresponds to the needs of farmers to diversify, because these structures can conserve water while it can be used to raise fish and to provide supplementary water for vegetable crops (Monsalud and Montesur, 2003a). These structures provide higher benefits in areas with a unimodal pattern of rainfall. They are established in areas that receive the most runoff from the farm, can meet the water requirements of rainfed farms, and provide a time-tested practice among rainfed farmers in central Luzon and other parts of the country. Their viability has been tested at the farm level. In addition, on rainfed farms, the presence of a small farm reservoir increases rice yields (0.3 t ha^{-1}) during the wet season because it serves as reservoir for excess runoff hence prevent flooding of the crops; allows other income-generating activities, such as dry season cropping, fish culture, and agroforestry; reduces the velocity of water flow from higher areas; and helps groundwater recharge.

Water harvesting is a method by which rainwater is captured during the rainy season and used in the dry season for irrigation. One such scheme or system uses the roof of the house as a rain collector and directs the water to a storage tank.

Cloud Seeding

Drought in agricultural areas can be alleviated by cloud-seeding operations. The Bureau of Soils and Water Management maintains two airplanes, RP C1243 and RP C1244, for making artificial rain (Monsalud and Montesur, 2003a). Cloud seeding is a form of weather modification and is used to change the amount or type of precipitation that falls from clouds. This is done by scattering substances into the air that serve as cloud condensation or ice nuclei. Silver iodide, dry ice, and salt are the substances most commonly used in cloud seeding (Monsalud and Montesur, 2003a).

Recent Technologies and Alternative Fuels

1M Agro-Fuel Development Ventures, Inc., in Silang, Cavite, Philippines, has developed an ecological alternative fuel to replace the conventional charcoal used in cooking by most households. The X-hot Charcoal Briquette is a high-quality charcoal briquette made from coconut wastes, such as husk and shell. This new technology is smokeless and odorless, and eight to 10 briquettes can produce 2 hours of heating. It is a suitable alternative fuel for homes and industries because of its affordability. Moreover, the conventional *uling* (wood charcoal) used in economical cooking comes from the cutting of trees. With the use of the X-hot Charcoal Briquette, environmental degradation is minimized, since this product comes from coconut wastes. In addition, the establishment of a charcoal processing plant can provide an alternative source of livelihood, especially in areas where coconut is abundant.

Forestry Mitigation Options

Rivera (2003) noted that forest protection ranked first in terms of its financial and economic profitability, and ability to increase carbon sequestration. Agroforestry ranked high in its economic and financial profitability but lower in its carbon sequestration ability when compared with forest protection.

To mitigate the impact of low rainfall, which adversely affects livestock because of lack of fodder, indigenous trees and shrubs were introduced as fodder. According to Calub and Lasco (1999), indigenous trees and shrubs provide good-quality fodder that supplements low-quality native grasses and crop residues during the dry months.

Mitigating Climate Change through Carbon Capture and Storage

The accumulation of carbon dioxide in the atmosphere and the destruction of forests contribute to climate change or global warming. Carbon capture and storage (CCS) is an approach to mitigate global warming by capturing carbon dioxide from large point sources, such as power plants, and subsequently storing the captured gas instead of releasing it into the atmosphere. The Clean Development Mechanism is based on the carbon capture and storage principle whereby carbon is traded (with a cap) with the industrial countries that emit carbon.

Role of Higher Education Institutions in the Philippines

Climate change is a real threat to agriculture, livelihoods, and the food and nutrition security of resource-poor farmers and fishers in the Philippines. It will have serious impacts on the four dimensions of food security (FAO, 2007): food availability, food accessibility, food utilization, and food system stability. An example of how food security is threatened is the recent typhoons and heavy rainfall events during the wet season in the Philippines; these destroyed an estimated PhP 17–23 billion worth of infrastructure and agriculture product, excluding the cost to lives, health (leptospirosis outbreaks in evacuation centers), and private property. Livelihoods based on agriculture are very vulnerable and may lead to food and nutritional insecurity due to risk of increased crop failure, new patterns and greater virulence of pests and diseases, and lack of climate change-adapted crop planting materials and animal breeds.

Because of this, there is a need to assist resource-poor farmers to improve their capacity to adapt, strengthen, and sustain their livelihoods and to ensure their food and nutrition security. The Philippines' Department of Agriculture, Bureau of Agricultural Research, has formulated a program for 2010–2015 that is anchored in conducting research, development and extension activities and strategies, systematic institutional responses, and development and implementation of science-based adaptive technologies. The program adopts a landscape approach to enhance the food and nutrition security of the local communities. It takes into consideration the fact that any effort to address the impacts of climate change on agriculture must be viewed in a holistic manner, considering the interconnectivity of the watersheds and upland and lowland agricultural systems and coastal and marine environments.

The program highlights the fact that adaptation to climate change and mitigation programs, whether long term or short term, are influenced by the variety of roles that institutions play in a secure livelihood, food, and nutrition. Hence, the performance of local institutions in climate change adaptation and mitigation for food security at the household and community levels needs to be strengthened. The program aims to develop a road map that would incorporate capacity-strengthening of the LGU, farmers and farmers' groups, NGOs, and other stakeholders through public education, focusing on climate change and the environment, people/farmer empowerment, and sustainability toward attainment of food and nutrition security and improved livelihood opportunities in response to climate change. Successful experiences and best practices should be communicated to a wider audience, scaled up, and scaled out to benefit a greater number of farmers and to influence the mainstream institutions to adopt mechanisms for adaptation to climate change. Major components of this program are research and development, policy development, and capacity building.

