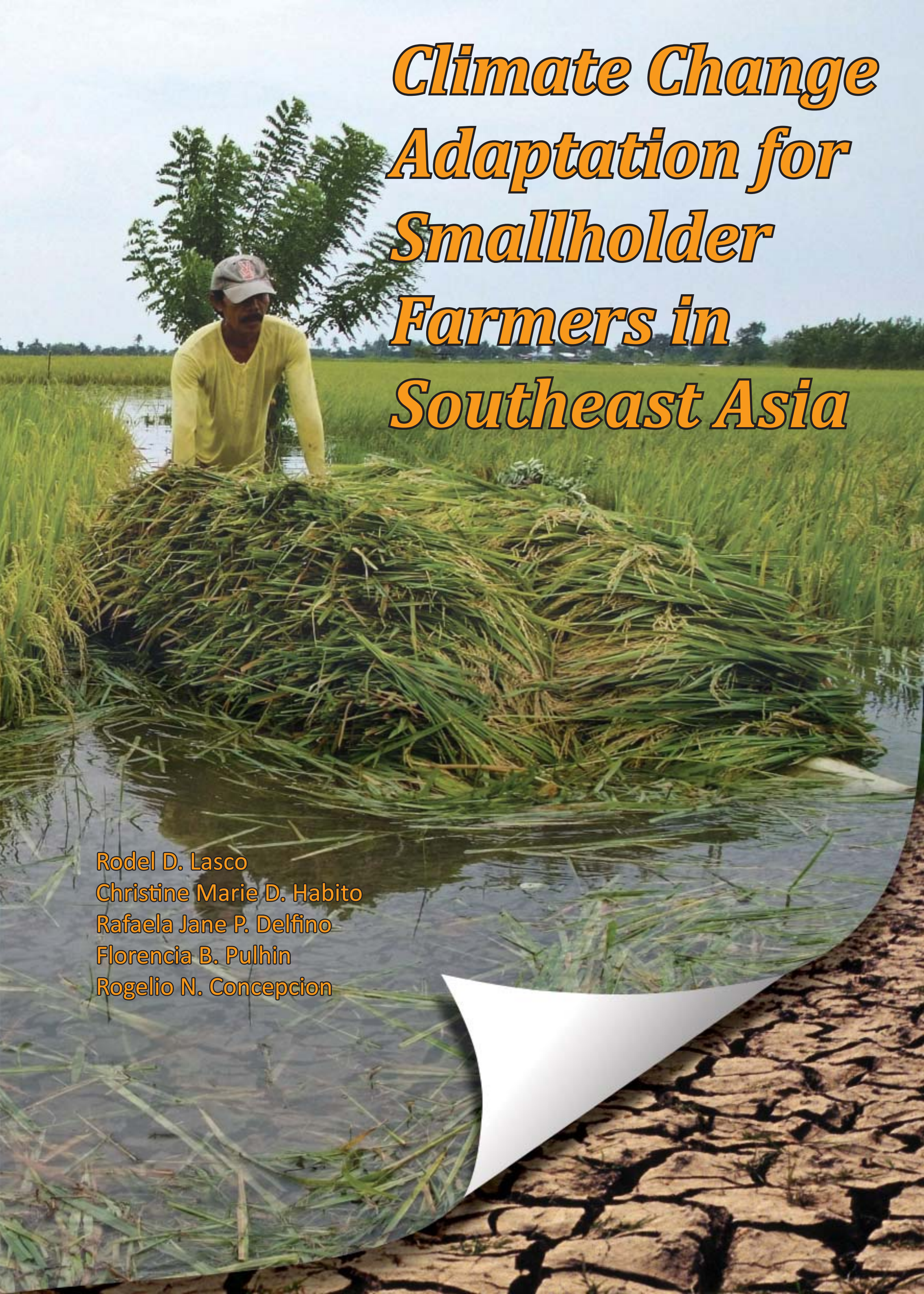

Climate Change Adaptation for Smallholder Farmers in Southeast Asia

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To more fully reflect our global reach, as well as our more balanced research agenda, we adopted a brand new name in 2002 'World Agroforestry Centre.' Our legal name – International Centre for Research in Agroforestry – remains unchanged, and so our acronym as a Future Harvest Centre – ICRAF likewise remains the same.

Views expressed in this publication are those of the authors and does not necessarily reflect the views of ICARF as an institution.

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TABLE OF CONTENTS

Table of contents **i**

Acknowledgement **ii**

1.0 Why be concerned with climate change **1**

1.1 What is climate change? 1

1.2 What causes climate change? 2

1.3 What are the evidences that climate is changing? 2

1.4 What are the effects of climate change in Southeast Asia? 4

2.0 What are the impacts of climate change in agriculture and smallholder farmers **7**

2.1 What are the impacts of climate change on agriculture? 8

2.2 What are the projected impacts of climate change on agriculture? 10

2.3 Why are smallholder farmers vulnerbale to climate change? 12

3.0 What are the existing response options to climate change? 13

3.1 What is climate change adaptation? 13

3.2 What are the goals of climate change adaptation? 14

3.3 Vulnerability, exposure, sensitivity and adaptive capacity 15

4.0 What can smallholder farmers do to adapt to climate change? **17**

4.1 Change crop variety 17

Box 1: Scuba rice 19

4.2 Climate in cropping pattern and crop calendar 20

4.3 Change in current farm management practices 21

Box 2: Technology transfer on water savings 23

Box 3: Ifugao rice terraces 24

Box 4: Communities against fire 25

Box 5: The farmer field school 28

4.4 Diversification of income and livelihood activities 32

4.5 Implementation of carbon finance activities 32

4.6 Collaboration with community organizations 34

Box 7: Small water impounding projects in the Philippines 37

Box 8: Climate change adaptation and gender 38

5.0 How can farmers developm an adaptation strategy **39**

5.1 What is ICRAF? 39

5.2 Case study: Lantapan in Bukidnon, Northern Mindanao, Philippines 42
Glossary of terms **49**
References **55**

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1.0 WHY BE CONCERNED ABOUT CHANGING CLIMATE?

1.1 What is climate change?

Climate change, defined as any change in the average daily weather pattern over an extended period of time (typically decades or longer) whether due to natural variability or as a result of human activity (Easterling et al. 2007, IPCC 2007a), is happening now, and is already affecting many natural systems around the world (IPCC 2007a).

The Intergovernmental Panel on Climate Change (IPCC) declared in its Fourth Assessment Report (AR4) that climate change is unequivocal (IPCC 2007a), evidenced by observed changes in several global and regional climatic indicators. The Food and Agriculture Organization (FAO) expects that considerable efforts would be required to prepare developing countries to deal with climate-related impacts, particularly in agriculture (FAO 2007). However, the IPCC also notes that recent studies show a high confidence that there are viable adaptation options that can be implemented at low cost and/or with high benefit-cost ratios (IPCC 2007a).

At the country level, climate change refers to observable changes and permutations (undefined geographic variations) of temperature, rainfall and extreme climate events and their single or collective impacts on various agricultural production and harvesting activities (Concepcion 2008). Increase in temperature would have whole year and day-to-day on-site impacts that accelerate the changes/decomposition of soil organic matter and loss of soil fertility, which ultimately affects the overall health of crops and livestock. Soil temperature and organic matter are useful indices of ecosystem recovery after disturbance of natural vegetation (Aust and Lea 1991). The varying intensity and patterns of rainfall and extreme climate events (typhoons and El Niño) during the remaining periods of rainy season would have expanded the coverage of climate change off-site impacts which include massive soil erosion and irreversible loss of sloping land soil fertility and life threatening floods and landslide (Concepcion 2008).

1.2 What causes climate change?

Naturally occurring greenhouse gases (GHG) such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3) are present in the atmosphere and are responsible for keeping the temperature on Earth at optimal levels to support life.

In pursuit of satisfying modern development and changing lifestyles, human beings contribute immensely to the accelerated accumulation of GHG in the atmosphere: carbon dioxide is released when forests are cut and burned to give way to commercial and subsistence farming and when fossil fuels are burned to generate energy and power to support industries; methane and nitrous oxides are emitted from various agricultural activities and changes in land use; artificial chemicals called halocarbons (HFC, PFC and CFC) and other long lived gases are released by industrial processes; ozone in the atmosphere is generated by automobile exhaust fumes and other sources (UNEP and UNFCC 2002).

The accumulation of GHG in the atmosphere is responsible for the greenhouse effect: the retention of heat energy inside the Earth's atmosphere, trapping heat inside the atmosphere instead of releasing it back into space (Figure 1.1). Higher concentration of GHG results in higher percentage of trapped heat. This phenomenon causes the increase in global temperature, also known as global warming, which in turn causes undefined variation and changes in temperature and rainfall and extreme climate events, better known as climate change.

1.3 What are the evidences that climate is changing?

The 2007 IPCC AR4 provides compelling evidence that Earth's climate is indeed changing as a result of human influence. Some of its major findings are presented below.

- Since the beginning of the industrial era in 1750, there is very high confidence that the global average net effect of human activities on the atmosphere has resulted in global warming.
- Global warming is happening now, evidenced by the changes in climate such as increases in surface temperature (both air and ocean), decrease in snow cover and melting of ice, causing the rise of global average sea level.

