EASYPol
Online resource materials for policy-making

Climate Change and Agriculture Policies

How to mainstream climate change adaptation and mitigation into agriculture policies?

Advanced Draft of Policy Guidelines

Version of 4 July 2009

Louis Bockel
TCAS, Policy Assistance Division TCA,

Barry Smit,
University of Guelph, Ontario, Canada

FAO Review team:
Materne Maetz TCA
Shelly Sayagh, consultant
Catherine Zanev, NRC
Anna Ricoy, NRC
Stephan Baas, NRC
Michele Bernardi NRC
Facon Thierry FAORAP

EASYPol
On-line resource materials for policy making

Table of Contents

ACRONYMS

ADB	African Development Bank
APF	Adaptation Policy Framework
CCA	Climate Change Adaptation
CIDA	Canadian International Development Agency
COP	Conference of the Parties
DFID	UK's Department of International Development
ERM	Environmental Resources Management Group
GEF	Global Environment Fund
FAO	Food and Agriculture Organization
IPCC	Intergovernmental Panel on Climate Change
LLPPA	Local-level participatory planning approach
MERET	Managing Environmental Resources to Enable Transitions
NAPA	National Adaptation Action Plan
NGO	Non Government Organization
OECD	Organisation for Economic Co-operation and Development
PICCMAT	Policy Incentives for Climate Change Mitigation Agricultural Techniques
PSNP	Productive Safety-Nets Programme
SPREP	Secretariat of the Pacific Regional Environment Programme
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WFP	World Food Programme

Executive Summary

These guidelines have been prepared by FAO to support national policymaking in agriculture, rural development and food security in light of climate change. They are intended to:

1. assist in the formulation of agricultural and rural development strategies, policies and programmes that increase the resilience and/or performance of the agriculture sector of developing countries faced with changing climate and weather conditions, by incorporating climate change adaptation in agricultural policies relating to production, livelihoods and the use of water, land and capital resources; and
2. help policy makers to take advantage of the potential for climate change mitigation within the sector (carbon, environment and income generation benefits) by choosing adaptation measures which also serve the aim of mitigation

Agricultural adaptation to a changing climate is needed in all countries, and many have lessons for incorporating adaptation into agricultural policies to share. Invariably, adaptations to climate change in agriculture have not been (and are not likely to be) undertaken in response to climate change alone or in isolation. The various lists of potential adaptations to climate change are all strategies, management methods or technologies that have been employed.

Key features for integrating climate change adaptation into agricultural development initiatives are that they increase the resilience and/or performance of the agriculture sector, they fit within the development priorities and processes of the country and they are accepted, supported and promoted by the country's decision-makers and stakeholders.

Agriculture also contributes to greenhouse gas emissions, and has a role to play in climate change mitigation through the reduction of emissions and carbon sequestration. Many agriculture mitigation options are estimated to also have positive effects on climate change adaptation, because they increase the resilience of agro ecosystems to perturbation from climatic variation by increasing the retention of nutrients and water and preventing soil erosion, degradation and flooding. Opportunities for climate change mitigation, including those that are synergistic with adaptation, can also be realized through their incorporation into national agricultural policies.

FAO prioritizes a set of high potential adaptation oriented policy options including (i) policies to encourage adapted crop development and farming practises, (ii) crop and income loss risk management policies, (iii) policies to promote soil conservation and land management, (iv) irrigation and water resource management policies and (v) disaster risk management policies. Among mitigation-oriented policy options, the priority is given to the following: (i) policies to promote conservation agriculture, (ii) options to reduce methane emissions from rice paddies, (iii) watershed management policies and (iv) livestock management policies.

Effective integration of climate change adaptation and mitigation into national policies require the active involvement of national agriculture policymakers, including those responsible of implementing policy and stakeholders in the agricultural sector.

The process of mainstreaming includes (i) climate change scenarios and estimate impacts on agriculture, (ii) identifying possible adaptation options (ch. 3) (iii) identifying relevant mitigation options, practises (ch. 4), (iv) selecting appropriate entry points for mainstreaming

climate change into existing policies (ch. 5) (v) appraising feasibility and implementation aspects (operational capacity, technical gaps), (vi) stakeholder and donor mobilisation (ch. 6.-6.3) and (vii) funding and implementation options (ch. 6.4)

The government's role in implementation will be more focused on: (i) ensuring commitment and resources, (ii) building capacity at several levels, (iii) gathering data to support planning tools and monitoring activities, (iv) guaranteeing effective institutionalization and coordination mechanisms.

The demand for rapid implementation, the need to work simultaneously at different levels (farmers at the field level and service providers, local, regional and national levels) and the wide range of stakeholders involved are all reasons to consider an approach that mobilizes all partners from the outset. Inspired by the need to find a rapid response to the current economic crisis, a real Innovation-Based Economic Stimulus Package for adaptation and mitigation actions could be built with donor partnership and adequate result-oriented monitoring.

An additional mechanism to scale up the integration process is to ensure that the newly formulated and on going projects are promoting technical adaptation and mitigation options and tools down to farmers and beneficiary level. The whole process of selecting and comparing project / micro project proposals in line with mitigation and adaptation will be based on expected performances (Ex ante appraisal) and appropriate monitoring.

Introduction

This paper is part of a wide series of policy assistance guidelines and modules developed by FAO TCA. The policy assistance function aims to support and influence development policy and implementation processes at national, regional and international levels by supporting the formulation, implementation and monitoring and evaluation of policies and strategies. This includes direct support to member countries in the formulation and implementation of policies through its field programme as well as normative policy-related work, providing guidance and analytical information to improve the efficiency of policy development and decision-making.

It is now widely recognized that climate change poses significant threats to agriculture, including crop and livestock production, water and land use, food security, rural livelihoods and incomes, and trade (Intergovernmental Panel on Climate Change IPCC and FAO Climate change and Food Security Conference, 2008). The agricultural sector and rural communities in developing countries is particularly vulnerable to climate change as a result of direct resource dependence, the importance of agriculture for food and livelihoods, and the limited financial, institutional and technical assets to deal with changing conditions.

The global response strategy of reducing net greenhouse emissions to slow or "mitigate" climate change has received great international attention, yet global emissions are continuing and climate change is accelerating (IPCC 2007)[1]. While more effective mitigation strategies are desperately needed, there is also an immediate need for "adaptation" to the changing climate, to help reduce the adverse effects in vulnerable countries and sectors. Studies have proposed a variety of potential adaptations, and numerous agricultural adaptation projects and initiatives have been launched in developing countries. Most of these have been at the local scale, initiated by international or bilateral agencies and NGOs.

In order for climate change adaptation to be sustainable and applicable on a wide scale, it must be incorporated, integrated or "mainstreamed" into the policy apparatus of governments (Klein, 2007)[2]. Most climate change adaptation measures relate closely to, or directly overlap with, existing strategies, policies and programmes (e.g. agricultural development, food security, livelihood maintenance, resources management, risk management). It has been suggested that the most efficient and effective way to achieve adaptive and resilient agricultural systems and rural communities is to incorporate climate change adaptation into other policies rather than creating separate, self standing climate change policies which may duplicate others (IISD).[3]

A similar situation exists with climate change mitigation. There is an increasing demand to reduce net greenhouse gas emissions, even among developing countries who have historically not contributed to emissions and climate change. This translates into pressures and incentives to alter practices in order to reduce emissions of greenhouse gases from crop and livestock operations, to capture carbon in land use practices and to realize market opportunities for biofuels. Climate change mitigation measures are invariably related to measures associated

---

[1] IPCC, Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the IPCC

[2] KLEIN, R. (2007): Adaptation to Climate Change: IPCC Findings and their Implications for Climate and Development Policy. Presentation held at a workshop in Bonn, 20 November 2007 http://www.germanwatch.org/termine/2007-11-20/klein.pdf

[3] IISD, Designing policies in a world of uncertainty, change, and surprise, Adaptive policy-making for agriculture and water resources in the face of climate change, International Institute for Sustainable Development, 2006

with soil conservation, land use, energy, livelihoods, incomes and trade. As with climate change adaptation, there are likely to be benefits of efficiency and effectiveness to incorporating climate change mitigation into existing policies.

The principle guiding FAO work with respect to activities related to climate change is the "no-regret" approach. It emphasizes measures that should be taken regardless - even in the absence of climate change - because they improve the efficiency of present agriculture practices as well as in forestry and fishery. At the same time, they put farmers, the foresters or the fisherfolk in a better position to adapt to or mitigate the effects of climate change.

This report focuses on the need to and opportunities for integrating climate change adaptation into national policies, with the expectation that implementing these policies will reduce the vulnerability of the agriculture by enhancing its resilience to changing climate and weather conditions.

Despite the need for climate change adaptation in agriculture, and notwithstanding the numerous possible, hypothetical or potential adaptations proposed in academic papers, reports, United Nations Framework Convention on Climate Change (UNFCCC) National Communications and the National Adaptation Programmes for Action (NAPAs), there are relatively few examples of national policies explicitly facilitating agricultural adaptation to climate change.

There is a growing body of expertise on climate change adaptation among development organizations in relation to developing countries. Many developing countries have government officers responsible for climate change adaptation (and/or mitigation). There are also numerous NGOs operating at international, national and local levels with considerable expertise in climate change adaptation and mitigation and in relating these to development programmes and projects.

Section 1 reviews the characteristics of climate change, including long-term and short-term effects, climate variations and extremes and their implications for agricultural resource production, livelihoods, food security and poverty reduction strategies. The section illustrates the many areas of agriculture that are vulnerable to climate change while highlighting potential policies that may address these gaps.

Section 2 outlines the roles of climate change adaptation and mitigation, notes the relationship between climate change adaptation and development programmes and outlines the connections between climate change response strategies and national agricultural policies. The section concludes with a summary of alternative routes for integrating climate change adaptation and mitigation into national policies.

Section 3 outlines the main types and forms of climate change adaptation methods that have been proposed or initiated, noting where they apply (e.g. water management, land use, risk management, crops and livestock, livelihoods) and the roles played by national governments and other stakeholders, notably farmers. This section provides the rationale for integrating climate change adaptation into national policies and notes conditions for its effectiveness.

Section 4 presents a brief review of mitigation options in agriculture. It outlines the existing synergies between adaptation and mitigation and features agriculture policy options with both adaptation and mitigation potential, including conservation agriculture, watershed management and livestock management.

Section 5 examines the means by which adaptation can be incorporated into the policy process. Alternative strategies, including separate policies for climate and "climate-proofing" existing policies, are outlined and assessed. Key considerations for effectively integrating adaptations into national policies are also provided.

Section 6 focuses on the process of mainstreaming adaptation into already existing agriculture policies, paying particular attention to the different categories of actors involved. It reviews the respective roles of government, donors and key stakeholders, outlining the different steps to be followed and implementation paths.

1. Agricultural Impacts of Climate Change

This section outlines the characteristics of climate change that have implications for agriculture (and hence for agricultural adaptation and policies), both as expected in the long term and as already experienced.

1.1. Long and Short-term Issues

Adaptations to climate change are intended to moderate its detrimental effects or to enable a country or sector to benefit from opportunities associated with changes in climate. Therefore, the characteristics of climate change and their implications are fundamental when considering adaptation strategies. Climate change scenarios focus on long-term future changes (10 to 100 years) in key climate variables, notably temperature, with an emphasis on temperature "norms" or averages. Most assessments of the potential impacts of climate change are based on climate change scenarios (either broad scale or spatially "down-scaled"). To isolate the influence of climate change alone, other agricultural factors and drivers of change are conventionally outside the analysis or are assumed to be constant.

Impacts identified from scenario-based studies typically include:

- A shift in agro-climatic zones
- Changes in the suitability of land for different types of crops and pastures
- A rise in sea level, which will inundate agricultural areas and/or lead to saltwater intrusions, precluding the use of certain areas for crops and livestock
- The increase in temperature in most places will decrease precipitation, alter evaporation processes, affect water supplies, alter the seasonality of extremes, as well as a decline in crop yields (and some increases), reduced production and revenues and stress on livestock compounded by disease and lower livestock productivity
- An increase in temperature coupled with a decrease in precipitation will seriously reduce productivity and constrain agricultural production
- Precipitation increases will result in crop yield gains, with associated benefits for production and incomes
- Precipitation decreases will lead to crop losses, diminished production and reduced revenues, will constrain livestock production and contribute to moisture deficits
- The increase in floods and droughts will lead to crop failure, livestock losses, disease outbreaks, destruction of infrastructure, hunger and displacement of people

Scenario-based impact studies have generated a range of possible or hypothetical types of adaptation, mostly related to estimated impacts of long-term changes in average temperatures. Some proposed adaptations to projected climate change include:

- change land use systems to better match evolving agro-climatic zones
- move people and production from areas that are expected to be inundated, subject to saltwater intrusion, or otherwise unviable for agriculture
- develop new drought-resistant crop types or varieties; introduce crop varieties better suited to changed agro-climatic conditions
- improve seasonal weather forecasts
- alter timing of crop management practices
- promote and/or expand irrigation
- improve efficiency of water use, especially with respect to irrigation
- develop weather-related insurance systems
- improve grassland and pasture management
- introduce or expand community food storage systems
- invest in infrastructure

Field studies of agricultural systems in developing countries, including experiences with variable weather and climate and adaptive responses, have shown that agriculture and rural communities are particularly vulnerable to the following:

- conditions that affect income, livelihoods, health and security
- conditions related to changes in the frequency, intensity, timing and duration of extremes, notably droughts, storms and intense rainfall
- indirect effects of changing climate, including periods of heat stress, moisture deficits, storm damage and flooding and disease risk to crops, livestock and people

In the agricultural communities of developing countries, research on vulnerabilities and actual adaptation processes has resulted in important lessons for adaptation policies and programs:

- Decision-makers are sensitive to existing and near-future climate conditions, so adaptation measures should relate to current and near-future conditions in addition to expected long-term changes as information on long-term (10 to 100 years) climate patterns alone are not sufficient to motivate or direct immediate adaptive actions.
- Average temperatures are rarely the key climate-related stimuli for agricultural decision-makers. Agricultural production, resource use, incomes, etc. are vulnerable to variability and extremes in heat and moisture conditions. Adaptation initiatives should relate to the climate conditions that are important in particular agricultural regions, sectors or communities, in addition to long-term changes in average temperatures.
- Adaptations in agriculture (production systems, resource management strategies, livelihoods, rural finance arrangements, marketing and trade) are not made in response to climate change alone. For a climate change adaptation initiative to be practical, it must recognize the interconnected roles of non-climate forces in agricultural decision-making processes at all levels.