The Philippine Commission on Higher Education (CHED) has registered 16 national universities and colleges that offer BS Agriculture programs and advanced degrees in agriculture in different regions of the country, as well as 51 provincial institutes and agricultural schools as shown in Table 2 (CHED, 2009). There are still a number of tertiary schools that remain to be assessed by CHED. This provides the capacity-building component of the program. These universities and colleges are strategically located throughout the country and could play a significant role in capacity building among local communities and local government units. However, they need to be engaged in the research activities of the line agencies in order to be at the forefront of climate change research in their respective regions. Led by a national university, such as UPLB, and other state universities located in each region, the promotion of innovative approaches and advocacy can be mainstreamed in an effective manner.

To date, key universities and state colleges have embarked on short-term and long-term research and development strategies to enhance food security and the adaptive capacity of farming and fishing communities. Two major networks of environmental education institutions such as the Environmental Education Networks of the Philippines and the Philippine Association of Tertiary Level Institutions for Environmental Management have spearheaded conferences and symposia to address issues confronting agriculture, the environment and natural resources, and human society in the context of climate change.

The educational institutions are also developing new curricular programs that place climate change education at the forefront of academic discussions. For example, a special topic on climate change is being offered to all departments of the graduate school at UPLB by an interdisciplinary team of professors who are engaged in climate change research. The special topic is the first step in institutionalizing a new course offering at the university. UPLB has also engaged in a tripartite arrangement with the Department of Education, Region V, and the Provincial Government of Albay (through Governor Joey "Sarte" Salceda), Region V, in an effort to mainstream climate change curricula in the country's basic education curricula. In this arrangement, a team of UPLB and other climate change scientists provide an information resource to the elementary, secondary, and tertiary level teachers of the Department of Education. In turn, the teachers are responsible for integrating climate change concepts in lesson plans in science, mathematics, English, Filipino, geography, and

Table 2. State Colleges and Universities in the Philippines in Agriculture (CHED, 2009)

Region	State Colleges and Universities with BS Agriculture	National Universities /Colleges in Agriculture	Provincial institutes in Agriculture	National Universities, State Colleges and Universities
1	4	1	3	Mariano Marcos State University
2	6	1	4	Isabela State University
3	8	1	6	Central Luzon State University
4a	6	1	4	University of the Philippines Los Baños
4b	5	1	4	Western Philippine University
National Capital Region	1			
5	9	1	6	Camarines Sur State Agricultural College
6	14	1	3	Aklan State University
7	8	1	2	Silliman University
8	7	1	3	Visayas State University
9	4	1	1	Western Mindanao State University
10	8	1	3	Central Mindanao University
11	11	1	2	University of Southeastern Philippines
12	6	1	3	University of Southern Mindanao
Autonomous Region of Muslim Mindanao	15	1	1	Mindanao State University Marawi
14 Cordillera Autonomous Region	8	1	4	Benguet State University
16	3	1	2	Agusan del Sur State College for Agriculture and Technology
TOTAL	123	16	51	

music and arts. Currently, scientists have already reviewed these lesson plans and these lessons plans have been evaluated by the Department of Education and are now ready for pilot testing.

In terms of policy development, university-based climate change scientists have provided inputs to legislative committees for the formulation of various laws related to climate change and disaster risk reduction. On October 23, 2009, the National Climate Change Act was promulgated as a law that provides the legal basis for the formulation of the National Climate Change Adaptation and Mitigation Action Plan.

These are some of the works in progress, but we need every hand, every heart, and every mind to create a new mindset that will help human society survive this century.

Conclusion

We conclude with a commentary on what we can do to meet the challenges of climate risk reduction and to strengthen our own capacities to adapt to, and cope with, projected climate change impacts. The IPCC has given us a grim picture of the possible impacts of climate change globally and in Asia. Philippine studies, albeit limited, have highlighted the fact that climate change (climate variabilities) needs to be addressed systematically and that we need to be proactive and coordinated if we are to seriously address these impacts.

Knowledge systems (indigenous and technical) for climate change adaptation and coping mechanisms are available. We have technologies that are available in research institutions and in farmers'/fishers'/community wisdom. However, we do not want to be trapped in a technical worldview that the coping process involves the simple selection of a technology. We have been cautioned by those before us that environmental problems (including climate change) are socio-natural problems and hence a paradigm is required that examines climate change adaptation through the coupled ecosystems lens of social and natural systems. Reducing vulnerability to climate risks requires that we view vulnerability to climate change not only from its external side—the exposure per se—but also in terms of the complex process of coping and adaptation, which requires that technologies be set within the socio-economic-political context. Here, the issue of capacity building of stakeholders is key.

Partnerships with different stakeholders in the Philippines environment need to be enhanced and made more efficient so as to optimize the resources available to us. Some modes of partnerships that work well involve local government units, the research and academic community, nongovernment organizations, and citizen organizations. These kinds of partnerships in various configurations (depending on their roles) can be utilized to implement an integrated program to enhance the capacities of local communities to adapt and cope with climate change in the Philippines.

Although partnerships and technologies are necessary elements of an overall strategy to address climate change impacts, these should be coupled with an information and communication plan to improve knowledge and awareness within both the formal and the informal educational systems, which will play a crucial role.

Acknowledgements

The authors wish to acknowledge the UPLB Interdisciplinary Program on Climate Change, a university-wide program established in June 2007 to respond to the challenges of climate change to agriculture, environment and natural resources, which provided us most of the literature and to Ms. Evangeline Alcantara and Mr. Andre Quiray, Research Associates at the School of Environmental Science and Management, UPLB for helping us complete the citations.

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