- Human activities are very likely the cause of most of the observed increases in global average temperatures in the last 100 years, with faster rate of increase observed from the 1950s onwards.
- Observed average retreat of mountain glaciers and snow cover in both hemispheres (not including the Greenland and Antarctic ice sheets) has contributed to the global rise of sea level.

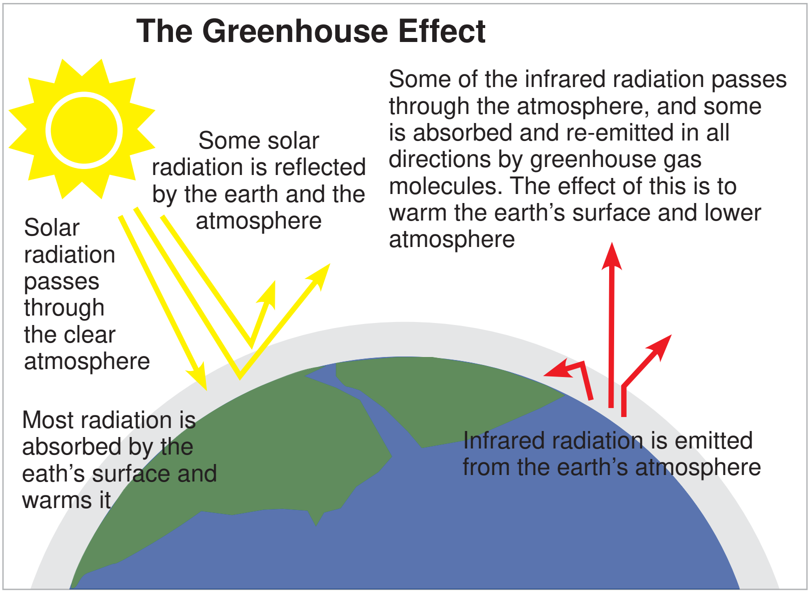

Figure 1.1. The greenhouse effect. Source: www.epa.gov/climatechange/science/index.html

- From 1961 to 2003, the global average sea level rose at a rate of 1.8 mm per year, exhibiting a faster rate of increase between 1993 and 2003 (about 3.1 mm per year). It is not yet established whether or not the faster rate of increase from 1993 to 2003 is attributable to short-term variability or long-term change, but there is high confidence that there was an increase in the rate of observed sea level rise from the 19th to the 20th century.

1.4 What are the effects of climate change in Southeast Asia?

Climate change literature consistently states that countries located in tropical areas are more susceptible to the impacts of climate change. Southeast Asia[1] (Figure 1.2) in particular, with its fast-growing population and increasing dependence on natural resources and agriculture, has already been experiencing climate change-induced phenomena, aside from pre-existing climatic conditions and events.

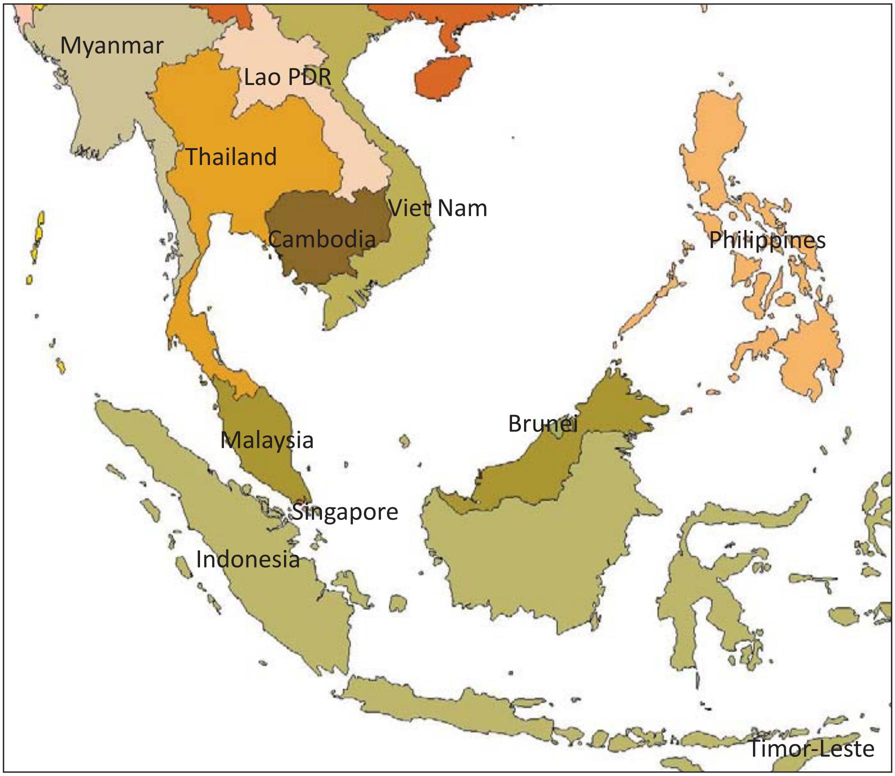

Figure 1.2. Southeast Asian countries.*

** Comprised of Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam.*

A recent report by the Asian Development Bank (ADB) in 2009 revealed that:

- Mean temperature in Southeast Asia increased by 0.1-0.3 °C per decade during the last 50 years of the 20th century.
- Declining rainfall was observed between 1960 and 2000.
- Sea levels rose by 1-3 mm per year.
- Number and intensity of extreme weather events, such as heat waves, droughts, landslides, floods and tropical cyclones increased (Table 1.1).

The same report by the ADB also examined existing studies that present projections of climate change impacts in the region, all of which infer that without intervention, impacts will intensify over time, further supporting the need for climate change adaptation and mitigation. Average mean temperature in the region is expected to rise by almost 5 °C by the year 2100 relative to 1990 levels. Consequently, mean sea level is projected to rise 70 cm during same period. In addition, prevalence of drier weather conditions is expected in the region within the next 20 to 30 years, particularly in Indonesia, Thailand and Viet Nam.

Table 1.1. Observed changes in extreme events and severe climate anomalies in Southeast Asian countries

Extreme Events	Key Trend	References
Heatwaves	Increase in hot days and warm nights and decrease in cold days and nights between 1961 and 1998	Manton et al., 2001, Cruz et al. 2006, Tran et al. 2005
Intense rains and floods	Increased occurrence of extreme rains causing flash floods in Viet Nam; landslides and massive and prolonged floods in 1990, 2004, 2008 and 2009 in the Philippines; and floods in Cambodia in 2000	FAO/WFP 2000, Environment News Service 2002, FAO 2004a, Cruz et al. 2006, Tran et al. 2005
Droughts	Droughts normally associated with El Niño in Indonesia, Lao PDR, Myanmar, Philippines, and Viet Nam; droughts in 1997 and 1998 causing massive crop failures and water shortages as well as forest fires in various parts of Indonesia, Lao PDR, and Philippines	Duong 2000, Kelly and Adger 2000, Glantz 2001, PAGASA 2001
Cyclones/ typhoons	On average, 20 cyclones cross the Philippine area of responsibility with about eight or nine making landfall each year; an average increase of 4.2 in the frequency of cyclones entering the Philippine area of responsibility during the period 1990—2003	PAGASA 2005

Source: Cruz et al. 2007

2.0 WHAT ARE THE IMPACTS OF CLIMATE CHANGE IN AGRICULTURE AND SMALLHOLDER FARMERS

The agriculture sector is a major source of livelihood in Southeast Asia. Approximately 115 million ha of the region's land is devoted to the production of rice, maize, oil palm, natural rubber and coconut (ADB 2009a). The region also raises a sizeable amount of livestock, whose production has been noticeably growing in developing countries in recent years (ADB 2009a, FAO 2006).

Figure 2.1. (above) Farmers weeding rice in Vietnam; (right) dairy cattle in Yunnan Province, China. Sources: Part of the image collections of the International Rice Research Institute (IRRI) and the International Livestock Research Institute

2.1 What are the impacts of climate change on agriculture?

With agriculture's dependence on optimal temperature and water availability, climate change has been and will continue to be a critical factor affecting the productivity of different activities within the sector.

2.1.1 Crop production

Major cereal crops such as rice and maize have experienced declining production potential due to heat and water stress (ADB 2009a). For instance, a study at the International Rice Research Institute (IRRI) shows that rice yields declined by 10% for every 1°C increase in mean night-time temperature. Faster rate of evaporation and transpiration due to higher surface temperature also lessens availability and quality of water for agricultural and industrial use, as well as human consumption (ADB 2009a).

Global warming would cause an increase in rainfall in some areas, which would lead to an increase of atmospheric humidity and the duration of the wet seasons. Combined with higher temperatures, these could favor the development of fungal diseases. Similarly, because of higher temperatures and humidity, there could be increased pressure from insects and disease vectors.

Farmers in the Philippines have already reported a number of 'climate change-related abnormalities' in terms of resurgence of pests and diseases in rice, corn and fruit trees. For instance, farmers have reported that a very destructive rice disease called 'tungro' has reappeared and that damages of corn plants by corn stem borer has been reduced, and even were reported to disappear in some places. Fruit trees are severely affected by surges in temperature and sporadic rainfall, which caused massive flower abortion, failed fruit development and a massive attack of scale insects and aphids.