1.2. Climate Change: Vulnerability to Variations and Extremes

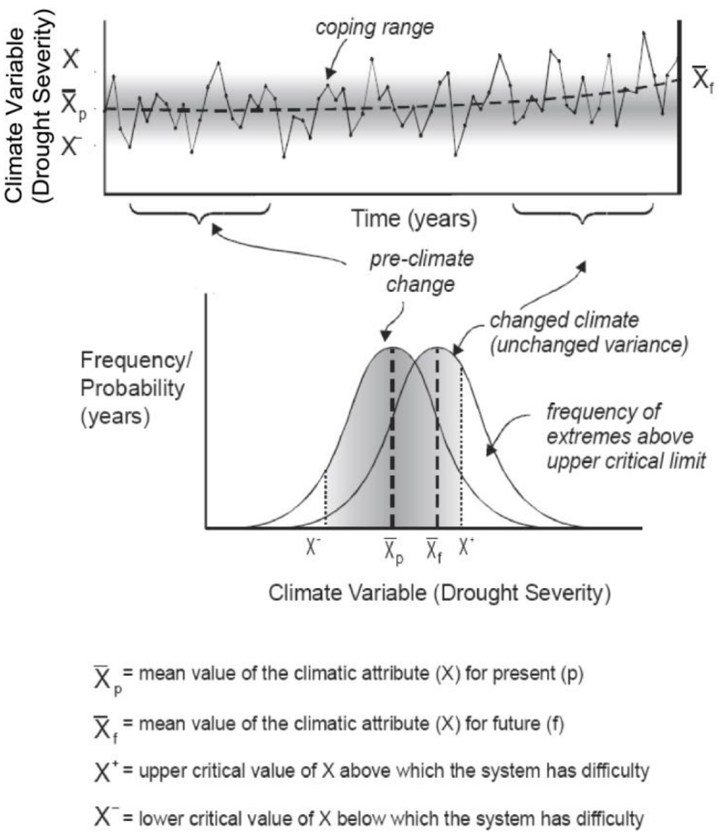
Climate change models (and most climate change impact frameworks) focus on long-term (10-100 years) changes in climate norms (notably mean temperatures). Agricultural decision-makers typically focus on short to intermediate futures (<1-10 years), and are sensitive to variations in particular weather conditions (notably extremes), such as the frequency and severity of drought, moisture at certain phonological periods, temperature/moisture durations as they relate to diseases, etc.

For adaptation purposes, these two perspectives – that of climate change science and the practicing farmer – should be merged. Climate change models have indicated vast and widespread changes in growing conditions to be expected over the longer term, hinting at some of the major structural adjustments that might be necessary to deal with projected impacts. Studies of agricultural systems can identify conditions that make people and production vulnerable as well as the natural adaptations of communities in order to cope. These vulnerability and adaptation studies have proven that the example of practical systems established as coping mechanisms for current climate-related risks (and risk management strategies) is an effective means of promoting adaptation to climate change.

Long-term climate change and variable weather and extreme events are not independent of each other: Figure 2 illustrates the relationship between them. Climatic conditions are inherently variable over time, be it years or decades. Variability goes along with and is an integral part of climate change. A change in mean conditions is actually experienced through changes in the frequency and magnitude of conditions each year, including extremes (Figure 2).

Figure 2 illustrates the inter-annual variation in a community-relevant climate attribute (X) such as drought severity. The average drought severity value rarely occurs, but there is gradually an increasing trend in drought severity, such that the future mean (X_f) is higher than the present mean (X_p), as might be projected with climate change.

<u>Figure 3. Climate change, extremes and coping range (Smit and Pilofosova 2001)</u>



Most communities and sectors can cope with conditions that deviate from the norm, but only to a degree. This ability to cope within a certain range of conditions is referred to as the coping range (Figure 2). The system is vulnerable to extremely dry or extremely wet conditions falling outside the coping range, as they exceed its adaptive capacity. While the boundaries of the coping range, also called coping or adaptation thresholds, may be portrayed as discrete values, in practice they are likely to be gradations, becoming more problematic for the system the greater the deviation from the norm. It is also likely that this vulnerability gradient is non-linear. Beyond a certain level of severity, vulnerability may increase exponentially (e.g., in case of system susceptible to famine) or it may tend to level off (e.g., in systems where insurance or other coping mechanisms become effective over time).

Figure 2 also shows the way in which climate change relates to the vulnerability and adaptive capacity of a system. The average drought severity increases over the time period (X_p to X_f), but even at the end of the period the average condition (X_f) is still within the coping range. The system has the capacity to deal with a changed average year. However, with a shift in average (yet, in this case, with no change in the variability), there are also changes in the frequency and magnitude of extremes. Without some adaptation or adjustment, and some shift in the coping range, the system is more frequently exposed and hence is more vulnerable.

Thus, adaptation to climate change necessarily includes adaptation to climatic variability and extremes. Vulnerabilities to changes in extremes and long-term norms and capacities to adapt vary from region to region, group to group and over time. Adaptation measures are intended to expand the capacity or coping range, equivalent to increasing resilience. Adaptations to long-term climate change usually also enhance the capacity to deal with imminent climate hazards.

An analysis of agriculture and rural systems in the context of climate change has yielded consistent insights:

- Agricultural systems are vulnerable to (and need to adapt to) climatic conditions other than average temperatures, and these ‘exposures’ are specific to locations and agricultural systems (frequency, severity, duration, extent).
- Agricultural systems have evolved to adapt to some variation in conditions, but climate change is expected to cause the coping range to be exceeded more frequently and more severely, resulting in increased vulnerability at many levels.
- Adaptation to climate change involves expanding the adaptive capacity (coping capacity, resilience) of the system to deal with more frequent, increasingly difficult conditions and gradual changes in climate norms.
- For developing country agriculturalists, near-term challenges, including immediate climate risks, are so great that adaptation to long-term climate change is not a priority. However, because most climate change risks represent exacerbations of current exposures, adaptation to climate change also serves as an adaptive strategy to deal with existing or immediate risks.

This confluence of adaptation to future climate change with the management of present variability has practical appeal for adaptation programming. Agricultural decision makers are aware of and sensitive to conditions that have affected them in some way, and climate change is most commonly experienced via the exacerbation of existing conditions. Adaptation measures can build on the processes, methods and experiences (successful and otherwise) that exist, rather than develop and adopt entirely new measures specific to climate change.

Almost all climate change adaptations (initiated or proposed) involve initiatives already in place (or being advocated for other reasons) into which climate change considerations are incorporated. Common agricultural adaptations to climate change relate to crop development, water management, risk aversion strategies, livelihood diversification and insurance, all of which have much wider applications. Adaptation to climate change can be incorporated (or ‘mainstreamed’) into agricultural development strategies, policies or programmes.

Implications on funding adaptation. Adaptations that reduce vulnerabilities to both current climate risks and future climate change are considered to be effective and efficient from the point of view of agricultural development. Being able to deal with droughts is beneficial, regardless of whether the next drought is 'natural' or 'human induced'. Of course, it is impossible to attribute particular climate-weather events to 'normal' or 'anthropogenic' climate change, and for farmers and families having to deal with droughts the distinction is hardly relevant. Yet, for adaptation initiatives under the UNFCCC and associated funds (e.g. through the GEF) the issue of support to deal with conditions other than those directly attributable to "anthropogenic climate change" has been problematic.

1.3. Impacts and Vulnerabilities in Agriculture

Climate change has significant global implications for agriculture and rural communities, and these are particularly problematic in developing countries (IPCC, Stern, etc.)

1.3.1. Relationships between climate change and elements of agriculture

The FAO has outlined the relationships between types of stress resulting from climate change processes or exposure and attributes of agriculture, including assets, activities, food security components, consumption and human health (see Figure 3).

Detail on the impacts noted in Figure 3 and possible adaptive responses are given in Appendix 2.

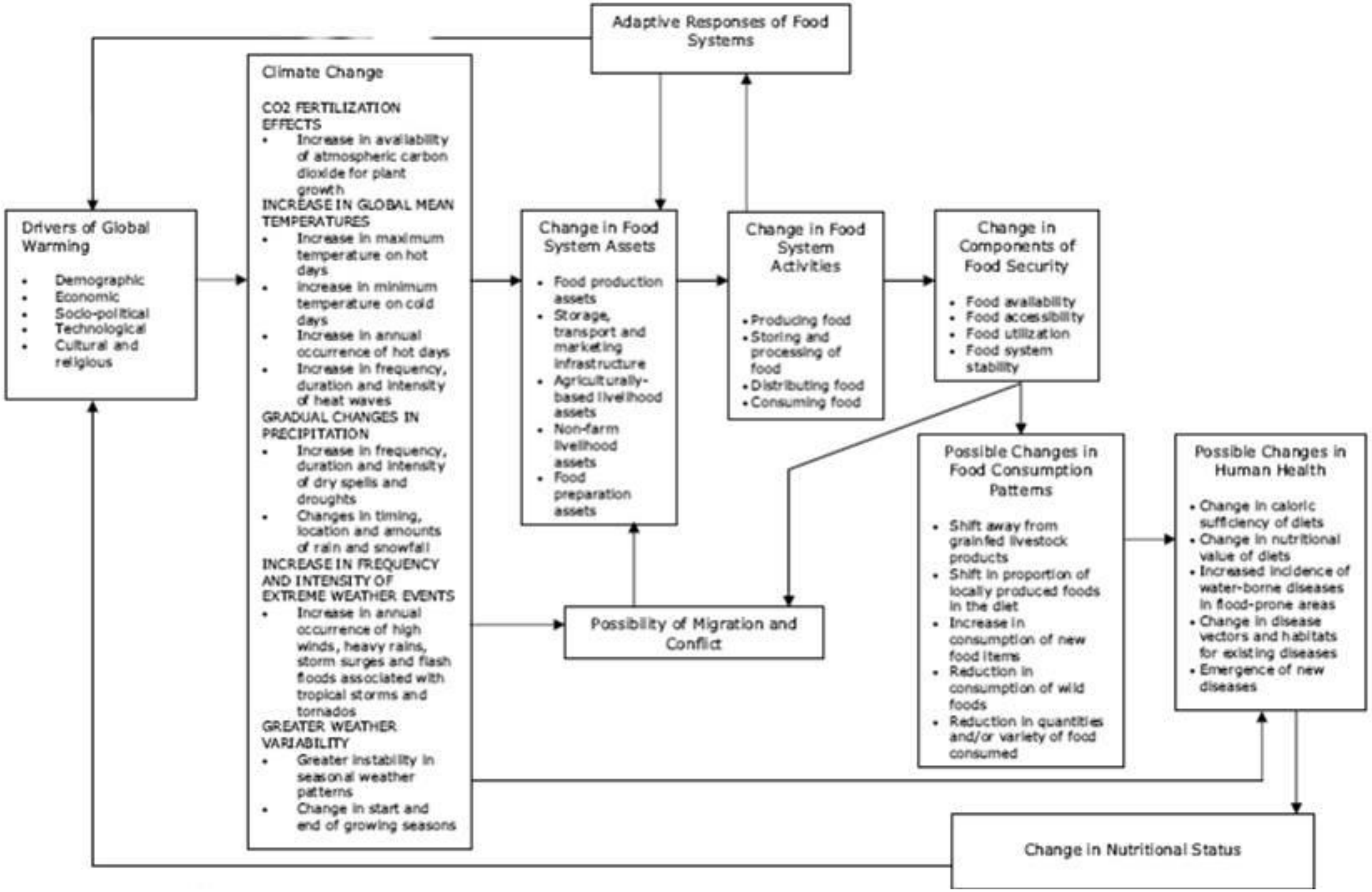


Figure 4: Climate change and food security (FAO/NRCB, 2008)

1.3.2. Climate Change as a Catalyst for Existing Challenges

An alternative to viewing climate-agriculture relationships to the climate scenario-impact is to start with existing challenges to agricultural and rural development (as addressed in policies), then consider how and where they are moderated, exacerbated or otherwise affected by climate change. A summary of challenges to agriculture and the impacts on them by climate change is given in Table 6.