The increase in incidence of observed climate extremes such as floods, droughts and tropical cyclones in the region have caused extensive damage to life and property (Figure 2.2). Occurrence of storms (including local and tropical storms, and tropical cyclones) in the region has increased from under 20 from 1950 to 1959, to over 120 from 2000 to 2009 (CRED 2009). Recent studies also indicate increase in hot days and warm nights and decrease in cold days and nights between 1961 and 1998 (Cruz et al. 2007). Meanwhile, droughts accompanying the onset of the El Niño Southern Oscillation (ENSO) have resulted in massive crop failures, water shortages, and forest fires, like the forest and brush fires caused by the 1997 El Niño in Indonesia, where 9.7 million hectares were burned (Cruz et al. 2007).

Figure 2.2. Flooding in Metro Manila, Philippines caused by Tropical Storm Ondoy (International name: Ketsana). *Source: Bullit Marquez/AP.*

2.1.2 Livestock and fisheries

The rapidly increasing population of developing countries has been adding more pressure on the agriculture sector to produce more livestock for agricultural uses (draught power, manure production) and human consumption (FAO 2006). Between 1980 and 2002, the average daily protein supply derived from livestock sources of developing Asia more than doubled (Steinfeld et al. 2006). This adds to the demand for already scarce natural resources and worse, contributing to global GHG emissions. Reduced nitrogen content in fodder has also been shown to reduce animal productivity in sheep, which depend on microbes in their gut to digest plants, which in turn depend on nitrogen intake (Scherer 2005).

The State of World Fisheries and Aquaculture 2008 (FAO 2008) emphasizes that climate change is already affecting the distribution of marine and freshwater species, with warmer-water species being pushed toward the poles and experiencing changes in habitat size and productivity. Seasonality of fish biological processes is also being affected, altering marine and freshwater food webs with unpredictable consequences for fish production. Asia is currently the world's aquaculture core in terms of productivity and is, thus, the most sensitive continent for the time being (FAO 2008).

2.2 What are the projected impacts of climate change on agriculture?

The IPCC AR4 warns of the adverse impacts of climate change on food security (Easterling et al. 2007). In tropical areas, it is projected that production will decrease with a 1-2°C rise in local mean temperatures. In addition, increased drought and flood frequency will affect subsistence sectors at low latitudes. Smallholder and subsistence farmers are especially vulnerable and could suffer complex, localized impacts. Their adaptive capacity being constrained, they face negative effects on crop yields, combined with a high vulnerability to extreme events.

In the longer term, there will be additional negative impacts of other climate-related processes such as sea level rise, and spread in prevalence of human diseases affecting agricultural labor supply. Freshwater availability in Southeast Asia, among others, particularly in large river basins, is likely to decrease due to climate change, along with the growing population and rising standard of living. This could adversely affect more than a billion people in Asia by the 2050s. An additional 49 million, 132 million and 266 million people, could be at risk of hunger by 2020, 2050 and 2080, respectively (Cruz et al. 2007).

2.2.1 Crop production

In some parts of Asia, about 2.5% to 10% decrease in crop yield is projected in 2020s and about 5% to 30% decrease in 2050s compared with 1990 levels. Intensification of agriculture will be the most likely means to meet the food requirements of Asia, which is likely to be invariably affected by projected climate change (Cruz et al. 2007). At higher temperature and atmospheric CO_2 concentration, the nutritional quality of rice will decline resulting to lower protein and micro-nutrients, iron and zinc contents (IPCC 2001).

2.2.2 Livestock and fisheries

Increasing surface temperature can cause heat stress in livestock which may result in behavioral and metabolic changes, including reduced feed intake leading to a decline in productivity (Thornton et al. 2008). The projected water shortage for livestock production can likewise cause water stress in animals (Cruz et al. 2007). Changes in temperature, rainfall patterns and CO_2 concentrations are expected to directly affect availability and quality of feed materials for livestock, as well as the life cycles of livestock diseases and disease vectors (Thornton et al. 2008). Pasture grasses will have reduced nitrogen content which would likely affect productivity of animal productivity, particularly sheep (IPCC 2001).

In a warmer world, ecosystem productivity in tropical and sub-tropical oceans, seas and lakes is likely to decline. Increased temperatures and incidence of extreme events will affect fish physiological processes (FAO 2008). Following the onset of sea-level rise and declining river runoff, it is expected that there will be an increase in habitats for brackish water fisheries due to sea-water intrusion. Coastal inundation is also likely to seriously affect the aquaculture industry, while increased frequency of El Niño events could lessen fish larval abundance in South and Southeast Asian coastal waters (Cruz et al. 2007). On top of this, there is an expected increase in risk of species invasions and spread of vector-borne diseases (FAO 2008).

2.3 Why are smallholder farmers vulnerable to climate change?

The IPCC states with high confidence that smallholder and subsistence farmers in developing countries are among those who will suffer the most from climate change impacts (Easterling et al. 2007). Reduction of crop yields due to crop damage and crop failure, waterlogging of soils due to increased rainfall and flooding, increased livestock disease and mortality and salinization of irrigation water can all be expected to affect the activities and productivity of smallholder farms (IPCC 2007c).

Smallholder farmers are very vulnerable to current and future climate risks (i.e. ENSO, drought, typhoons). Indeed an 'adaptation deficit' exists where adaptation strategies available now are not being taken advantage of (Leary et al. 2007). This is evidenced by the high loss of property and life in recent climate-related hazards around the world. Without the application of productivity improvements and adaptations, the agriculture sector in Southeast Asia stands to suffer significant losses, threatening food security in the region (ADB 2009a).

3.0 WHAT ARE THE EXISTING RESPONSE OPTIONS TO CLIMATE CHANGE?

Ideally, a comprehensive climate change strategy should include adaptation and mitigation. However, for most people whose livelihoods are already being affected by the impacts of climate change, adaptation is the more urgent option (IFAD 2008).

3.1 What is climate change adaptation?

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007b). AR4 further establishes adaptation practices as actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate (Adger et al. 2007). Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation. The end goal of all adaptation is to address climate risks, enhance resilience and reduce vulnerability (GECHS 2008).

Autonomous adaptations are responses to changes in climate that do not require the intervention of other institutions or sectors (i.e. policy, research) in their implementation (FAO 2007). For example, when a farmer changes planting schedule to adapt to changes in rainfall patterns, he can do so without involving local policy makers. On the other hand, planned adaptations are those formulated with the involvement of institutions and use of policies, the end goal being the enhancement of adaptive capacity through maximization of opportunities and use of new technologies and infrastructure (FAO 2007, Dolan et al. 2001). An example of this is the introduction of some climate-resilient crops which are developed through the efforts of research organizations.

Reactive adaptations are those that are implemented after the impacts of climate change have been experienced, while anticipatory adaptations are proactive and undertaken before impacts of climate change are fully felt (Dolan et al. 2001).

The key findings of the 2007 IPCC Working Group II (IPCC 2007a) on climate change adaptation are as follows:

- Some adaptations are occurring based on observed and projected future climate change, but on a limited basis.
- Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions.
- A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits and costs, but these are not fully understood.
- Sustainable development can reduce vulnerability to climate change, and climate change could impede nations' abilities to achieve sustainable development pathways.
- A portfolio of adaptation and mitigation measures can diminish the risks associated with climate change.

3.2 What are the goals of climate change adaptation?

The main goals of climate change adaptation are to reduce vulnerability and build resilience to the impacts brought by climate change (Brooks and Adger 2005). Vulnerability to climate change is the degree of susceptibility to harm, damage or loss as a result of climate change impacts or events (IPCC 2001). On the other hand, climate change resilience is having the ability to plan for, survive, recover from and even thrive in changing climatic conditions (ECA 2009).

The resilience of a system is closely tied to its adaptive capacity. Adaptive capacity is the ability of a system to respond to change quickly and easily in order to expand its coping range to current or future climatic stimuli (IPCC 2001). Adaptive capacity connotes proactive preparedness and response: from understanding and identifying potential impacts of climate change, to making the appropriate responses to maximize opportunities or minimize negative outcomes brought by actual changes in climate, whether or not these were anticipated (Brooks and Adger 2005). A system that has high adaptive capacity will likely be more resilient to the impacts of climate change.

3.3 Vulnerability, exposure, sensitivity and adaptive capacity

In general, the level of vulnerability (V) of farmers to climate risks can be expressed as follows (IPCC 2007, Smit and Wandel 2006):

$$V = f(E, S, AC)$$

where E= exposure, S= sensitivity, AC= adaptive capacity including adaptation measures

Exposure (E) refers to the nature and degree to which a system is exposed to climatic variations, while sensitivity (S) is the extent to which a system is likely to be affected by changes in climate (IPCC 2001). In the short term (i.e. annual cropping season and up to the next few years), E and S can be assumed to be the same. Thus, the focus will be on how to enhance AC. However in the long term (time tn), E,S and AC can all change as follows:

$$V_{tn} = f(\uparrow\downarrow E, \uparrow\downarrow S, \uparrow\downarrow AC)$$

Many of the initial research and adaptation planning on climate change made in developing countries focused on this future and long term scenarios. As a result, their recommendations tend to have little relevance for the current situation of farmers and find little resonance with policy makers concerned with more immediate needs (low salience). In addition, there is an implicit assumption that adaptive capacity is constant while climate exposure is changing.