Table 2. Challenges to agriculture and influence of climate change

	Challenge	**Possible Impact of Climate Change**
Natural Resources	• Precipitation in semi-arid and arid developing world is highly variable • Irrigation: Water critical to increasing productivity in Asia; opportunities far more limited in Africa, where agriculture will rely heavily on rain-fed systems in the future. • Degradation of the natural resource base	• Increased variability of precipitation • Increased competition for water, particularly between utilization for productive agriculture vs. domestic/non-agriculture-related needs. Agriculture will have to consume less water and/or irrigate far more efficiently. • Increased degradation, especially in Africa
Population	• Agricultural development is limited in places with low population densities and small markets • HIV/AIDS is reducing agricultural productivity	• Increased migration and changing population densities in different parts of the world - changing markets • Adaptation hindered as coping / adaptive strategies and local knowledge not passed between generations
Transportation / Infrastructure	• Poor transport infrastructure limits market access for many farmers • Transport costs account for high proportion of export costs in many African countries	• Infrastructure threatened by disasters e.g. floods. • Transport costs likely to rise as a result of (shipping and airfreight) mitigation measures – implications for global and local competitiveness
Commodity prices	• Commodity prices have fallen steadily since the 1960s • Volatility of input and output prices discourages investment in increasing productivity	• Global prices for commodities may increase but there will be significant inter-regional differences • Price volatility will increase under climate change scenarios
Access to markets	• Product standards imposed by supermarkets are a barrier to market entry by small producers • High value cash crops (e.g. horticulture and floriculture) provide opportunities for growth though small farmers receive small share of market value	• Phyto-sanitary standards may increase due to concerns about new disease corridors resulting from climate change • Changing consumption patterns and increased transport costs reduce access to supermarkets in developed countries
Agricult ure growth	• Links between agriculture and wider growth may not be as strong today as during the Green Revolution	• Increased costs of global shipping and changing consumer demands regarding food miles may stimulate local diversification and linkages
Role of the state	• In many developing countries, fiscal unsustainability has forced states to reduce / withdraw support to agriculture with only rarely successful private substitution. • Public expenditure on agriculture has fallen over the last 3-4 decades, especially in research	• Climate change suggests an increased role for the state to ensure successful adaptation and mitigation strategies but whether this will result in a rejuvenation of Agriculture Ministries or 'more of the same' is not clear • Different and increased public expenditure in agriculture is required under climate change scenarios.

(Slater, 2007; ODI, 2007)

1.3.3. Impacts on rural livelihoods, poverty and food security

The implications of climate change go beyond conditions during growing seasons and crop and livestock productivity – it clearly affects the livelihoods and lives of rural people. Changes in climate – particularly droughts, heat waves, flooding and storms – will impose significant stresses on rural livelihoods, threatening existing food production and income systems and limiting options in the future.

It is evident that poor, natural resource-dependent households will bear a disproportionate burden as climate change-induced hazards cause losses in food production and contribute to ecosystem degradation, heat waves, fires, disease and conflicts. In some parts of the world, these effects may already be in place with potentially disastrous consequences for the poor (Adger et al., 2007).

Combined with a limited adaptive capacity in developing countries, climate change could undermine efforts to reach the Millennium Development Goals. Increasingly, development programmes and projects involving international agencies, national development and aid agencies and NGOs, are considering the risks of climate change in their planning and implementation.

Initiatives to reduce poverty and hunger are at risk to climate change, relative to its direct effects which include floods, droughts, storms and the associated losses in crops, livestock and assets, and indirect effects associated with livelihood assets, food, disease, health and loss of homes, infrastructure and lives.

Programmes to sustain and improve food security are clearly at risk. Regions, communities and people who are already vulnerable face increased risks in all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability. Examples of groups particularly sensitive to climate change include:

1. low-income groups in drought- and flood-prone areas with poor food distribution infrastructure and limited access to emergency response;
2. low- to middle-income groups in flood-prone areas that may lose homes, stored food, personal possessions and means of obtaining their livelihood, particularly when water rises very quickly and with great force, as in sea surges or flash floods;
3. farmers whose land becomes submerged or damaged by sea-level rise or saltwater intrusions;
4. producers of crops that may not be sustainable under changing temperature and rainfall regimes or producers of crops at risk from high winds;
5. poor livestock keepers in drylands where changes in rainfall patterns will affect forage availability and quality;
6. managers of forest ecosystems that provide forest products and environmental services;
7. fishermen whose infrastructure for fishing activities, such as port and landing facilities, storage facilities, fish ponds and processing areas, becomes submerged or damaged by the rise in sea-level, flooding or extreme weather events; and
8. fishing communities that depend heavily on coral reefs for food and protection from natural disasters.

2. CLIMATE CHANGE, AGRICULTURE AND FOOD SECURITY: ROLE OF ADAPTATION AND MITIGATION

2.1. Climate Change and Agriculture

Climate change represents an additional stress on agriculture. Agriculturalists (crop and livestock producers, resource suppliers, managers, processors, marketers, etc.) have always had to deal with variations in weather and growing conditions, as well as variations in their resources, assets, inputs, costs, markets and so on. Even without climate change, many people (in many communities in many countries) struggle to meet basic food and livelihood needs. Climate change adds a cumulative, irregular, stress to the conditions rural people already deal with.

Changes in temperature and precipitation and in the frequency and severity of extreme weather events will translate into land and water resource constraints and losses in crops and livestock, threatening in turn livelihoods, food production, incomes and also access, security, and stability in the supply, trade and usage of food. In some regions, the changes may occur faster than the population's capacity to adapt.

Agriculture refers to the various aspects of the agro-food system, including crops, livestock, fisheries, forestry, production, assets, land use, resource use, processing, livelihoods, income, and trade and food security. It involves decision-makers at many levels including farmers, communities, businesses and other private sector agents, regional and national governments, NGOs, bilateral and multilateral agencies and organisations, among others.

The IPCC assessment[4] shows that developing countries are likely to suffer serious negative impacts of climate change. Poor countries and poor people are most vulnerable to climate change as they are more dependent on natural resources and they have the least financial, technical and institutional means to adapt. Climate change is expected to cause water stresses, production losses and increased damages from extreme weather events, threats to food security, increases in vector-borne diseases and their impacts on public health and the displacement of millions becoming “climate refugees”.

Agriculture is not only affected by climate change, it is also a contributor to climate change, representing a significant source of greenhouse gases. Globally, agricultural production (crops and livestock) is responsible for the majority of methane emissions (cattle, rice plantations, and wetlands) and nitrous oxide (application of fertilizer). Changes in land use, such as deforestation and soil degradation – two devastating effects of unsustainable agricultural practices – release large quantities of carbon into the atmosphere, also contributing to climate change.

2.2. Projected Impacts by sector

[4] *IPCC, Climate change 2007, synthesis report, UNEP-WMO, 2007* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

PHENOMENON AND DIRECTION OF TREND	LIKELIHOOD OF FUTURE TRENDS BASED ON SRES SCENARIOS	EXAMPLES OF MAJOR PROJECTED IMPACTS BY SECTOR			
		AGRICULTURE, FORESTRY AND ECOSYSTEMS	WATER RESOURCES	HUMAN HEALTH	INDUSTRY SETTLEMENT AND SOCIETY
Over most land areas, fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snow melt; effects on some water supply	Reduced human mortality from decreased cold exposure, increased mortality and illness due to malaria	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves. Frequency increases over most areas	Very likely	Reduced yields in warmer regions due to heat stress; wild fire danger increase	Increased water demands; water quality problems, e.g., algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially-isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on elderly, very young and poor
Heavy precipitation events. Frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land due to water logging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries, infectious, respiratory and skin disease	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation, lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread stress on water supply or availability	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Increased incidence of extreme high sea level (excludes tsunamis)	Likely	Salinization of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure

Information for this exhibit was taken from "Climate Change Impacts, Adaptation and Vulnerability - Summary for Policy Makers of the Working Group II (World)." IPCC. http://www.ipcc-wg2.org/.

<u>Figure 1: Impact of Climate change phenomena by sector</u>

The livestock production system contributes to global climate change directly by producing GHGs emissions[5] and indirectly by destroying biodiversity, land degradation and desertification and water and air pollution. There are three main sources of GHG emissions within the livestock production system: enteric fermentation of animals, manure (waste products) and feed and forage (field use) production (Dourmad, et al., 2008[6]). Meanwhile, indirect sources of GHGs from livestock systems mainly originate from changes in land use and deforestation to create pasture land. For example, 70% of the deforestation experienced by the Amazon rainforest occurred in order to create grazing lands for livestock. Smallholder livestock systems have, in general, a smaller ecological footprint compared to large scale industrialized livestock operations (IFAD 2008).[7]

2.3. Climate change and food security

Food security is the outcome of *food system processes* all along the *food chain* (production, processing, distribution, preparation and consumption). It exists when all people at all times have physical or economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. There are at least four channels by which climate change affects food security:

- **Increase in temperature.** Higher temperatures lead to heat stress for plants, increasing sterility and lowering overall productivity. Higher temperatures also increase evaporation from plants and soils, increasing water requirements while lowering its availability.
- **Changing patterns.** In many places, growing seasons are changing, ecological niches are shifting and rainfall is becoming more unpredictable and unreliable both in its timing and its volume. This is leading to greater uncertainty and heightened risks for farmers, potentially eroding the value of traditional agricultural knowledge such as when to plant particular crops.
- **Rising sea levels.** Rising seas contaminate coastal freshwater aquifers with salt water. Several small island states are already having serious problems with water quality, which is in turn affecting their agricultural productivity. Higher seas also make communities more vulnerable to storm surges which can reach up to 5–6 metres in altitude.
- **Water.** The interactions between climate change, water scarcity and declines in agricultural productivity could lead to regional tensions and even open conflict between states already struggling with inadequate water supplies due to rising populations and the necessary over-pumping of groundwater.

The *impacts of climate change on food systems and food security* will be felt most immediately through the adverse effects of more frequent and more intense extreme weather events on food production, food distribution infrastructure and livelihood assets and opportunities in both rural and urban areas. Changes in mean temperatures and rainfall and increasing weather variability will have less immediate effects, affecting primarily land suitability for different types of crops and pasture, the incidence of and vectors for different types of pests and diseases, and the biodiversity of natural habitats.

Food prices could increase as a result of growing scarcities of water, land and fuel and the introduction of payments for environmental services to mitigate climate change, should this

[5] FAO, Livestock's Long Shadow report , 2006
[6] Dourmad, J., Rigolot, C., and Hayo van der Werf, 2008. *Emission of Greenhouse Gas:Developing management and Animal farming systems to assist mitigation.* Livestock and Global Change conference proceeding. May 2008, Tunisia.
[7] IFAD, Livestock thematic papers, livestock and climate change, 2008, http://www.ifad.org/lrkm/events/cops/papers/climate.pdf

become a common practice. However, current projections suggest that globally, continued economic growth will push up average incomes faster than any likely price increases, demand for animal protein as a share of total food consumption will continue to increase and the share of food in average household expenditure will continue to decline.

Vulnerable livelihood systems include: a) small-scale rain-fed farming systems, pastoralist systems and forest-based systems in locations where productivity declines are projected as a consequence of climate change and b) low-income farmers, fishers and city dwellers whose access to food and sources of livelihood are at risk from the impact of extreme weather events.

The food security of persons belonging to these systems could be at increased risk, but this risk could be offset by the adoption of measures to strengthen resilience and sustainability in the face of a wide range of possible impacts of climate change.

2.4. Climate Change Mitigation and Adaptation

Climate Change refers to ongoing changes in the global climatic system resulting primarily from anthropogenic global warming as a consequence of the increased and continuing emissions of greenhouse gases and the loss of vegetation cover and other Carbon sinks. It refers to gradual changes in climate norms, notably temperature, and changes in the frequency, extent and severity of climate and weather extremes.

Climate Change Adaptation refers to spontaneous or organised processes by which human beings and society adjust to changes in climate by making changes in the operation of land and natural resource use systems and other forms of social and economic organisation in order to reduce vulnerability to changing climatic conditions.

Climate Change Mitigation refers to organised processes whereby society seeks to reduce the pace and scale of climate change by reducing emissions of Carbon and other greenhouse gases and increasing the sequestration of atmospheric Carbon through absorption by vegetation or other forms of carbon sinks.

Climate change introduces policy and management needs and opportunities in agriculture in two distinct ways, as concerns about human-induced (anthropogenic) climate change and its impacts on ecosystems and socio-economic systems, including agriculture and food security and the livelihoods of rural communities in developing countries, have introduced the need to react to unequivocally to these changes.

a) Climate change is causing agriculturalists to experience changes in temperature, heightened precipitation and evaporation, extreme weather conditions (floods, droughts, etc) in addition to effects of changing water supplies, higher incidence of water and vector-borne diseases and so on. These have direct immediate implications for agricultural production (crops and livestock) and hence for livelihoods, food security and rural incomes. In order to reduce vulnerabilities to climate change, to minimize its negative impacts (and take advantage of opportunities where they arise), modifications can be made in production systems, via changes in land use, crops, livestock, inputs, resource management, etc. In the climate change field, adjustments in a system to reduce or moderate effects of climate itself are called "**adaptation**" responses. The target (direct beneficiaries) of adaptation initiatives are agriculturalists and the food production system.

b) As concerns over climate change and its impacts grow, at longer term, there is recognition of the need to reduce greenhouse gas emissions in order to slow, stop or mitigate the changes in the climate. Actions to reduce emissions or enhance “sinks” (sequestration) are called “**mitigation**” responses. The direct target of mitigation initiatives is the climate itself. If mitigation efforts were to stop or slow climate change then impacts would be reduced and the need for adaptation would be less urgent. Notwithstanding international mitigation efforts, greenhouse gas emissions have continued to increase, the climate is rapidly changing, and the effects of this change are being increasingly experienced (IPCC 2007).

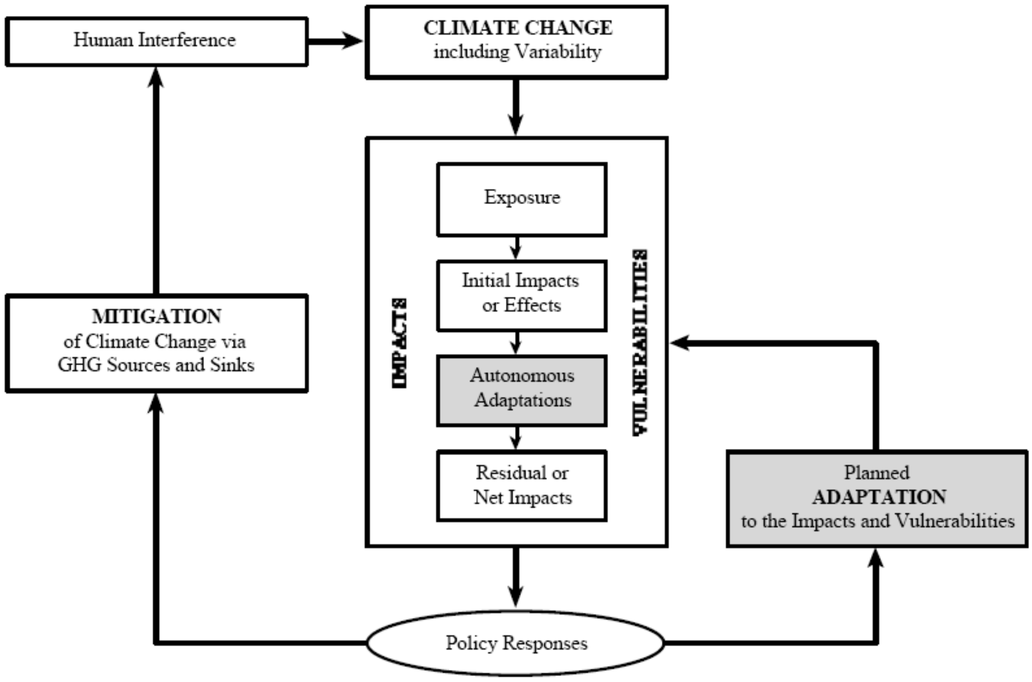


Figure 2: Roles of mitigation and adaptation in the climate change issue (from IPCC 2001; after Smit et al. 1999)

Agriculture is a major source of greenhouse gases (GHG), contributing 14% of total global emissions. When combined with related changes in land use including deforestation (for which agriculture is a major driver), agriculture’s contribution rises to more than one-third of total GHG emissions. Between 1990 and 2005 agricultural emissions in developing countries increased by 32% and are expected to continue to increase. Reducing and removing emissions from the sector, while ensuring food security and enabling economic growth will need to form part of an urgent global effort to achieve the ultimate objective of the UN Framework Convention on Climate Change (UNFCCC), contained in Article 2. Under the UNFCCC, countries are committed to “formulate, implement...national and, where appropriate, regional programmes containing...measures to facilitate adequate adaptation to climate change” (4.1.b); and to “cooperate in preparing for adaptation to the impacts of climate change” (4.1.e). Developed countries are committed to “assist developing country parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation...” (4.4).

The potential for technical mitigation in the sector is high and 74% of this potential is in developing countries. The IPCC and global financial indicators highlight that the magnitude of the challenges to stabilize GHG concentrations will require utilizing Agriculture, Forestry and

Other Land Use (AFOLU)-related emission reductions to the fullest sustainable extent possible, until new technologies are affordable (FAO, 2009).[8]

Some mitigation initiatives may be compatible with adaptation activities. Some mitigation measures may be inconsistent with climate change adaptations geared towards sustaining food production or rural incomes. Some adaptation practices (e.g. a change to no-till agriculture) can also reduce emissions and others may be neutral or inconsistent with mitigation. Just as mitigation measures in agriculture should not be at the cost of impairing farmers or communities from sustaining livelihoods, nor should adaptation measures be undertaken at the expense of mitigating greenhouse gas emissions.

Both adaptation and mitigation efforts involve stakeholders from the international to the local levels. Broad global agreements on mitigation targets and timelines are sought under the UNFCCC (as in the Kyoto Protocol) and via various multilateral agreements. Countries address mitigation (either within or without international agreements) through measures including information provision, taxes and subsidies, regulation, investments and technological development. Communities and individuals may change their emissions in light of such policies or independently.

Adaptation, for the most part, has been focussed at the local level. International agreements on adaptation (Adaptation Fund, NAPAs, Nairobi Work Plan, etc.) have yet to be reflected in significant changes in agricultural resource use and production systems. Some developing countries have climate change policies that make reference to adaptation. Adaptations to climate are occurring in some agricultural communities, mostly autonomously or spontaneously and reactively. However, there are an increasing number of development initiatives aiming to promote or facilitate changes in production methods, resource use, livelihoods and risk management in order to improve the adaptive capacity of rural communities and food security.

2.5. Adaptation to Climate Change and Development

Numerous programs, initiated at international, national, regional or community levels are underway to achieve the Millennium Development Goals in addition to a wide range of objectives related to food security, rural development and sustainable development, livelihood and income, sustainable land management, biodiversity, gender and equity, energy efficiency and so on. Achieving these targets and goals in the absence of changes in the climate is challenging given constraints imposed by resource limitations, heavy and competing demands, overburdened infrastructures and limited finances and inequities of access. Climate change adds an additional burden to these challenges.

The ‘additionality’ of climate change has important implications for adaptation. The effects of climate change – both long-term trends in ‘norms’ and changes in the frequency and severity of extremes – are experienced in addition to normal weather variability and together with stimuli and constraints relating to other factors – resources, inputs, markets, social conditions, policies, etc. From the practical point of view of an agriculturalist in a developing country, climate change (even if the person is aware of it and its implications) is rarely the most pressing issue – sometimes it is not even a consideration at all.

[8] FAO, Anchoring Agriculture within a Copenhagen Agreement, A Policy brief for UNFCCC parties by FAO, 2009 http://www.fao.org/climatechange/media/17790/0/0/

Invariably, adaptations to climate change in agriculture have not been (and are not likely to be) undertaken in response to climate change alone or in isolation. The various lists of potential adaptations to climate change (UNFCCC's inventory, FAO (2008), etc.) are all strategies, management methods or technologies that have been employed (or would have utility) in the absence of climate change. Climate change provides an additional incentive for adopting such strategies. They become climate change adaptations as they are designed or modified to address conditions expected with climate change.

It is now widely accepted that most climate change adaptation strategies are not peculiar to climate change, but relate to existing principles and programs dealing with livelihood enhancement, risk management, food security, asset or resource management, sustainable production, poverty alleviation, etc. Integration or "mainstreaming" climate change adaptation into existing development programs and policies is both efficient and effective (Huq and Reid, 2007). Furthermore, poor people in developing countries do not have the luxury of being able to prioritize the possible climate several decades in the future. The onus falls on policy makers and Governments to anticipate these changes and take measures to address their implications. Initiatives which improve adaptability to near future conditions as well as to longer term climate change have a greater chance of success. Development agencies (World Bank, ADB, IIED, IISD, DFID, CIDA, SIDA.....) typically address climate change adaptation by integrating it into their development programmes already underway.

The Nairobi Work Plan recognizes weak links among international agreements, national programmes and practical implementation of climate change adaptation. At the international and national levels there is a considerable body of information that could inform or facilitate adaptation (e.g. impact studies, vulnerability assessments, prioritization of areas or sectors for adaptation, such as National Adaptation Plans of Action - NAPAs, and inventories of potential adaptation measures), but there are still few examples of practical and effective adaptations implemented through international agreements and national programmes. On the other hand, at local levels there are many isolated practical examples of adaptation, often implemented via development programs and NGOs.

It is indeed challenging to find successful examples of climate change adaptation widely applied in areas of need. This could occur as a "scaling up" of local adaptation processes (such as through a national policy) or the incorporation of insights from local applications into national policies, which then are applied or disseminated widely. In either case, it is important to consider how climate change adaptation can be incorporated into national policies, and the effectiveness of its mainstreaming into national policies.

2.6. Comparing climate change adaptation in national policies alternatives

Two broad strategies to address climate change (adaptation and mitigation) in the national policy arena are:

Develop National Climate Change Policies: envisage separate national climate change policies (e.g. climate change policy, climate change adaptation policy and/or climate change mitigation policy). The benefits of this route are that:

- It provides a point of contact (or builds on existing contact points) for interaction with the UNFCCC processes (including NAPAs, the Adaptation Fund, Nairobi Work Plan, etc.);
- It promotes the branches of government responsible for information about climate and weather (usually environment or meteorology agencies);

- It should provide a clearing house for information on climate and climate adaptation and mitigation across all sectors;
- It should facilitate the co-ordination of initiatives relating to climate change.

The disadvantages of this approach to integration are that:

- It introduces additional policies to governments already facing difficulties in achieving existing goals because of resource constraints, etc.,
- It can introduce policies that relate directly to existing policies (e.g. agricultural development, resource management, risk management), potentially affecting overall policy coherence and contributing to issues of duplication, competition and co-ordination;
- Environment agencies (environment, meteorology, etc.) rarely have expertise in or authority on adaptation (e.g. changing production practices, livelihoods, insurance) or even (frequently) mitigation (e.g. livestock management, land use management, biofuels);
- Adaptation measures are invariably specific to sectors and types of activity, and it is impractical for a central agency to develop and implement programmes and measures in areas unrelated to their expertise and authority, and in which other agencies and polices have considerable expertise.

Overall, there are serious doubts about the effectiveness – or even feasibility – of a stand-alone climate change policy in facilitating widespread adaptations to improve the overall resilience of agricultural systems. Experience indicates that, at a minimum, some kind of operational connection with agencies responsible for agricultural development, crop and livestock production, resource and risk management, livelihoods, trade and food security, etc. would be necessary for this option to significantly improve the adaptive capacity of agriculture in developing countries.

Mainstream Climate Change Adaptation in Other National Policies: Integrate climate change considerations into existing national agriculture policies (e.g. adaptation to climate threats to food production addressed in food security policies, adaptation to climate extremes addressed in risk management policies, mitigation through carbon sequestration addressed in land use and land management policies). The benefits of this route are that:

- It does not require additional policies and their associated bureaucracy to be added to already stretched government institutions;
- It does not increase duplication, potential incompatibilities or conflicts among policies and agencies;
- It has adaptation initiatives fall within policies that are already established in agencies with expertise, experience and stakeholder connections in policymaking;
- It focuses more directly on practical adaptation (and mitigation) initiatives than on climate monitoring, models and predictions.

The disadvantages of this approach are miscellaneous (many programmes and agencies to work with, how to distinguish accomplishments in climate change adaptation and in development, etc.)

While both of these routes can be considered to address climate change adaptation, "mainstreaming" into national policies is highly favoured to facilitate implementation.

The current country situation shows various situations where no strategic choice has been made. The two options coexist and NAPA implementation is at best at the half-way mark with poor results, while sector policy implications of climate change have not yet been well elaborated.

Within policy assistance for climate change adaptation, the role of FAO includes assisting countries to identify potential adaptation options and to mainstream climate change responses in food and agricultural policies and programmes. In countries with a NAPA, FAO will facilitate the inclusion of appropriate actions from the NAPA in the agriculture and food security policy framework and implementing programmes and projects. Where there is no NAPA, FAO will provide necessary support for incorporating priority adaptation measures in the agriculture and food security policy framework

2.7. National Agriculture Strategies and Policies

A **strategy** constitutes both a vision of what the sector should look like in the future and a 'road map' showing how to fulfil this vision. Its point of departure is the current situation of the sector and the issues that it faces. It should be firmly grounded in both history and an assessment of the sector's future potential. A strategy must be realistic, but its vision of the future should be based on the sector's strengths and opportunities. It also needs to clearly identify the constraints to be overcome in order to achieve its full potential. A strategy that does not offer a vision of a better future, backed up by concrete policies for realizing such a vision, cannot motivate the rural population to participate in its implementation. At the same time, the more realistic it is, and the better its analytic underpinnings, then the greater are the chances of attaining its objectives.

Policy refers to a set of interrelated actions concerning the setting "of goals and the means of achieving them within a specified situation", based on a set of preferences and choices. Policy is a process of action, ideally to implement a strategy. Policies are constituted by objectives and instruments, including public investment, used to produce related desired outcomes.

National Policies are those policies undertaken or initiated under the authority of public agencies at the national or country level. National government policies may be consistent with or supported by international strategies or frameworks, and the implementation of national policies may involve regional or local (i.e. sub-national) public organizations and/or NGOs.

National Agriculture Policies are those policies of national governments that deal with or relate to agriculture. These could include national policies pertaining to agriculture sector development, crop and livestock production, forest, fishery, livelihood enhancement, water resource management, land use and land tenure, food security, rural development, risk and disaster risk management, marketing and trade, rural poverty, drought management, etc.

Policy Instruments refer to the specific actions of governments to undertake a policy, and may include controls, regulations, incentives and disincentives (taxes, subsidies, rules, laws, etc.).