The vulnerability of farmers to current climate risks (at time t_1) can be expressed as:

$$V_{t1} = f\,(E_{t1}, S_{t1}, AC_{t1})$$

Small farmers are currently highly vulnerable to climate risks. V_{t1} is high primarily because AC_{t1} is low. Assuming that E and S are constant in the short term and it is impractical to change them, then the way to reduce V is to increase AC. Ideally, V should approach 0, although this is of course impossible.

We can then envision a condition at time t2 where the V of small farmers is lowered to acceptable levels:

$$V_{t2} = f\,(E_{t2}, S_{t2}, AC_{t2})$$

where V_{t2} is the acceptable level of vulnerability
$V_{t2} << V_{t1}$ because $AC_{t2} >> AC_{t1}$

The adaptation challenge then is how to attain AC_{t2} through project interventions. In other words, the main objective of climate adaptation projects should be how to enhance adaptive capacity to acceptable levels so that farmers are able to adapt to current climate risks. At the end of the project, the farmers should have the capacity to develop in a sustainable manner.

Once the vulnerability of small farmers to current climate risks have been reduced to acceptable levels, then it is hypothesized that they will be able to cope with the gradual change in climate. This is based on the assumption that the change in climate (and thus ΔE and ΔS) will be so gradual as to allow small changes in the farming systems.

4.0 WHAT CAN SMALLHOLDER FARMERS DO TO ADAPT TO CLIMATE CHANGE?

Farmers in Southeast Asia have long been exposed to climate variability and have long been implementing adjustments in farm management practices in response to climatic stimuli. In the agriculture sector of Southeast Asia, some of the most commonly used adaptation techniques involve changes in cropping patterns and cropping calendar, improved farm management, and use of climate-resilient crop varieties (ADB 2009a). The more important aspect of adaptation is the fitting of crops to their best use in the individual subplots of the farm. While in some cases, individual adaptations can be sufficient to address impacts of particular climate stresses, combinations of adaptation measures are also commonly used and required (Adger et al. 2005 as cited in Locatelli et al. 2008). Adaptations are also seldom undertaken in response to climate change alone, and will likely be applied along with strategies addressing other stresses (IPCC 2007c).

The following measures are commonly practiced and 'owned' by climate change-exposed small farmers from within and outside Southeast Asia and can therefore be considered strong building blocks for future climate adaptation. These represent specific actions and/or options of affected farmers to reduce and/or totally avoid climate change-related risks.

4.1 Change crop variety

Changing crop variety involves switching from one crop variety to another in response to climatic stresses and changes. This is demonstrated in adoption of climate-resilient crop varieties that are able to withstand a single or a range of climate stresses.

In commercial farms in Viet Nam, both seasonal and semi-permanent adoption of climate-resilient rice varieties are practiced (Snidvongs 2006). The availability and use of short-cycle rice varieties allows farmers to produce two cycles of rainfed rice within the seven months of rainy season in the Mekong River delta. The effectiveness of this adaptation is largely dependent on the precision of climate forecasts (which would serve as the guide for farmers in crop management and timing of operations), availability of climate-resilient rice varieties and acceptability of the final rice product to the market (Snidvongs 2006).

Figure 4.1. A stalk of hybrid rice. *Source: IRRI image collection.*

In an effort to build resilience to a number of possible climate conditions, women of the Pwalugu area in Ghana are experimenting with different crop mixes. Some areas are simultaneously planted with maize, sorghum and millet, while other areas are planted with early and late maturing varieties of the same crop, which helps ensure that at least one of the crops planted will produce harvest (ActionAid 2008).

Box 1: Scuba rice. In support of building crop resilience to climate change, researchers and collaborators of the International Rice Research Institute (IRRI) have identified a waterproofing gene called *Sub1A*, which allows rice crops to survive being completely submerged for two weeks. The gene has been bred into rice varieties in Bangladesh and India, producing high yields and minimizing crop losses due to flood (CGIAR 2007). Rice varieties bred with the waterproofing gene (Sub1A) have become known as 'scuba rice' (Figure 4.2).

Figure 4.2. (Left) Swarna Sub1A plant conserves its energy at normal height while Swarna (control) elongates its leaves under submerged conditions. (Center) Field test of Swarna rice variety is badly damaged after days of flooding and (right) field test of Swarna (Sub1A) remains in good condition (Photos taken in Chinsurah, India on November 5 and 6, 2008). Sources: ICRAF 2009, Adam Barclay and IRRI image collection .

4.2 Change in cropping pattern and crop calendar

4.2.1 Change in cropping pattern

Change in cropping pattern involves introduction of new crops to add to or replace existing crops, or application of changes in how crops are cycled within a season. An example of this can be observed in the Palu River watershed in Central Sulawesi, Indonesia. Although not widely practiced, some farmers in Central Sulawesi increased the land area share of maize crops in lieu of rice crops during times of drought caused by El Niño (Keil et al. 2007). Similarly, farmers in the drought-prone semi-arid areas of Brazil have realized that several varieties of a single crop species can occupy a common land area, incorporating several bean varieties, maize and sorghum, among others, to increase harvest potential amid climate stresses (ActionAid 2008). Farmers in northern Philippines, where there is distinct wet and dry seasons, shift from irrigated rice with limited irrigation water to tobacco and other drought tolerant cash vegetable crops. For those located in the freshwater swamps in Central Luzon, farmers shift from wetland rice to high value crops, melons and vegetables, during the dry months, taking advantage of residual soil moisture to sustain good crop production.

4.2.2 Change in cropping technique/calendar

Changing cropping techniques/calendar is another common adaptation to climate variability at the farm level, which largely involves altering the timing of farm activities to suit climatic variations or changes. In the upland farms of Pantabangan, Nueva Ecija in the Philippines, farmers adapt to the early onset of rainy season through early cultivation of upland farms, which results in high agricultural production for the season and higher household income from farm activities (Lasco and Boer 2006).

In response to the threat to food security brought by increased incidence of climate extremes, some farmers in the semi-arid region of Brazil have altered crop calendars, such that different crops will be planted in succession (i.e. different times of the year) in order to ensure a harvest of at least one crop at different points in time (ActionAid 2008).

4.3 Change in current farm management practices

4.3.1 Land management

Altering farm management practices is another widely used adaptation measure to changes in climate in Southeast Asia. For example, in rainfed rice farms of Kandal Province, Cambodia, some farmers have split their rice plots into two using different management approaches to address uncertainty in rainfall. Half of the rice plot uses conventional wet-paddy rice techniques (which can survive heavy rains), while the other half uses a drought-resistant, less water-intensive cultivation technique called system of rice intensification (Resurreccion et al. 2008). The practice helps increase chances of harvest even in the event of extreme rainfall events and variable water availability.

System of rice intensification (SRI) was developed and popularized in the 1980s by a Jesuit priest named Henri de Laulainé. Considered more of a natural resource management methodology than a standardized technology, SRI is said to improve rice yields with less water, less seeds and less chemical inputs than most conventional methods of rice production. SRI has eight basic principles:

- Prepare high quality land
- Developing nutrient-rich and un-flooded nurseries
- Using young seedlings for early transplanting
- Transplanting seedlings singly
- Ensuring wider spacing between seedlings (25 x 25 cm spacing, about 16 plants per square meter)
- Preferring compost or farmyard manure over synthetic fertilizers
- Managing water carefully so that the plants' root zones moisten, but are not continuously saturated

- Weeding frequently (labor intensive)

Organic agriculture (OA) is a holistic approach to farming which promotes and enhances agroecosystem health by emphasizing the use of management practices as opposed to relying heavily on off-farm inputs (FAO/WHO 1999). OA maximizes the use of cultural, biological and mechanical methods instead of synthetic materials (FAO/WHO 1999), thus promoting increase of soil organic matter (Muller 2009). Increasing soil organic matter allows soil to capture and retain more water, which reduces the vulnerability of OA systems to climate extremes such as droughts and floods (Muller 2009) and can also help to regulate soil erosion (ITC FiBL 2007). In addition, OA's focus on maintaining diverse farming systems (i.e. planting different crop species) also helps diversify potential sources of income for farmers, making the farming household more resilient to adverse impacts of climate on agricultural production (Muller 2009).

4.3.2 Soil management and conservation

Smallholder farmers in sub-humid Southwestern Cameroon, Africa have been adapting to variations in rainfall through planting herbaceous and woody plants along farm contours and establishment of waste weirs to conserve soil fertility. These practices are also coupled with mixed cropping and multi-cropping in an effort to reduce vulnerability to climate, and to increase crop yields and farm income (Molua 2002).

4.3.3 Water management and conservation

In 2002, field trials conducted by IRRI, PhilRice and the National Irrigation Authority (NIA) introduced *alternate wetting and drying (AWD)* or controlled irrigation to rice farmers in Tarlac province in the Philippines. With only one deep-well pump shared between several farmers and the threat of decreasing water availability, practicing AWD helped farmers to reduce the water requirement by 25% while maintaining yields of 5-6 tons per hectare, which is the same as yields under traditional irrigation schemes. After years of continuously flooding their rice fields, farmers learned that rice need not be continuously flooded to produce optimum yields, and that 3-5 cm of flooding is enough compared with the 10 cm convention prior to introduction of AWD. Time spent using the deep-well pump was also reduced by bout half, consequently decreasing fuel cost of the farmer. In addition, AWD was also found to be less labor intensive than continuously flooded fields, resulting in savings of 20-25% of management cost. This has allowed some farmers to go from subsistence farming to making a modest income (Barclay 2009).

The International Water Management Institute (IWMI) has been developing and promoting alternative water management technologies for small farmers in the face of climate change, particularly in Southern Africa. A technology which could apply to parts of Southeast Asia is the 'bucket and drip' irrigation system. A raised bucket supplies water to pipes with emitters along plots and water is regulated through a slow release mechanism. The system requires an investment of only US$5 and allows farmers in water-scarce areas to produce good harvests using just the right amount of water (CGIAR 2007).

On the opposite extreme is the abundance of water due to increased incidence of heavy rainfall. Farmers in the Mekong River delta in Vietnam have adapted to the onset of floods through investment in the construction of irrigation systems and embankments (Snidvongs 2006).

Box 2: Technology Transfer on Water Savings. This project was initiated in 2001 by IRRI, NIA and PhilRice in partnership with farmers in Tarlac province in the Philippines. The objectives of the project included the development of strategies and methodologies for the proper transfer, adaptation and adoption of water-saving technologies. The implementation of controlled irrigation versus standard farmers' practices (continuous shallow flooding) in pilot farms resulted in average water savings of 20% in farms with deepwell irrigation systems, and 11%-15% in farms with shallow tube well irrigation systems, with some farmers even able to reach 40% water savings (Lampayan et al. 2004, IRRI 2004).

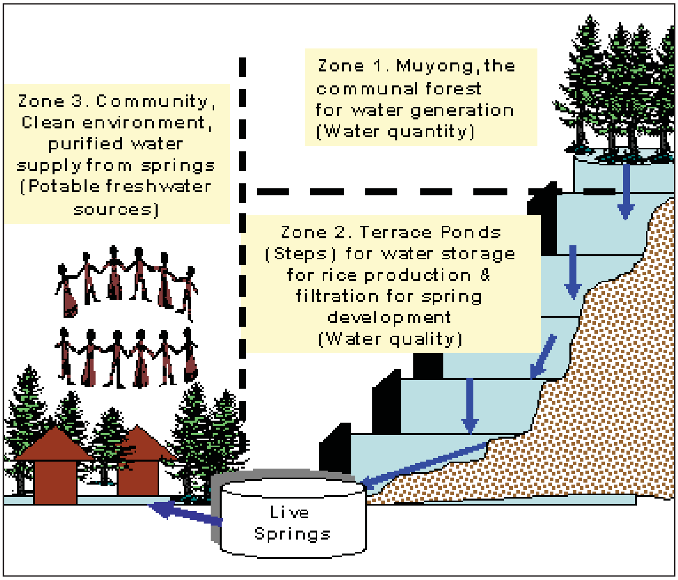

Figure 4.3. Soil and water conservation mechanism in the Ifugao Rice Terraces, Philippines. *Source: Concepcion 2008*

Box 3: Ifugao Rice Terraces. The Ifugao indigenous peoples of the Ifugao Rice Terraces in the Philippines have been successful at water management and conservation through the use of micro-watersheds in highland areas. Each micro-watershed is dedicated to communally managed clusters of rice terraces with common source of water. The Ifugao Rice Terraces, a water-centered construction technology and freshwater management, are actual demonstrations of stabilizing steep mountain ecosystems through the implementation of balanced micro-watershed land and water use (Figure 4.4). Farming sequences and activities are conducted in biological rhythm with sunlight availability, rainfall distribution and day to day variations in temperature and humidity. In 2000 years of continued use, the Ifugao farmers managed freshwater use and reuse for rice, fish and vegetable production for non-marketable outcomes that serve the needs of various social and religious rituals and its subsequent recovery as spring water for domestic use by the farming communities (Concepcion et al. 2010).

4.3.4 Fire management

Increasing temperature coupled with reduced water availability makes forests, shrublands, brushlands and grasslands more prone to outbreak of fires. In addition to biophysical drivers, anthropogenic activities also increase likelihood of fires.

The population growth of the Southeast Asian region is accompanied by the growing demand for agricultural, industrial and residential lands. Fire has long been used as an instrument for land clearing and preparation, particularly in swidden agriculture and establishment of settlements (Karki 2002). The use of fires in and around forest areas for purposes such as this can lead to uncontrolled forest fires, which not only contribute to climate change through GHG emissions, but also result in deforestation (The Nature Conservancy 2009).

Regional Community Forestry Training Center (RECOFTC) coined the term 'Community-based fire management' (CBFiM). It pertains to a type of land and forest management which involves the community in the immediate vicinity of an area in the prevention, control and utilization of fires through participation in decision-making and implementation of activities (Ganz et al. 2003; FAO 2003).

Box 4: Communities against fire. Community-based fire management (CBFiM) is already being implemented in various parts of Southeast Asia. Many communities in Indonesia have systems of fines and penalties for mismanagement of fires and causing damage to neighbors' property. Aside from this, swidden agriculture communities in Indonesia also practice the controlled use of fire by gathering farm residues into piles to isolate and burn. Natural buffer strips are also maintained alongside fields to prevent the spread of fires while also serving as passage for humans and animals and as mechanisms for controlling the spread of pests from other fields (Karki 2002).

CBFiM also includes fire prevention activities. For example, in the Song Da watershed in Vietnam, villagers are involved in the drafting of regulations/rules and their implementation, which has resulted in reduction of forest fires during dry season and improved forest conditions. In the Mount Kitanglad National Park in Mindanao, Philippines, a team of volunteers from different ethnic tribes in the area (known as the Kitanglad Guard Volunteers) is responsible for assisting the government in containing fires and implementing other conservation activities (Karki 2002).

4.3.5 Pest management

Among the observed and expected impacts of increase in temperature in Southeast Asia is the increased outbreak of pests and diseases in both agricultural and forest areas (ADB 2009a). Studies indicate that integrated pest and disease management may be necessary to offset the adverse effects of climate change on pests and diseases (Kurukulasuriya 2003).

Integrated pest management (IPM) involves the use of a combination of complementary pest management techniques to effectively guard against infestations while ensuring efficient use of available resources and protection of the surrounding environment and ecosystems (EPA 2009). IPM techniques include inspection and monitoring of crops for damage, use of mechanical devices, biological pesticides (i.e. natural predators and pathogens) and (if necessary) chemical pesticides (EPA 2009).

A study explored the benefit-cost ratio of using integrated rodent management techniques on lowland rice farms in Indonesia (Singleton et al. 2004). Villages underwent rodent campaigns 2 weeks prior to planting of crops, maintained general hygiene around villages and gardens, and kept irrigation canal width <30 cm to prevent rat nesting. These measures were supplemented by the installation of trap-barrier systems (TBS) – a plastic fence with built-in traps (Figure 4.5) – around 20 m x 20 m plots with rice crops grown 3 weeks earlier than surrounding crops (Singleton et al. 2004). At night, rats follow the line of the plastic until they reach a hole, which they enter to reach the rice. They are then caught and removed the following morning (IRRC undated). The results of the study revealed strong return on investment as well as 50% reduction in use of chemical rodenticides (Singleton et al. 2004). Similar systems are used in farms across Southeast Asia (IRRC undated).

Figure 4.4. A trap barrier system (TBS) in the Ifugao rice fields, Philippines. Source: Grant Singleton - IRRI image collection.

A farmer leader based in Bukidnon province in the Philippines developed a model farm to train other farmers in the area on the use of various forms of non-chemical pest control traps (Figure 4.6, left). One such trap involved collecting dry coconut fronds, which are potential breeding place for pests, and relocating them to nearby creeks where they serve as a breeding place for frogs (Figure 4.6, right). The frogs are predators of small insects and at the same time, they are a delicacy among upland farmers in the area.

Figure 4.5. Binahon Model Farm in Lantapan Bukidnon. (Top left) An example of a zero-chemical pest control measure. (Bottom rght) Waste management of dry coconut fronds for frog habitat development.

Box 6: The Farmer Field School. This is a form of adult education which evolved from the concept that farmers learn optimally from field observation and experimentation. It was developed to help farmers tailor their integrated pest management (IPM) practices to diverse and dynamic ecological conditions (van den Berg 2004). Farmer field schools promoting IPM have been implemented in several Southeast Asian countries since it was first launched by the Food and Agriculture Organization of the United Nations (FAO) in Indonesia in 1989 (Bartlett 2005). The range of benefits from the implementation of IPM due to FFS training includes reduction in use of chemical pesticides, better-informed farmers (i.e. agro-ecosystem management, health risks associated with pesticide use, pests and natural enemies), development of technical and social skills of farmers, and increases in yield of some crops (van den Berg 2004).

4.3.6 Livestock waste management

It is well-known in climate change research that the livestock industry has been a major contributor to global GHG emissions that has been exacerbating global warming. However, there are some livestock management practices that could help smallholders to better adapt to changing climate.

One such option for smallholders is through the proper collection, processing and application of animal manure as crop fertilizers (Zijpp 2008). In South Asia and China, some livestock producers are coming up with innovative ways of storing and removing animal waste. Modeled after those found in large scale production, small scale biogas production units break down bio-solids in underground fermentation units which produce gas for cooking, lighting and energy for on-farm activities. These small-scale units utilize dairy, poultry or pig waste, and can serve the energy requirements of two or more households. Solids broken down in fermentation units can also be used as fertilizers in crop production, or sold for cash (FAO 2006).