The development of an **agricultural strategy** may be motivated by an economic crisis in the sector or other problems that catalyze a decision to make fundamental changes (expansion of rural poverty, food security crisis, market and food trade pressures, etc.). In most cases, the agricultural strategy was designed after an evaluation of past strategies highlighted critical gaps. Whatever the motive for developing a strategy, it usually requires the support of principal actors in the sector, i.e. the farmers, if it is to be successful.

In its operational form, an agricultural strategy is an integrated package of policies for the sector, complemented by an investment program. Some of the policies may be designed to generate outcomes immediately or in the short term, but most of them typically represent deep reforms whose effects will be felt increasingly throughout the sector over a period of many years. The chief advantages of developing policy reforms in the context of a comprehensive strategy are that: (i) the policies are derived from, and support, specified national objectives and a clear vision of the future, (ii) they are designed to be mutually consistent across all facets of the sector and with the country's current macroeconomic policy, (iii) no important areas of policy reform are overlooked, and (iv) the effort of developing a strategy represents an opportunity to work out a consensus among principal interest groups in the sector.

In some contexts, the usage of the terms 'strategy' and 'policy' is reversed, so that the broader concept is called an 'agricultural policy', and it consists of 'operational strategies' in each area. The important point is that an overall strategy or policy document should contain both **a vision for the sector** and the **concrete instruments of governmental action** that are needed for implementation.

Underpinning strategies and policy concepts, the government is also concerned with issues related to coherence, transparency, synergy-building and efficiency on the use of public means through a coherent policy framework. To develop separate policies for each issue may target each issue more precisely and connect more directly with particular international frameworks, but numerous separate policies may introduce duplication, exhaustion of resources and ineffectiveness at country level.

Both adaptation and mitigation are closely interconnected with many of the existing policies pertaining to agriculture. Therefore seeking to integrate/mainstream issues of climate change adaptation and mitigation into the national policy apparatus and within sectoral policies such as agriculture should help to accelerate effective implementation.

Policies that relate to agriculture in developing countries take a wide range of forms. Some target agriculture directly (and may fall under the authority of an agriculture ministry), whereas others have broader mandates (and may be administered by other ministries) which also relate to agriculture (Table 1).

Table 1: Agricultural Policies and Agriculture-linked Domains

Sub sector policies integrated in agriculture policy and usually managed by Ministry of Agriculture	Crop Production Fishery Land Use Agricultural finance Agrobusiness Food Trade Irrigation and water Soil Conservation	Livestock Forestry Food Marketing Extension and research Input support and mechanisation Agricultural Risk Management Drought Management Inputs
Other Policies related to agriculture	Water Management Disaster Relief Management	Environment Land Tenure
Higher level policies integrating agriculture	Economic Development Food security	Poverty Reduction Rural development
Other sector policies affecting agriculture	Infrastructure Energy	Health Education

National agriculture policies commonly involve other levels of government (local and international), non-governmental organisations and private sector stakeholders. The integration of climate change adaptation and mitigation into national policies involves incorporating adaptation and/or mitigation considerations into existing policies that are or will conceivably be affected by climate change.

3. CLIMATE CHANGE ADAPTATION POLICY OPTIONS IN AGRICULTURE

3.1. Different ways of how adaptation can be addressed through policies

Adaptation within agriculture, food systems and rural communities involves adjustments in land and water management, resource use, access to assets and livelihood strategies, among others. Agricultural adaptations are invariably undertaken autonomously or spontaneously by individuals or households (private agents at the farmer level), and often as reactionary measures (*ex post*). Public agencies, from community to national levels, can facilitate or constrain adaptations, and they have a role to play in promoting anticipatory or planned (*ex ante*) adaptations. Adaptations are influenced by the structures, functions and actions of governments at local, national and international levels as well as by conditions and forces largely beyond the direct influence of national governments (markets, preferences, cultures, technologies, etc.).

Many (perhaps most) climate change adaptations are initiated and undertaken at the local level. However, adaptations can be initiated, enhanced or constrained by national policies. Policies relating to land and water management, use of resources, access to assets, environmental conservation, livelihood strategies, crop development, land tenure, risk management, food security, and trade all have the potential to influence adaptation to climate change.

Researchers, practitioners and international organizations focusing on climate change have increasingly called for the "mainstreaming" of climate change adaptation into established policies and programs, so that the policies are "climate proofed", in the expectation that this will sustain or "scale up" climate change adaptation beyond somewhat *ad hoc* projects which are mostly local and mostly initiated by international development agencies.

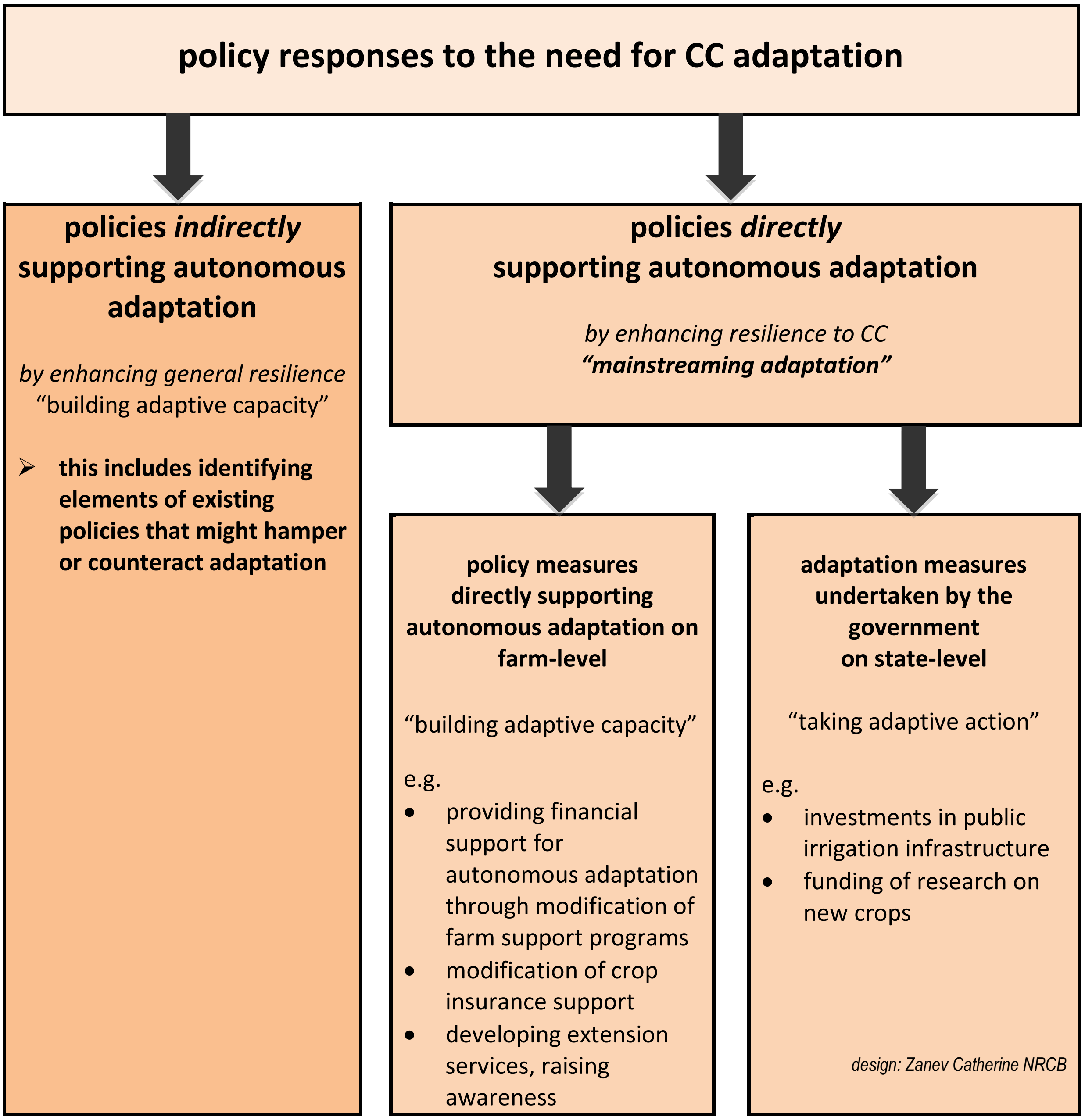
Adaptations are highly specific to people, places and situations, reflecting physical-ecological conditions, socio-economic situations and the realities of each community, (resources, access, social networks, culture, institutions), household (land, tenure, resources, financial means, family composition, education) and type of agriculture. In those cases where agricultural adaptations have been implemented and have benefited individuals, farmers, households:

- they have been locally-oriented or community-based, rather than national in scope;
- they addressed local conditions to which the farms are exposed and vulnerable, to which additional risks from climate change are added;
- they have been facilitated, prompted, aided, supported and/or subsidized through a project or the initiative of an external agency (development organization, international agency, NGO, etc.), sometimes in collaboration with a national agency;
- the adaptations represented modifications of existing strategies to manage risks, manage resources, sustain incomes and/or enhance livelihoods, rather than independent measures exclusively addressing climate change;
- farmers did not undertake a systematic evaluation of a suite of CCA options to select the 'best'; they modified their management strategies in one or more ways to address existing risks and their possible exacerbation;
- as with other agricultural innovations, adaptations were initially implemented by 'innovators', who demonstrated their utility (or otherwise), leading to a second adoption of measures and their implementation;

- Adopting adaptation options in developing countries is greatly constrained by the limited adaptive capacity in those countries, which is often related to conditions beyond the control of individual households.

Clearly, there is a huge variety of measures and management strategies that could be employed to help agricultural systems adapt (become more resilient and have less vulnerability) to climate change. Very few (if any) of these options or activities are peculiar or unique to climate change. Almost all climate change adaptations directly entail or are closely related to strategies and measures designed and applied to meet other objectives, such as risk management, sustaining or increasing production and rural incomes or improving food security.

Figure 5: Alternative Policy Responses to Climate Change adaptation



Mainstreaming adaptation will pass through the various channels illustrated below, from autonomous adaptation to planned adaptation policies which include (i) adaptation measures undertaken by the government at the national level (e.g. fund research on local impacts of climate), (ii) policy measures supporting autonomous adaptation at the farm-level: (e.g. strengthen extension services, etc.), (iii) policies indirectly supporting adaptation.

3.2. Proposed Climate Change Adaptation options in Agriculture

A wide array of agriculture-based adaptations to climate change has been proposed. Some were hypothetical adaptations, suggesting ways of addressing projected impacts of climate change. Others were based on experience with development, resource management and risk management related to agriculture in developing countries. In most inventories of climate change adaptations, the broad strategies or types of activity are noted, with less attention to the processes and roles of participants involved in implementing adaptations. In each of the broad adaptation categories (or strategies), there are distinct roles for the private sector, including farmers and rural households and public services and partners, both being supported by appropriate policies/ programmes.

The actual adaptations involve enterprise and livelihood choices by farmers and households at the local level. These may be facilitated by government programs, NGOs, and local community organisations.

They have been organized into five panels of policies.

Three directly cover adaptation of agricultural production and use of factors of production (land and water):

1. Policies to encourage adapted crop development and farming practices
2. Policies to promote soil conservation and land management
3. Policies on irrigation and water resource management

The other two are linked with risk management:

4. Crop and income loss risk management policies
5. Disaster risk management policies (flood, drought...)

The tables of policies proposed below indicate different implementation channels: (i) possible immediate implementation at the producer level; (ii) possible rapid implementation through technical services and projects/programmes; or (iii) wide-scale public support through public policies.

3.2.1. To encourage adapted crop development and farming practises

A commonly stated agricultural adaptation is with crop management, involving existing crops types and varieties, the development of new varieties or replacing crops (which is then reflected in changes in the spatial location of crops) in order to rely on crop types and varieties that are better suited to a changed climate.

Biodiversity increases resilience to changing environmental conditions and stresses. Genetically-diverse populations and species-rich ecosystems have a greater potential to adapt to climate change. FAO promotes the use of indigenous and locally-adapted plants as well as the selection and multiplication of crop varieties and autochthonous races adapted for or resistant to adverse conditions.

At the national level this is translated into programs to develop new crops or varieties in research programs (e.g. to be more heat tolerant or drought resistant), to maintain genetic resources and to develop crop management practices, all to be disseminated to farmers via outreach programmes.

These become agricultural adaptations when crop types and varieties are actually changed (reflected in changed crop location or patterns). At the local level, this involves farmers' decision making, reflecting personal risk perceptions and trade offs and resulting in particular crop choices.

Reducing the reliance on industrialised mono-cropping and diversifying the range of crops cultivated will reduce vulnerability as well as create jobs and potentially reduce irrigation needs. Development of more and better heat and drought resistant crops would help fulfil current and future national food demand by rapidly improving production efficiencies in marginal areas.

Table 3: Actions to encourage adapted crop development and farming practises

Channels	Actions to encourage adapted crop development and farming practises
farmer technological/ strategic options	• Diversify crop types and varieties, including crop substitution, to address the environmental variations and economic risks associated with climate change • Change timing of farm operations to address the changing duration of growing seasons and associated changes in temperature and moisture
Public services and external/project support	• Develop new crop varieties, including hybrids, to increase the tolerance and suitability of plants to temperature, moisture and other relevant climatic conditions • Develop farm-level resource management innovations to address the risk associated with changing temperature, moisture and other relevant climatic conditions
Support policies	• Promote seed banks to maintain different varieties of the crop so as to help farmers diversify crops and crop varieties • research and development of new crop types and varieties that are more resistant to heat and drought • Strengthen Department of Agriculture capacity to provide seeds of a diverse mixture of crops and crop varieties that better tolerate climate risks • Develop agricultural extension schemes to encourage adjustments in planting and harvesting dates • Set tax and price policies that reflect disincentives to mono-culture • Set tax and other incentive policies to increase diversification of crops and crop varieties

3.2.2. <u>To promote Soil conservation and land management</u>

Climate change adaptation requires higher resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). A key element to respond to both problems is soil organic matter, which improves and stabilizes the soil structure so that soils can absorb higher amounts of water and thus prevent surface run off, which could result in soil erosion and, further downstream, in flooding. Soil organic matter also improves the water absorption capacity of the soil during extended periods of drought.

At the national level, land use and tenure policies, the development of sustainable soil and land use management practices, and policies to encourage such practices can influence land use and land management, so that grazing or cropping are more resilient to climate extremes and changes.

At the local level, farmers make land use decisions, including soil management choices, based on their personal circumstances and the inducements and constraints imposed by economic, cultural and institutional conditions.

Table 4: Actions to promote Soil conservation and land management

Channels[9]	**Actions to promote Soil conservation and land management**
farmer technological/ strategic options	• Change the location of crop and livestock production to address the environmental variations and economic risks associated with climate change • Reduce soil evaporation through conservation practices
Public services and external/project support	• Change land topography to address moisture deficiencies associated with climate change and reduce the risk of farm land degradation
Support policies	• Develop and implement policies and programs to influence farm-level land and water resource use and management practices in light of changing climate conditions • Conduct programs to encourage terracing and contour planting when the land has an undulating topography • Develop schemes to develop windbreaks along borders • Undertake reforms in tenure practices and land tenure laws • Develop schemes to promote changes in farming practices, such as minimum/zero tillage

3.2.3. Irrigation and Water resource management

Local level adaptations are the strategies and decisions farmers make with respect to water management, including use or irrigation (if available and affordable), small-scale capture and storage. National governments can affect water management through policies relating to water rights, regulations, pricing, controls and allocation. Sometimes authority is transferred to lower levels of government. National governments also influence water management adaptations by providing and managing infrastructure, particularly in water capture, storage, distribution and use (including irrigation schemes).

Table 5: Typology of climate change impacts and response options for agricultural water management

[9] The table of policies proposed below indicates different implementation channels either (i) immediate possible implementation at producer level, (ii) rapid possible implementation through technical services and projects programmes or (iii) wide scale public support through public policies.

System	Current status	Climate change drivers	Vulnerability	Adaptability	Response options
1 Snow Melt Systems					
Indus System	Highly developed, water scarcity emerging. Sediment and salinity constraints	20 year increasing flows followed by substantial reductions in surface water and groundwater recharge. Changed seasonality of runoff and peak flows. More rainfall in place of snow. Increased peak flows and flooding. Increased salinity. Declining productivity in places	Very high (run of river): medium high (dams)	Limited room for manoeuvre (all infrastructure already built)	Water supply management: Increased water storage and Drainage; Improved reservoir operation; Change in crop and land use; Improved soil management; Water demand management including groundwater management and salinity control
Ganges Brahamaputra	High potential for groundwater, established water quality problems. Low productivity		High (falling groundwater tables)	Medium (still possibilities for groundwater development)	
North Western China	Extreme water scarcity and high productivity		High (global implications, high food demand with great influence on prices)	Medium (adaptability is increasing due to increasing wealth)	
Red and Mekong	High productivity, high flood risk, water quality		Medium	Medium	
Colorado	Water scarcity, salinity		Low	Medium: excessive pressure on resources	
2 Deltas					
Ganges Brahmaputra	Densely populated. Shallow groundwater, extensively used. Flood adaptation possible; low productivity	Rising sea level. Storm surges, and infrastructure damage. Higher frequency of cyclones (E/SE Asia); Saline intrusion in groundwater and rivers; Increased flood frequency. Potential increase in groundwater recharge.	Very high (flood, cyclones)	Poor except salinity	Minimise infrastructure development; Conjunctive use of surface water and groundwater; Manage coastal areas.
Nile river	Delta highly dependent on runoff and Aswan Storage – possibly to upstream development		High (population pressure)	Medium	
Yellow river	Severe water scarcity		High	Low	
Red River	Currently adapted but expensive pumped irrigation and drainage		Medium	High except salinity	
Mekong	Adapted groundwater use in delta - sensitive to upstream development		High	Medium	
3 Semi-arid / arid tropics: limited snow melt / limited gw					
Monsoonal: Indian sub continent	Low productivity. Overdeveloped basin (surface water and groundwater)	Increased rainfall. Increased rainfall variability. Increase drought and flooding. Higher temperature.	High	Low (surface irrigation); Medium (groundwater irrigation)	Storage dilemma; Increase groundwater recharge and use; higher value agriculture (Australia)
Non monsoonal: sub-Saharan Africa	Poor soils; Flashy systems; over-allocation of water and population pressure in places. Widespread food insecurity	Increased rainfall variability. Increase frequency of droughts and flooding. Lower rainfall, higher temperature. Decreasing runoff	Very high. Declining yields in rainfed systems. Increased volatility of production.	Low	
Non monsoonal: Southern and Western Australia	Flashy systems; overallocation of water; competition from other sectors		High	Low	
4 Humid Tropics					
Rice: Southeastern Asia	Surface irrigation. High productivity but stagnating	Increased rainfall. Marginally increased temperatures. Increased rainfall variability and occurrence of droughts and floods	High	Medium	Increased storage for second and third season; Drought and flood insurances; crop diversification
Rice: Southern China	Conjounctive use of surface water and groundwater. Low output compared to northern China		High	Medium	
Rice: Northern Australia	fragile ecology		Low	High	
Non-rice - surface irrigation			low	Medium	
Non-rice - groundwater irrigation			Medium	Medium	
5 Temperate (supplementary irrigation)					
Northern Europe	High value agriculture and pasture	Increased rainfall; Longer growing seasons; Increased productivity	Surface irrigation: medium; groundwater irrigation: low	Surface irrigation: low; groundwater irrigation: high	Potential for new development. Storage development; Drainage
Northern America	Cereal cropping; groundwater irrigation		Medium	Medium	Increased productivity and outputs; Limited optyions for storage
6 Mediterranean					
Southern Europe	Italy, Spain,Greece	Significantly lower rainfall and higher temperatures, increased water stress, decreased runoff	Medium	Low	Localised irrigation, transfer to other sectors
Northern Africa	Morocco,Tunisia: High water scarcity		High	Low	Localised irrigation, supplementary irrigation
West asia	Fertile crescent	Loss of groundwater reserves	Low	Low	
7 Small islands					
Small islands	Fragile ecosystems; groundwater depletion	Sea water rise; saltwater intrusion;increased frequency of cyclones and hurricanes	High	Variable	Groundwater depletion control; Water demand management

Increasing water scarcity and changes in the geographic distribution of available water resulting from climate change pose serious risks for both rain-fed and irrigated agricultural production around the world. With a more variable climate and less reliable weather patterns it will be essential to increase water storage capacity for agriculture in order to maintain global food supplies while satisfying other competing uses for agricultural water (Parry *et al.*, 2007).

Looking ahead to 2030, irrigated areas will come under increasing pressure to raise the productivity of water, both to buffer the more volatile rain-fed production (and maintain national production) and to respond to declining levels of this vital renewable resource. This risk will need to be managed by progressively adjusting the operation of large-scale irrigation and drainage systems to ensure higher cropping intensities and reduce the gaps between actual and potential yields.

The inter-annual storage of excess rainfall and the use of resource-efficient irrigation remain the only guaranteed means of maintaining cropping intensities. Water resource management responses for river basins and aquifers, which are often trans-boundary, will be forced to become more agile and adaptive (including near-real-time management), as variability in river flows and aquifer recharge becomes apparent (IDWG CC, 2007).[10]

Competing sector demands for water will increase pressure on the agriculture sector to justify the allocations it receives. Reconciling these competing demands will require agriculture to engage with other productive users and use transparent means of negotiating allocations.

Table 6: Irrigation and water resource management actions

Channels	Irrigation and water resource management
farmer technological/ strategic options	• Implement irrigation practices to address moisture deficiencies associated with climate change and reduce the risk of income loss due to recurring drought • Reduce soil evaporation through conservation practices • Plan for more water-efficient crop varieties • Enhance soil fertility to increase yields per unit of water utilized • Decrease runoff from cultivated land
Public services and external/project support	• Modernization and service orientation of irrigation system management to allow for changing cropping systems and the adaptation of farmers' practises • Develop water management innovations, including irrigation, to address the risk of moisture deficiencies and increasing frequency of droughts. • Improve infrastructure for small-scale water capture, storage and use • Reuse wastewater for agricultural purposes.
Support policies	• Develop and implement policies and programs to influence farm-level land and water resource use and management practices in light of changing climate conditions. • Improve irrigation services' reliability and flexibility to enable farmers to change practises or cropping patterns in their fields • Develop schemes to reduce distribution losses of irrigation water by maintaining canals and monitoring better • Improve demand management and water allocation to encourage efficiency of use • Encourage improved irrigation methods like drip and sprinkler irrigation • Undertake research to develop crop varieties requiring little water • Develop extension schemes to promote best timing and dose of irrigation • Set tariff reforms on electricity used for agricultural production, remove subsidies for electricity used for pumping irrigation water

[10] FAO IDWG CC, Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities, Intyer departmental working group on Climate Change, 2007

Key adjustments for maintaining cropped areas include:

1. optimizing operational storage, i.e., manageable water resources such as water stored behind a dam;
2. controlling releases to improve hydraulic performance and salinity control;
3. optimizing crop-water productivity;
4. allocating and releasing water to agriculture across river basins is essential for improving operational performance; and
5. targeting investment to small-scale water control facilities.

3.2.4. Crop and Income loss Risk management

Highly linked with climate change adaptation, risk management strategies and programmes are common in many sectors in many countries. Broadly, they seek to reduce losses from hazards where there are uncertainties about the occurrence of events and about outcomes of exposure to events. In agriculture, the objective of risk management is to protect assets, livelihoods and food supplies against the effects of the increased frequency and severity of extreme weather and climate conditions and events. Typical components of national risk management policies and programmes include:

1. monitoring and forecasting of hazardous events, including weather
2. climate information
3. reliable and timely early warning systems
4. investments in infrastructure to minimize exposure
5. insurance and other risk financing instruments
6. emergency response capacity
7. livelihood investments to enhance resiliency in outcomes

It could involve changes in the mix of income-generating activities which may include crops, livestock, land and water management so that rural households are less vulnerable to variations in climatic conditions.

Most adaptations can be considered as forms of “risk management” in that their purpose is to reduce the likelihood of losses associated with climate change. In this category we focus on risk management strategies related to losses in production, income, livelihoods or structures as a result of local weather conditions.

Identifying insurance programs that work for poor farmers in developing countries is an ongoing challenge. Some analysts have raised the question as to whether insurance tends to maintain production systems and practices that are otherwise not well adapted to the variable climate, thereby perpetuating vulnerability.

Other types of risk management are apparent, including community food storage and sharing systems to moderate large fluctuations in food and rural incomes. The risk management that households practice is not limited to defensive or reactive strategies. It is part of a broader set of institutions that include proactive strategies implemented over long periods. All of these strategies can be grouped under the concept of household *safety nets.*

Table 7: Crop and income loss risk management actions

Channels	Crop and income loss risk management
farmer technological/ strategic options	• Diversify crop types and varieties, including crop substitution, to address environmental variations and economic risks associated with climate change • Purchase crop insurance to reduce risk of climate-related income loss • Diversify source of household income to address the risk of climate-related income loss • Strengthen self help groups involved in risk management
Public services and external/project support	• Establish weather/meteorological stations • Promote private insurance to reduce climate-related risks to farm-level production, infrastructure and income • Participate in income stabilization programs to reduce the risk of income loss due to changing climate conditions and variability
Support policies	• Mobilize adequate community based risk management tools[11] to face crop failures and soaring food prices (grain banks, tontines, self help groups) • Modify crop insurance programs to influence farm-level risk management strategies with respect to climate-related loss of crop yields • Develop innovative risk financing instruments and insurance schemes to spread residual risks

3.2.5. Actions for disaster risk management (flood, drought...)

Disaster risk management involves the establishment and maintenance of institutions and mechanisms to avoid, prepare for, and/or recover from losses associated with extreme weather events. At the national level this would include promotion of insurance schemes, disaster prediction and preparedness, and recovery programs.

At the local level, disaster risk management involves early warning systems, preparedness, and response strategies. Financial risk management at the local level includes local insurance programs (involving communities, private sector NGOs, perhaps within a national scheme). A key element for climate change adaptation in agriculture is the actual use of insurance by farmers and the effectiveness of such insurance in dealing with extremes and recurring hazards.