4.3.7 Application of agroforestry

Agroforestry is the practice of planting woody perennials (trees/shrubs) on the same land management unit as agricultural crops or animals, or both. Simply put, agroforestry is trees on farms. Given the large contribution of land use conversion and the forestry sector to GHG emissions of Southeast Asia, agroforestry presents an opportunity to counter the adverse impacts of climate change through the joint action of adaptation and mitigation (Verchot et al. 2007). Trees on farms enhance the coping capacity of small farmers to climate risks through crop and income diversification, soil and water conservation and efficient nutrient cycling and conservation (Lasco and Pulhin 2009).

Multi-storey cropping involves layering of tree and crop species in order to maximize the productivity of agricultural land, while protecting against climate risks. This practice conserves soil moisture and porosity, lessens soil erosion, runoff and fertilizer requirement, and allows for more diverse production and income sources for smallholder farmers. Agroforestry systems like the planting of cacao plants under multi-storey systems not only aid in increasing carbon sequestration and storage, but also bring short term economic returns in line with traditional practices (ASB 2009).

Particularly for upland farms, agroforestry includes the use of sloping agricultural land technology (SALT). SALT techniques, such as contour hedgerow systems (Figure 4.8) and natural vegetative strips (NVS), help to minimize erosion and increase the availability of organic fertilizers, fuel wood and fodder for ruminants (Lasco and Pulhin 2009). An example of NVS can be seen in farms in Claveria, Misamis Oriental, Philippines (Figure 4.9).

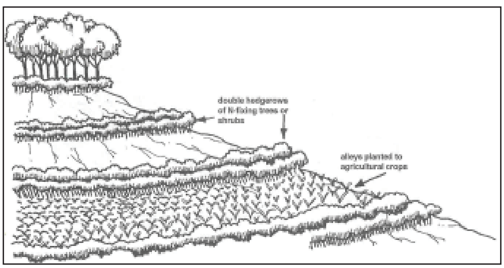

Figure 4.6 (Left). Contour hedgerow system. Source: Lasco and Pulhin 2009

Figure 4.7 (Right). An example of natural vegetative strips (NVS) in Claveria, Misamis Oriental, Philippines. Source: Mercado et al. 1997

Vegetable-Agroforestry (VAf) system is the integration of vegetables in tree-based systems, or tree integration in vegetable production system (Figure 4.11). It provides multiple benefits, including provision of micronutrients to the diet of the rural community and enhancement of on-farm biodiversity and environmental sustainability. VAf system can be a viable farming system in the uplands, particularly for smallholders.

Figure 4.8. An example of vegetable agroforestry (VaF). Source: Catacutan and Pinon 2008.

Also in Mindanao, rubber-based agroforestry systems (RAS) provide positive prospects for smallholders (Mercado and Harrison 2009). Aside from the low investment requirement, the good market demand for rubber latex provides higher and more regular income from tapping. The RAS can also allow intercropping of annual vegetables, perennial food and cash crops which can be consumed by the farming household or sold for additional income.

4.4 Diversification of income-generating and livelihood activities

Upon the onset of unfavorable climate conditions for crop production, some farmers opt to explore other on-farm sources of income. In the Vientiane Plain and Savannakhet Province in Lao PDR, it is common practice to raise livestock and harvest natural products in surrounding areas to alleviate loss of income from crop production due to climate stresses (Snidvongs 2006).

A recent project in Yasothorn province, Thailand assisted local smallholders in climate change adaptation for organic rice (Oxfam 2009). Due to uncertainty of climate change impacts on rice production, many farmers (mostly women) diversified their crops by planting fruits and vegetables before and after rice cultivation. Produce from these activities supplemented the food supply of the farming household while excess was sold at local markets, earning the household an additional 500 to 1,500 baht (US$15-40) per week.

In Jamalpur District and other flood-prone coastal areas in Bangladesh, farmers have collaborated to establish community rice/fish farms to take advantage of abundance of water. Through a practice known as integrated agriculture–aquaculture (IAA) farmers gain an alternative source of food and nutrition, and additional income. IAA simply involves setting aside a small amount of the farm lot for fish farming and the use of farm and kitchen wastes as food for fish species like tilapia (WorldFish 2008). The practice promotes more efficient use of resources and cooperation among community members (ADB 2009). Similar practices have also been observed in parts of India and Africa (Figure 4.12).

4.5 Implementation of carbon finance activities

Adaptation measures are intended to reduce vulnerability and build resilience to the impacts of climate change that can no longer

Figure 4.9. An example of Integrated Agriculture-Aquaculture (IAA) in Malawi, Africa. Source: Randall Brummett/ Credit: The WorldFish Center (www. worldfishcenter.org/v2/img/randy-africapond-b.jpg).

be reversed. However, , adaptation alone will not be enough to offset the effects of climate change, and will thus still need to be supplemented by concerted mitigation efforts (ECA 2009).

The Asian Development Bank stresses the need for carbon to be recognized as a global externality, with carbon valued through carbon trade to increase the value of sustainable farming practices (ADB 2009b). A central theme of the Kyoto Protocol is the reduction of greenhouse gas (GHG) emissions through market-based mechanisms such as the Clean Development Mechanism (CDM) (UNFCCC 2009b).

For the smallholder farmer, CDM projects present potential benefits that can be felt at the local level through the synergy between mitigation and adaptation. For example, a CDM project aimed at afforestation and reforestation aids in carbon sequestration through the action of trees, while also lessening runoff and soil erosion, thus reducing vulnerability and increasing resilience of the farmers to climate risks. CDM emission reduction/removal projects implemented in developing countries by developed countries allow the sponsoring developed country to gain certified emission reduction (CER) credits, which are traded or sold to meet part of their emission reduction targets under the Kyoto Protocol (UNFCCC 2009b). However, early experience shows that CDM projects are not easily accessible to small farmers due to high transaction costs and complex processes.

4.6 Collaboration with community organizations

4.6.1 Community-based adaptation (CBA)

Climate change is a global concern, but its effects are felt at regional and local levels. Another approach to curb the impacts of climate change is community-based adaptation (CBA) which largely involves mobilization of community members to assess their situations, and then decide and act based on their specific needs (Huq 2008).

Community organizations enhance resilience of small farmers by strengthening social capital and collaboration. Through CBA, local people are encouraged to harness their own knowledge and skills which builds their self-reliance, drive and commitment to respond to the challenges brought by climate change (Kiser 2008).

In Bangladesh, smallholder farmers in flood-prone areas have adapted to waterlogging through a form of CBA called *baira* (floating vegetable gardens). Bamboo frames are placed around water hyacinth and more of the plants are added until a compacted floating mat is produced (Figure 4.15). Soil, animal manure and rotting baira are then placed on top of the floating mat to act as the growing medium. Vegetable seedlings are then transplanted onto the baira. Commonly planted vegetables include cauliflower, tomatoes, okra, leafy vegetables and gourds (Kiser 2008). The practice of farming on baira helps ensure household food supply and provides additional income (IEED 2008).

Figure 4.10. (Top) Water hyacinth base used for baira. (Botttom) Farmer stands by baira with growing vegetables. Source: IUCN Bangladesh Photo Albums (www.iucnbd.org/photo_albums/Baira_Album/index.html)

planting schedules, crop mixes, and cultivars are not expected to be sufficient to offset the significant climate change damages (Rosenzweig and Parry 1994, Butt et al. 2005). Adaptation measures involving infrastructure can also be useful for smallholder farmers, but with some limitation depending on the farming household's available resources.

In drought-prone areas in Northwest Bangladesh, some farmers have adopted a relatively low cost infrastructure to limited water supply during drought. Small-scale water harvesting structures in the form of mini-ponds are made by digging 5m x 5m x 2m ponds (Figure 4.17) in the corner of the farm. Through the structures, farmers are able to store rainwater for supplemental irrigation. This practice requires relatively small capital (total cost estimated at about US $40) in areas where soils are clayey, since no cement will be needed and family labor can be employed. In areas with sandy soil conditions, the cost of construction/excavation may be significantly higher due to the cost of cement (Selvaraju 2007).

Figure 4.11. Small-scale water harvesting structure in Northwest Bangladesh. Source: Selvaraju 2007.

Box 7: Small water impounding projects in the Philippines. There are flood control and drainage programs being implemented by the Philippine government in response to climate stresses and scarce water resources. The Bureau of Soils and Water Management (BSWM) has installed Small Water Impounding Projects (SWIPs), aimed at reducing flood damage, improving efficiency of use of water resources, and generating electricity (ADB 2009a). As part of the initiative, the BSWM has been training farmer-beneficiaries to practice sustainable agriculture in the operation and maintenance of the SWIPs, which will eventually be turned over to them (ADB 2009a; Jaranilla-Sanchez et al. 2007). Similar initiatives have also been implemented in priority areas of Viet Nam, and some districts of Indonesia (ADB 2009a).