[11] *Bockel L, Thoreux M, Sayagh S Food Security and Risk Management by Local Communities, Lessons learned and recommendations on development policy (Niger, India), FAO Easypol Policy Brief, 2008*

Table 8: Preparedness and recovery actions

Channels	Disaster risk management policies (flood, drought...)
farmer technological/ strategic options	• Diversify source of household income to address the risk of climate-related income loss
Public services and external/project support	• Develop early warning systems that provide daily weather predictions and seasonal forecasts • Invest in infrastructure to protect against asset loss • Protect equipped areas from flood damage and maintain drainage outlets
Support policies	• Strengthen the meteorological department/stations, improve data collection, data management, and forecasting capacity • Introduce incentive policies to encourage better drought management programs • Research programs to develop high-temperature/drought resistant varieties • Design and implement policies to alter cropping patterns to suit drought conditions • Adopt conservation agriculture practices to reduce soil evaporation • Plant more water-efficient and/or drought tolerant crop varieties • Invest in infrastructure to protect against asset loss

4. CLIMATE CHANGE MITIGATION POLICY OPTIONS IN AGRICULTURE (SYNERGIES BETWEEN ADAPTATION AND MITIGATION)

Climate change mitigation refers to actions intended to reduce greenhouse gas emissions and capture greenhouse gases, so that climate change itself is mitigated. The direct and intended beneficiary of climate change mitigation is the climate system. Ultimately, all countries, sectors and communities adversely affected by the changing climate will benefit from mitigation.

Ideally, climate change mitigation would be sufficiently effective that climate change would be slowed or stopped, and there would be no risks of climate change impacts on agriculture, in which case there would be no need for climate change adaptation. However, notwithstanding the efforts towards greenhouse gas reduction agreements, climate change is accelerating and the impacts are already becoming more and more apparent, especially in developing countries. So there is an urgent need for adaptation to the changes in moisture, temperature, storms, droughts, etc., just as there is urgent need for mitigation of the climate change itself.

> "*Agricultural land is able to store and sequester carbon. Farmers that live off the land, particularly in poor countries, should therefore be involved in carbon sequestration to mitigate the impact of climate change*," (Mueller, 2009[1]).

Carbon markets that provide strong incentives for public and private carbon funds in developed countries to buy agriculture-related emission reductions from developing countries could provide important investments to spur rural development and sustainable agriculture in developing countries. Product standards and labels could be developed to certify the mitigation impact of agricultural goods.

4.1. Selection of Climate Change Mitigation Options in Agriculture

After forestry, the search for mitigation options is seeking out other uses of land, such as agriculture, with growing interest in developing countries, even though they contribute a relatively small proportion of the greenhouse gases involved in climate change.

There is a considerable variety of initiatives in agriculture that can contribute to climate change mitigation (see references including several FAO papers). Three broad categories of climate change mitigation and agriculture can be identified, each with implications for their compatibility with national policies and with climate change adaptation:

- Reducing greenhouse gas emissions
- Capturing greenhouse gases and carbon sequestration
- Finding and using alternative energy sources including biofuels

Because agriculture is one of the most vulnerable sectors to climate change *impacts* it is also important to consider the side-effects of agricultural mitigation practices on the adaptive capacity of farmers and farming systems. The main adaptation challenges for agriculture under climate change relate to the predicted intensification of hydrological cycles leading to more intensive rainfall and longer dry periods, as well as an increase in the occurrence of extreme high temperature events and inter-seasonal variability in temperature and rainfall. In summary, the main adaptation options for agriculture that are also relevant for mitigation are the following (Frelih-Larsen et al, 2008):[12]

- Measures that reduce soil erosion
- Measures that reduce leaching of nitrogen and phosphorus
- Measures for conserving soil moisture
- Increasing diversity of crop rotations by choice of species or varieties
- Modification of microclimate to reduce temperature extremes and provide shelter
- Land use change, involving abandonment or extensification of existing agricultural land cultivation of new land improved pasture management

The table below illustrates the side-effects of mitigation practices on these six categories of adaptation issues in Europe (Policy Incentives for Climate Change Mitigation Agricultural Techniques, PICCMAT).[13]

Table 9: Side-effects of mitigation practices on these six categories of adaptation issues[14]

[12] Frelih-Larsen et al, Deliverable D11 Climate change mitigation through agricultural techniques Policy recommendations**,** PICCMAT European project, Policy Incentives for Climate Change Mitigation Agricultural Techniques, 2008

[13] The PICCMAT practices provide a menu of measures with detailed information on their mitigation potential, cost and feasibility of implementation, co-benefits and trade-offs, and their compatibility with adaptation to climate change in European Context. From this list, measures can be chosen and combined according to regional needs and opportunities. http://climatechangeintelligence.baastel.be/piccmat/

[14] "+" if the measure may assist adaptation) or "-" if the measure is likely to hamper adaptation

Mitigation measure	Soil erosion control	Nutrient loss reduction	Soil water conser-vation	Genetic diversity	Micro-climate modify-cation	Land use change
Catch crops etc	+	+	–			
Reduced tillage	+		+			
Residue management	+		+		–	
Extensification						+
Fertiliser application		+				
Fertiliser type		+				
Rotation species	+	+		+		
Adding legumes	+	+		+		
Permanent crops	+	+	–	+		
Agroforestry	+	+			+	
Grass in orchards & vineyards	+	+	–		–	
Optimising grazing intensity			+			
Length and timing of grazing	+					
Grassland renovation				+		
Optimising storage manure						
Application techniques						
Application to cropland vs grassland			+			
Peatland management						+

Therefore some climate change mitigation initiatives are consistent with climate change adaptation objectives, some are independent of climate change adaptation, and some are less consistent with climate change adaptation. This is illustrated in table 12 below in which the most appropriate options have been highlighted (light red background).

On this basis of positive convergence and trade-off with other policies, three policy options will be considered and further developed. These are policies to promote conservation agriculture, watershed management policies and livestock management policies.

Table 10: Consistency of mitigation policy options with other policies

category	Initiative	inconsistency with other policies	Consistency with other policies
Mitigation Via reduction of greenhouse gas emissions	**Improve energy efficiency, use less fossil fuel, in irrigation, land work, processing, transportation**	• Inconsistent with efforts for high labor productivity through mechanized production.	• Consistent with energy efficiency policies, income policies, input cost risk policies, management policies • Consistent with reduced tillage, which retains moisture retention, as is climate change adaptation strategy • Compatible with efficient water use (reduced pumping, water saving) and adaptation
	Reduce fertilizer input to emit less N_2O (Nitrous Oxide) Conservation agriculture		• Decreasing fertilizers through IPNS compatible with food security policies • Consistent with livelihood income policies aiming at reducing input costs • Consistent with climate change adaptation initiatives to reduce dependence on chemical inputs in order to make production more resilient
	Reduce CH_4 (Methane) from livestock production, including grazing		• Compatible with policies to adapt livestock population • Compatible with carbon sequestration and GHG policies
	Reduce Methane emission from rice paddies, through water saving		• Fully compatible with food security, especially under scarce water resources • Consistent with climate change adaptation policies requiring water saving
Mitigation via Alternative Energy, Biofuels	**Convert land-use from food crops to energy crops**	• Inconsistent with local food production and broad food security policies • Unclear net energy balance	• Possibly consistent with the energy policy (if energy balance is positive) • Consistent with income and livelihood adaptation strategies - where the price for energy for crops is greater than the price for food crops
	Generate alternative energy from wind or water	• Tourism	• Consistent with livelihood and income policies
Mitigation via capture of greenhouse gases, including	Reduced tillage to retain carbon in the soil (conservation agriculture)		• Consistent with agricultural policies aiming to reduce soil degradation • Consistent with policies to reduce costs of inputs • Consistent with climate change adaptation measures to improve moisture retention in soil

Carbon sequestration	Watershed management through rehabilitation (reforestation, agro-forestry, terracing) of degraded hilly areas, resilience-building of cropping systems		• Consistent with poverty reduction and food security through social safety net effect of labor-intensive public works • Consistent with agriculture policies to improve disaster resilience of production areas • Consistent with climate change adaptation with improved climate shock resilience of rural communities • Consistent with water management policies • Consistent with rural development and infrastructure policies
	Conversion of land use from crop to pasture in order to retain (or sequester) carbon in the ground	• Inconsistent with food security /income policies • Inconsistent with climate change adaptation • Inconsistent with climate change mitigation regarding methane from animals	
	Conversion of land use from grazing to forest-covered-grazing to retain carbon	• Inconsistent with food security policies	• Consistent with forestry policies • Consistent with immediate climate change adaptation goals regarding food, livelihoods, income

4.2. Policy options with both Adaptation and Mitigation potential in Agriculture

4.2.1. Conservation agriculture

Conservation agriculture and organic agriculture that combine zero or low tillage and permanent soil cover are promising adaptation options promoted by FAO for their ability to increase soil organic carbon, reduce the use of mineral fertilizers and reduce on-farm energy costs.

Production risks can be spread and buffered by a broad range of land management practices and technologies. Enhancing residual soil moisture through land conservation techniques is a significant help at the margin of dry periods, while buffer strips, mulching and zero-tillage mitigate soil erosion risk in areas with increasing rainfall intensity.

Conservation agriculture is an option for adaptation as well as for mitigation because the increase in soil organic matter reduces vulnerability to both excessive rainfall and drought. The impact is not immediate; soil under zero-tillage tends to increase the soil organic matter content by approximately 0.1 to 0.2 percent per year, corresponding to the formation of 1 cm of new soil over a ten-year period (Crovetto, 1999). However, not only does organic matter facilitate soil structuring, and hence the infiltration and storage of water in the soil, but it also directly absorbs up to 150 cubic meters of water per hectare for each percent of soil organic matter. In addition, under conservation agriculture, no soil moisture is lost through tillage and seedbed preparation.

This means that seeding often does not need rainfall, because the seed can use the existing soil moisture. The total water requirements for a given crop are also lower in conservation than in conventional agriculture, which is of particular interest where water is scarce; reported water savings amount to at least 30 percent. This is because less water is lost through surface runoff and unproductive evaporation, and more is stored in the soil. Crops under conservation agriculture suffer much less from drought conditions, and are often the only crops to yield in such situations. Yield fluctuations under conservation agriculture are generally much less severe than under comparable conventional agriculture (Tebrügge and Bohmsen, 1998; Derpsch, 2005).

Table 11: Conservation agriculture actions

Channels	Conservation agriculture
farmer technological/ strategic options	• Use alternative fallow and tillage practices to address climate change-related moisture and nutrient deficiencies • Reduce use of energy-dependant inputs
Public services and external/project support	• Subsidise catch or cover crops • Encourage crop rotations, preferably with perennial crops (free planting material) • Promote through insurance/subsidy crop systems with reduced reliance on fertilizers, pesticides and other inputs • Promote rotations or inter-cropping with leguminous crops
Support policies	• Develop schemes to encourage conservation practices such as conservation tillage, zero tillage, furrow diking (requires equipment, training) • Put in place programs to scale up cover cropping with leguminous cover crops to preserve soil moisture, increase soil

	organic matter and reduce soil erosion • Develop schemes to promote use of farm equipment, including tractors, harvesters and other equipment

Among the disadvantages of conservation agriculture is its tendency to produce issues related to the presence of weeds and which require chemical herbicides to control; it is a technology requiring relatively high management skills, as many of the field operations must be implemented with a considerable degree of precision. Although permanent soil cover is ideal in the long term, there are short-term costs that must be covered before the system is well-established. Start-up incentives and training may therefore be needed to encourage farmers to adopt the conservation agriculture approach.

4.2.2. Policy Options to reduce methane from rice paddies

Rice is grown on more than 140 million hectares worldwide and is the most heavily consumed staple food on earth. Ninety percent of the world's rice is produced and consumed in Asia, and 90 percent of rice land is—at least temporarily—flooded (IFPRI 2009).[15] Emitting between 50 and 100 million tonnes of methane a year, rice agriculture is a big source of atmospheric methane, possibly the biggest of man-made methane sources. The warm, waterlogged soil of rice paddies provides ideal conditions for methanogenesis, and though some of the methane produced is usually oxidized by methanotrophs in the shallow overlying water, the vast majority is released into the atmosphere. On average, the rice paddy soil is only fully waterlogged for about 4 months each year. Through a more integrated approach to rice paddy irrigation and fertilizer application substantial reductions remain possible. Many rice varieties can be grown under much drier conditions than those traditionally employed, with big reductions on methane emissions without any loss in yields. Additionally, there is the great potential for improved varieties of rice, able to produce a much larger crop per area of rice paddy and so allow for a smaller total area of rice paddies, without a cut in rice production. Finally, the addition of compounds such as ammonium sulphate, which favor the activity of other microbial groups over that of the methanogens, has proved successful under some conditions.

Table 12: Options to reduce methane from rice paddies

Channels	reduce methane from rice paddies
farmer technological/ strategic options	• Use alternative rice varieties adapted to drier conditions or to partial irrigation • Adopt intermittent irrigation practises • Use modern cultivation techniques that allow periodic draining fields[16] • Apply rice crop waste (rice straw) off-season
Public services and external/project support	• Promote off-season application of rice crop waste and discourage straw burning • Implement a water-saving technology called alternate wetting and drying (AWD), developed by IRRI
Support policies	• Methane reduction from irrigated rice should be made eligible for offsets and other mitigation funding opportunities • Modify water-management strategies coupled with efficient application of fertilizer

[15] Wassmann et Al, Agriculture and Climate Change: An Agenda for Negotiation in Copenhagen Reducing Methane Emissions from Irrigated Rice, IFPRI, 2009, http://www.ifpri.org/2020/focus/focus16/focus16_03.pdf

[16] Global methane emissions from rice paddies could be cut by 30 per cent if fields are drained at least once during the growing season and rice crop waste is applied off-season

Case study: Mitigation within an irrigation system in the Philippines

Bohol Island, one of the largest rice-growing areas in the Visayas region of the Philippines, has experienced declining productivity and income as a result of existing irrigation systems. The problem was aggravated by the practice of unequal water distribution and unnecessary water use by farmers who insist on continuous flooding to irrigate their rice crop. The construction of a new dam was accompanied by a plan to implement a water-saving technology called alternate wetting and drying (AWD), developed by IRRI in cooperation with national research institutes.