In the Philippines, particularly in parts of Mindanao, where rainfall is erratic and unpredictable and where it is projected to have more droughts in the future, rainwater harvesting is one of the best options. However, mechanical earthworks can be expensive. Mercado (2009) suggested the following steps on how rainwater harvesting pond can be made simple and efficient by using local resources:

- measuring desired rainwater harvesting pond;
- plowing pond by using conventional moldboard plow;
- scraping and mounting soil by using wooden animal drawn scraper;
- trampling and paddling pond bottom and sides using carabaos or cows;
- making inflow canal from the roadside or other catchment areas.

Box 8: Climate change adaptation and gender. A special case in Salima, Malawi shows an initiative of the Salima Women's Network on Gender (SAWEG), where individual women farmers pool together to maintain community (club) gardens (Figure 4.16). This has helped the women farmers to support the food requirements of their households amid the impacts of climate change (ActionAid 2008). Through regular meetings, the women have been able to share tools, seeds and knowledge on diverse farming methods, and members have been able to increase production level to more than what they could have grown individually (ActionAid 2008). Excess in production also becomes an additional source of income through sales at local markets. Women in Salima are now more food secure than they were before the farmers' club started (ActionAid 2008).

Figure 4.12. Women farmers in Salima, Malawi tend to their gardens[7]. *Source: ActionAid 2008 via http://us.oneworld.net/article/357923-women%E2%80%99s-network-malawi-adapts-climate-change*

5.0 HOW CAN FARMERS DEVELOP AN ADAPTATION STRATEGY?

As shown in the examples, there are several adaptation measures that can be implemented at the farm level to reduce vulnerability to climate risks. However, it is also important to remember that most of the adaptation options presented are not only potential responses to climate change, but also practices or methods that affect other aspects of the farm production system which are influenced by conditions other than climate (Dolan et al. 2001). Thus, in planning and selection of adaptation options, a systematic approach to evaluation of these options should be followed, keeping in mind potential effects on other farm activities and processes.

To assist development workers in helping smallholder farmers, the Integrated Climate Risk Assessment Framework for Small Farmers (ICRAF) can be used.

5.1 What is ICRAF?

ICRAF is a rapid appraisal tool best implemented by a team of interdisciplinary and inter-sectoral researchers, development workers and farmers. For example, a team may include an agriculturist/agroforester, economist, climatologist, and a farmer.

Several approaches can be used to generate and analyze information depending on available resources: focus group discussions, surveys, multi-sectoral workshops, review of literature, GIS mapping, and computer simulation.

ICRAF has the following characteristics: participatory, iterative, interdisciplinary, bottom-up, and multi-stakeholder.

5.1.2 Steps in Implementing ICRAF

The key steps to ICRAF are: adaptation deficit analysis, adaptation planning, implementation and monitoring (Figure 5.1).

Step 1: Adaptation deficit analysis. The objective of this step is to identify the climate risks farmers are facing and their level of adaptation. An adaptation deficit exists if farmers are not utilizing available technology, practices and measures to adapt to climate risks. The following are the specific activities under this step:

- Assess current climate risks faced by small farmers.
- Analyze vulnerability of small farmers to climate risks.
- Document local adaptation.
- Assess the strengths and weaknesses of current adaptation.
- Assess the effectiveness of an adaptation strategy
- Determine if an adaptation deficit exists.

Step 2: Planning to build adaptive capacity. Using a multi-stakeholder approach, measures to enhance adaptive capacity of farmers to climate risks will be identified. The key activities are as follows:

- Determine strategies and measures to enhance resilience of small farming systems.
- Assess strengths and weaknesses (and costs and benefits) of potential adaptation options.
- Assess future climate risks and what adaptation can be done now.

Step 3: Implementation, monitoring, and improvement. This step involves implementation of planned adaptation measures. The specific activities are:

- Implement adaptation strategies and measure.
- Monitor and evaluate progress.
- Study ways to further improve adaptive capacity based on experience.

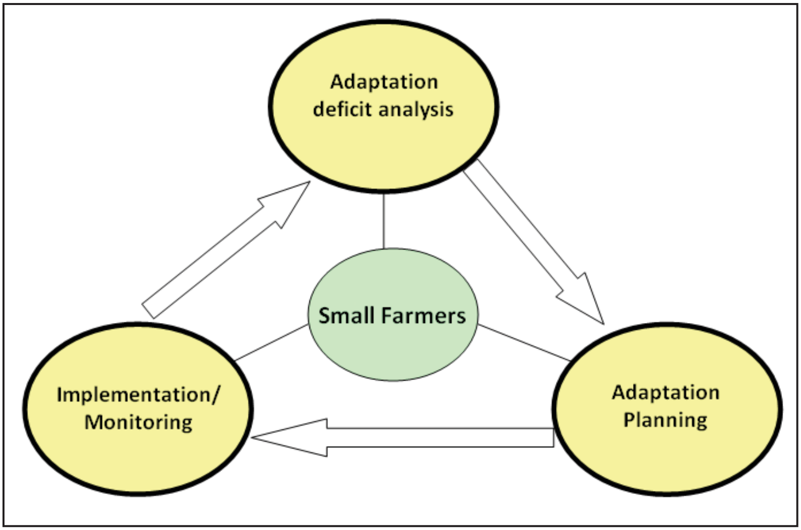

Figure 5.1. ICRAF's conceptual diagram.

5.2 Case study: Lantapan in Bukidnon, Northern Mindanao, Philippines

Lantapan is one of the municipalities of the province of Bukidnon in Northern Mindanao, Philippines (Figure 6.1). Lantapan lies between 8˚2’00’ and 8˚5’0’ north latitude and 124˚51’00” and 125˚11’00” longitude. It has a total area of 34,465 ha. Lantapan has relatively cool climate with an average annual temperature of 19^{o}C and monthly average temperature not exceeding 21^{o}C. It is relatively dry from November to April and wet from May to October. Average monthly rainfall is 224.54 mm.

Lantapan is generally rugged and steep particularly in the upper portion but gently sloping in the lower section. Elevation ranges from 500 – 2,150 masl with an average elevation of 600 masl. Maximum elevation is found in Kitanglad ranges at 2,938 masl.

In terms of land use, agriculture, forests and built up/industrial comprise Lantapan. Agriculture covers the largest area while built up/industrial occupies the least. Almost 50% of the total area is covered by agriculture while 40% is covered by forests. The remaining 10% is occupied by the industries and settlement.

There has been an increase in agricultural land expansion, replacing the forest and permanent crops by annual crops, and the spread of annual cropping in high altitudes and steeply sloping areas. The economy of Lantapan is highly agricultural, with 90% of the households depending on smallholder farming (Catacutan and Pinon 2008).

The most commonly experienced climate hazards are prolonged rains, El Niño (drought), and delayed onset of rains (Figure 6.2).

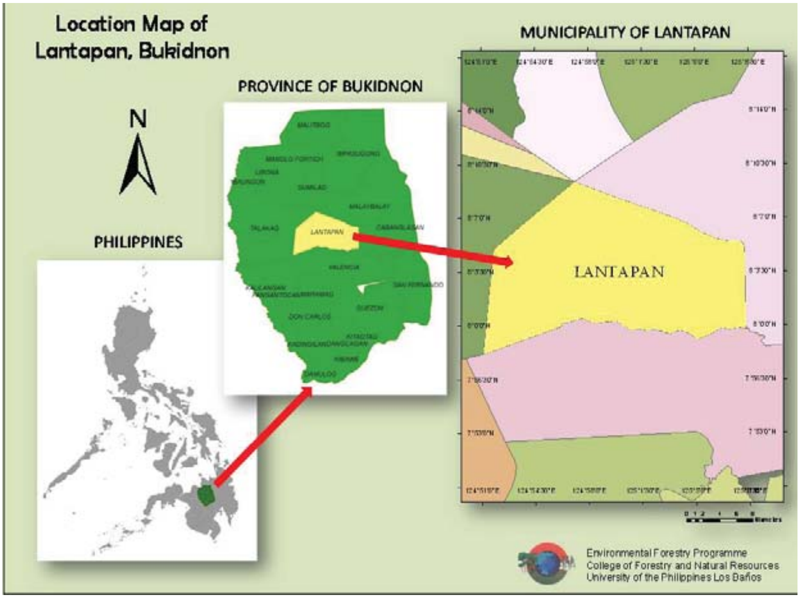

Figure 6.1. Location map of Lantapan, Bukidnon, Philippines. *Source: CFNR, UPLB.*

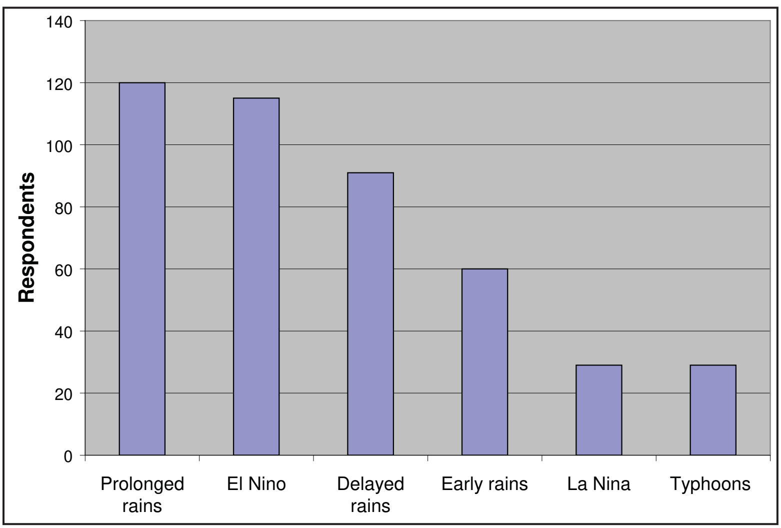

Figure 6.2. Most commonly experienced climate hazards in Lantapan, Bukidnon, Philippines. *Source: Pulhin et al. 2009.*

More than 50% of the affected respondents that experienced drought opted to do nothing (Table 5.1). Another 13% sought off-farm sources of income, while 10% explored alternative sources of water. Less than 10% of those affected adopted more proactive climate adaptation measures such as crop diversification, fertilizer application and farming in another place.

Table 5.1. Adaptation strategies employed by the respondents to cope with impacts of El Niño (drought) on crop production

Adaptation strategies	Frequency	Percentage
Affected but do nothing	55	51.40
Off-farm work	14	13.08
Get water from other source	10	9.35
Disposal of assets	8	7.48
Credit	6	5.61
Crop diversification	5	4.67
Fertilizer application	3	2.80
Did not harvest the crops to save expenses	2	1.87
Government assistance	2	1.87
Farming in other place	1	0.93
Praying	1	0.93
TOTAL	**107**	**100.00**

N(107) = number of affected respondents

In response to delayed onset of rainy season (Table 6.2), almost 55% of the affected respondents chose to do nothing. About 19% of those affected applied supplemental watering, while another 15% opted to wait for rainy season to come. There was a small number of respondents who tried diversifying their crops (less than 2%) and sources of income through off-farm activities (less than 3%). This is indicative of a possible adaptation deficit, wherein lack of information or technical support may have prevented respondents from implementing cost-effective climate adaptation strategies.

Table 5.2. Adaptation strategies employed by the respondents to cope with impacts of delayed onset of rainy season on crop production

Adaptation Strategies	Frequency	Percentage
Affected but do nothing	40	54.79
Supplemental watering	14	19.18
Wait for rainy season to come	11	15.07
Fertilizer and chemical application	3	4.11
Off-farm work	2	2.74
Crop diversification	1	1.37
Praying	1	1.37
Wait for next cropping season	1	1.37
TOTAL	**73**	**100.00**

N (73) = number of affected

Given the above information, ICRAF can be used. Some of the Step 1 activities have already been conducted: current climate risks faced by the smallholder farmers and existing local adaptation in the study area have already been determined. Assessments of the vulnerability of the smallholder farmers to the current climate risks, strengths and weaknesses of current adaptation and the effectiveness of these adaptation strategies will need to be conducted to determine if an adaptation deficit exists.

Step 2 activities will involve a multi-stakeholder approach, possibly involving an agriculturist/agroforester, economist, climatologist and farmer. Strategies and measures to enhance resilience of small farming systems to climate risks can be identified through rapid data gathering techniques such as key informant interviews and focus group discussions. Review of historical information on past trends and experiences can also be conducted to aid in the assessment of strengths and weaknesses and costs and benefits of potential adaptation options. Consultations with key stakeholders can be conducted in order to formulate adaptation systems that can immediately be done in anticipation of expected future climate risks.

Step 3 will require the continued participation of the stakeholders involved in Step 2, along with other concerned community members. The adaptation strategies identified through Step 2 activities can be prepared and implemented, placing emphasis on the need to regularly monitor and evaluate the progress of implementation. Documentation of the individual experiences of farmers through farm logbooks/journals can help development and local government workers to pick up on best practices which can in turn be recommended to other farmers in need of technical assistance.

The current practices can still be improved to further reduce the negative impacts of climate risks. The use of ICRAF for smallholder farmers offers a systematic, participatory means of planning, implementing, monitoring and evaluating sound climate adaptation practices. Through multi-stakeholder collaboration, existing adaptation strategies in the area of Lantapan can be further enhanced or supplemented with additional adaptation systems using the inputs of farmers and development workers on the ground.

The ICRAF tool is still under development and users' comments are very much welcome.

GLOSSARY OF TERMS

Note: Terms and definitions taken from the IPCC AR4 Glossary of Terms.

Adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
Adaptive capacity	The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
Afforestation	Direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.
Anthropogenic	Resulting from or produced by human beings.
Aquaculture	The managed cultivation of aquatic plants or animals such as salmon or shellfish held in captivity for the purpose of harvesting.
Carbon sequestration	The process of increasing the carbon content of a reservoir/pool other than the atmosphere.
Climate	Climate in a narrow sense is usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the *climate system*. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).

Climate change	Refers to any change in *climate* over time, whether due to natural variability or as a result of human activity. This usage differs from that in the *United Nations Framework Convention on Climate Change (UNFCCC)*, which defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global *atmosphere* and which is in addition to natural climate variability observed over comparable time periods'. See also *climate variability*.
Climate variability	Refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the *climate* on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the *climate system* (internal variability), or to variations in natural or *anthropogenic* external forcing (external variability). See also *climate change*.
Deforestation	Natural or *anthropogenic* process that converts forest land to non-forest. See *afforestation* and *reforestation.*
Drought	The phenomenon that exists when precipitation is significantly below normal recorded levels, causing serious hydrological imbalances that often adversely affect land resources and production systems.
Ecosystem	The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, *biomes* at the continental scale or small, well-circumscribed systems such as a small pond.

El Niño Southern Oscillation (ENSO)	El Niño, in its original sense, is a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. This oceanic event is associated with a fluctuation of the inter-tropical surface pressure pattern and circulation in the Indian and Pacific Oceans, called the Southern Oscillation. This coupled atmosphere-ocean phenomenon is collectively known as El Niño-Southern Oscillation. During an El Niño event, the prevailing trade winds weaken and the equatorial countercurrent strengthens, causing warm surface waters in the Indonesian area to flow eastward to overlie the cold waters of the Peru current. This event has great impact on the wind, sea surface temperature, and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world. The opposite of an El Niño event is called *La Niña*.
Erosion	The process of removal and transport of soil and rock by weathering, mass wasting, and the action of streams, *glaciers*, waves, winds and underground water.
Extreme weather event	An event that is rare within its statistical reference distribution at a particular place. By definition, the characteristics of what is called 'extreme weather' may vary from place to place. Extreme weather events may typically include floods and *droughts*.
Food security	A situation that exists when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development and an active and healthy life.
Greenhouse effect	The process in which the absorption of infrared radiation by the *atmosphere* warms the Earth. In common parlance, the term 'greenhouse effect' may be used to refer either to the natural greenhouse effect, due to naturally occurring *greenhouse gases*, or to the enhanced (*anthropogenic)* greenhouse effect, which results from gases emitted as a result of human activities.

Greenhouse gas	Greenhouse gases are those gaseous constituents of the *atmosphere*, both natural and *anthropogenic*, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the *greenhouse effect*. Water vapour (H2O), *carbon dioxide* (CO2), nitrous oxide (N2O), methane (CH4) and *ozone* (O3) are the primary greenhouse gases in the Earth's atmosphere. As well as CO2, N2O, and CH4, the *Kyoto Protocol* deals with the greenhouse gases sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).
Human systems	Any system in which human organisations play a major role. Often, but not always, the term is synonymous with 'society' or 'social system' e.g., agricultural system, political system, technological system, economic system; all are human systems in the sense applied in the AR4.
(Climate change) Impacts	The effects of *climate change* on natural and *human systems*.
Industrial revolution	A period of rapid industrial growth with far-reaching social and economic consequences, beginning in England during the second half of the 18th century and spreading to Europe and later to other countries including the USA. It marked the beginning of a strong increase in combustion of fossil fuels and related emissions of *carbon dioxide*. In the AR4, the term '*pre-industrial*' refers, somewhat arbitrarily, to the period before 1750.
Mitigation	An *anthropogenic* intervention to reduce the anthropogenic forcing of the *climate system*; it includes strategies to reduce *greenhouse gas sources* and emissions and enhancing *greenhouse gas sinks*.
Mortality	Rate of occurrence of death within a population; calculation of mortality takes account of age-specific death rates, and can thus yield measures of life expectancy and the extent of premature death.
Reforestation	Planting of forests on lands that have previously contained forests but that have been converted to some other use.

Resilience	The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.
Runoff	That part of precipitation that does not *evaporate* and is not *transpired*.
Sea-level rise	An increase in the mean level of the ocean.
Sensitivity	Sensitivity is the degree to which a system is affected, either adversely or beneficially, by *climate variability* or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to *sea-level rise*).
Sustainable development	Development that meets the cultural, social, political and economic needs of the present generation without compromising the ability of future generations to meet their own needs.
United Nations Framework Convention of Climate Change (UNFCCC)	The Convention was adopted on 9 May 1992, in New York, and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the 'stabilization of *greenhouse gas* concentrations in the *atmosphere* at a level that would prevent dangerous *anthropogenic* interference with the *climate system*'. The Convention entered in force in March 1994.
Vector-borne diseases	Diseases that are transmitted between hosts by a *vector* organism (such as a mosquito or tick); e.g., *malaria*, *dengue fever* and leishmaniasis.
Vulnerability	Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of *climate change*, including *climate variability* and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its *sensitivity*, and its adaptive capacity.
Water stress	A crop is water-stressed when actual *evapotranspiration* is less than potential evapotranspiration demands.

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