The visible success of AWD in pilot farms and specific training programs for farmers has helped to dispel the widespread misperception of possible yield losses in non-flooded rice fields. The adoption of AWD facilitated the improved use of irrigation water and increased rice productivity. Using the Intergovernmental Panel on Climate Change (IPCC) methodology, the modification of the water regime can also reduce methane emissions by almost 50 percent as compared to rice produced under continuous flooding. The Bohol case is an example of new technologies that increase the income of poor farmers while decreasing GHG emissions.

(Wassmann et Al, IFPRI 2009 http://www.ifpri.org/2020/focus/focus16/focus16_03.pdf)

4.2.3. Watershed management

Whether or not they arrive with tropical cyclones or hurricanes, floods generally follow heavy rains and generally affect a country's low geographical areas (basins, low-levels, etc.). Highlighting and protecting watersheds is generally the most suitable tool for managing flood risk. Indeed, the value of a watershed stems from its capacity to absorb and clean water, recycle excess nutrients and maintain the soil's stability in order to prevent flooding. Rebuilding degraded watershed areas presents a high potential for climate mitigation through carbon fixing as a result of reforestation and improved land use management.[17]

Table 13: Watershed management actions

Channels	Watershed management
farmer technological/ strategic options	• Use alternative practices to reduce soil erosion (terracing) • Adopt adapted agro-forestry practises in sloped areas • Participate in maintenance of water drain channels
Public services and external/project support	• Promote reforesting of degraded hillside areas • Provide adequate tree planting materials for households • Develop local watershed/land use planning through municipality and community participatory planning
Support policies	• Develop schemes to improve building of watershed climate resilience at the community level[18] • Mobilize municipality- driven semi permanent labor-intensive public works (socio-environmental safety nets) to strengthen infrastructure, hillside reforesting, terracing, drain maintenance, anti-erosive dams (cash for work), etc. • Monitor carbon-fixing impact generated to allow Carbon funding to support such actions • Combine with conservation agriculture practises (see adaptation)

[17] Bockel L, Thoreux M, Sayagh S, Resilience of rural communities to climatic accidents: a need to scale up socio-environmental safety nets (Madagascar, Haiti), FAO Easypol Policy Brief, 2009

[18] The concept of resilience, borne out of research on the dynamic of ecological systems (Holling, 1973), is defined in a way that is almost diametrically opposed to that of vulnerability: indeed, it is "the capacity of a complex system to absorb shocks while still maintaining function, and to reorganize following a disturbance

Land-use policy is part of prevention policies whose goal is to anticipate the eventual manifestation of a risk by mitigating its destructive effects, which brings about a greater resilience on the part of the area where these infrastructures have been developed.[19]

Growing interest in the potential for social protection to reduce livelihood risks and allow farmers to take higher risk investments to escape poverty have led to a resurgence of interest in different forms of agricultural insurance. *"Social protection initiatives are as much at risk from climate change as other development approaches. They are unlikely to succeed in reducing poverty if they do not consider both the short and long-term shocks and stresses associated with climate change. Adaptive social protection involves examining opportunities that approaches to social protection provide for adaptation and for developing climate-resilient social protection programmes". (www.ccdcommission.org)*

***EXAMPLE:* large-scale productive safety-nets programme**

Ethiopia is one of the poorest countries in the world, where natural resource degradation constitutes a serious obstacle to development. In this context, for more than 30 years donors and the UN World Food Programme have developed a partnership with the government on the topic of reforestation and soil conservation within the framework of the MERET project (Managing Environmental Resources to Enable Transitions to More Sustainable Livelihoods). This project covers 600 communities, and benefits over one million people every year. It is based on a participatory approach to supporting local communities. Since 1991, soil and water conservation uses a local-level participatory planning approach (LLPPA), through which local district (woreda) authorities collaborate with communities for participatory planning, implementation and evaluation. Regional and federal authorities ensure the piloting of accompanying measures and provide technical and financial resources.

Since 2005, the MOARD (Ministry of Agriculture) rallied heavily in order to train technical personnel at the district levels to implement a large-scale Productive Safety-Nets Programme (PSNP), supported by WFP and other donors. It includes employment in public works programs which have the ability to cover the construction of soil and water conservation structures in zones that are not covered by the MERET project. We are currently tending towards the expansion of funds destined toward social safety-nets for vulnerable populations. The example of PSNP, launched in 2007 to consolidate the resilience of vulnerable populations to shocks which are becoming increasingly severe with the effects of climate change, exemplifies this phenomenon. (Source: IRIN: Africa safety nets help to climate-proof the poor, IRIN, Ethiopia: Safety Nets Help to Climate-Proof the Poor, 2007)

4.2.4. Livestock Management

Livestock can play an important role in both mitigation and adaptation. Mitigation measures could include technical and management options in order to reduce GHG emissions from livestock, as well as the integration of livestock into broader environmental services. Livestock has the potential to support the adaptation efforts of the poor. In general, livestock is more resistant to climate change than crops because of its mobility and access to feed. However it is important to remember that the capacity of local communities to adapt to and mitigate the impacts of climate change will also depend on their socio-economic and environmental conditions and on the resources that they have available.

Mitigation of GHG emissions in the livestock sector can be achieved through various activities, including (i) different animal feeding management, (ii) manure management (collection, storage, spreading, etc.), and (iii) management of feed crop production.

[19] **Land-use planning** is also an intelligent response to the issue of economic growth and the security of the society. An efficient land-use scheme insures good spatial distribution of activities and guarantees a coherent rural renovation policy. Specifically, this ultimately means rebuilding the national territory on the basis of integrating the national space, solidarity between rural and urban areas and the competitiveness of different areas.

Feeding management links with:

- the *selection of faster growing breeds* (improved livestock efficiency to convert energy from feed into production), and reducing losses through waste products;
- increasing *feed efficiency* by improving the digestibility of feed intake for all livestock practices: these are potential ways to reduce GHG emissions and maximize production
- *improved feeding composition* – the composition of feed has affects the enteric
- *fermentation* and emission of CH4 from the rumen or the hindgut (Dourmad, et al., 2008)

Improved waste management creates the opportunity for the design of different mechanisms such as covered storage facilities, which is also important. The amount of GHG emissions from manure (CH4, N2O, and CH4 from liquid manure) will depend on the temperature and duration of storage. Therefore, long-term storage in high temperatures will result in higher GHG emissions. In the case of ruminants, pasture grazing is an efficient way to reduce CH4 emission from manure, because no storage is necessary.

One of the major contributions of GHG emissions as a result of livestock production comes from forage or feed crop production and the land use of feed production. Thus, pasture grazing and proper pasture management through rotational grazing is the most cost effective way to mitigate GHG emissions from feed crop production. Animal grazing on pastures also helps reduce emissions from animal manure storage. Introduction of grass species and legumes into grazing lands can enhance carbon storage in soils.

Finally, improving waste management involves changing current practices, including land management and input use to promote efficiency and sustainable production systems (both intensive and extensive) to minimize environmental degradation and pollution from waste materials, conserve the resource base and minimize net greenhouse gas emissions while providing secure livelihoods for rural people. National governments may encourage alternative land and livestock management systems, employ incentives or disincentives to degrade the environment, influence prices of inputs, promote agro forestry, etc.

At the local level, adaptations involve adjustments in community or household use of resources, livestock numbers and management, etc.

Table 14: Livestock management actions

Channels	Livestock management
farmer technologic / strategic options	• Diversify livestock types and varieties to address the environmental variations and economic risks associated with climate change.
Public services and external / project support	• promote proper pasture management through rotational grazing • *Selection of faster growing livestock breeds* • promote improved animal manure storage
Support Policies	• Schemes to improve pasture quality • Research and development to improve productivity through breeding and heifer management • Schemes to include additives that reduce methane formation • Programs to prevent degradation of pastures • Programs to encourage adjustments in intensity and timing of grazing to increase carbon sequestration in pasture lands

5. ENTRY POINTS FOR CLIMATE CHANGE POLICY OPTIONS IN AGRICULTURE

While including policy options on climate change into existing policies/strategic frameworks is emphasized as a main entry point, the direct inclusion of these policy options within adaptation practices in extension work and actions included in new projects constitutes a relevant alternative, and can compensate for slow policy implementation or policy implementation gaps. Furthermore it allows for the testing of innovative policy paths.

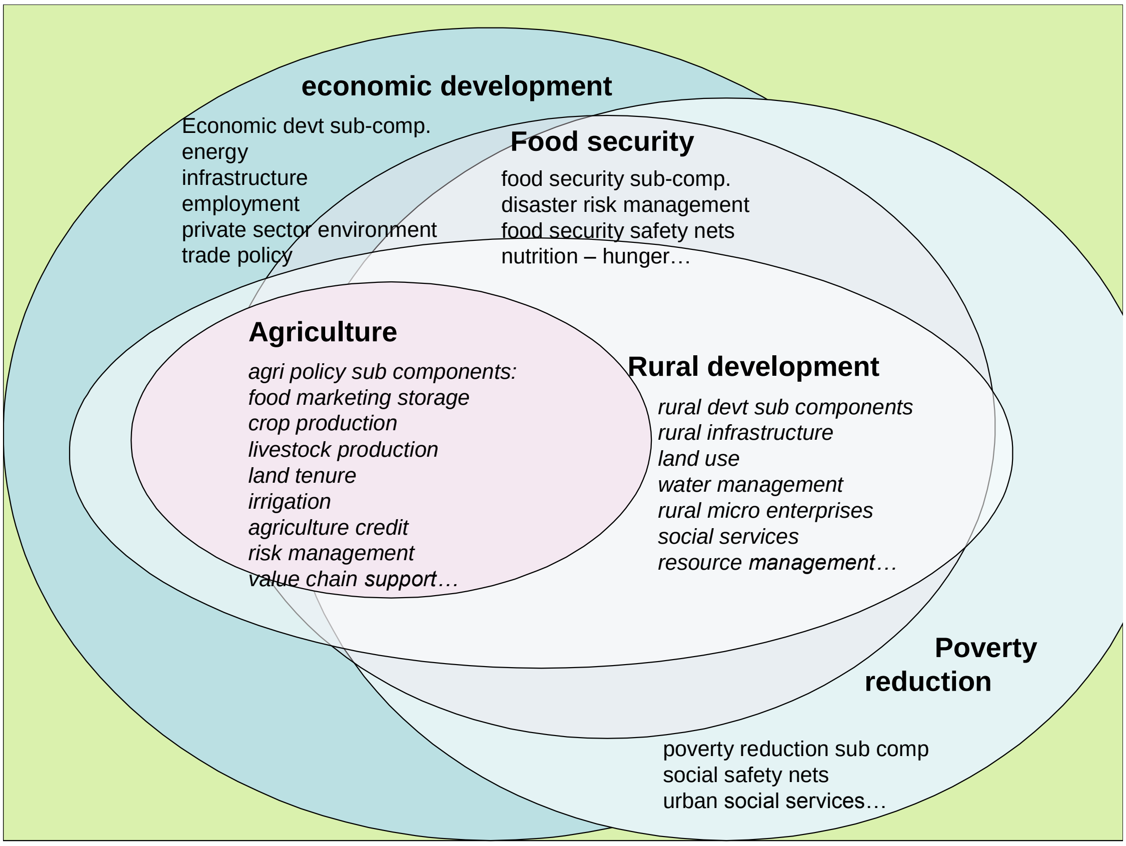
However this integration process should be profiled to fit with the choices of the Government in question as well as with the degree of partner mobilisation using the following paths separately or jointly:

1. Begin with policymaking as a driver;
2. Promote local entry points to test and multiply pilot experiences which will help design adequate policies;
3. Wait for donors to come with innovative projects (?); or
4. Simultaneously promote mainstreaming at all levels with synergic effects of self-led local initiatives vis-à-vis public policies.

5.1. Entry points in sector policies, strategies

A great number and variety of climate change adaptation strategies and measures have been proposed (and some applied) to reduce the vulnerability of agriculture. Habitually, adaptation initiatives relate to one or more existing policies or programmes. Figure 4 shows an array of overlapping domains related to agriculture to which climate change adaptations relate. Of course, there are considerable overlaps and connections among the domains, and they are not all explicitly or effectively addressed in all developing countries.

Figure 6: Domains targeted and domains for integrating climate change adaptation.



Depending on the country, such policies or strategic frameworks have a bigger or smaller reference and orientation role with respect to public actions and external donor funded actions. In most country situations, integration into national policies is a precondition for effective scaling up through multi-partnership, public fund mobilisation and official recognition of a priority towards implementation process.

In each of the main policy domains represented in the figure, certain types of climate adaptation relate to the objectives and operations of the policy area and could therefore be envisaged for integration in this particular policy area.

The integration of climate change adaptation into national policies is probably feasible in most developing countries, in some form. Some countries have already incorporated adaptation into their policies, with assistance or encouragement from the international community.

On the question of effectiveness, the form of integration into policy can vary greatly. One example would be a statement of principle or intent in a policy that could make no material difference to production systems, resource use, water management or livelihoods and their adaptability to climate change. In another case, a change in policy could be implemented that significantly alters water use, production or risk management in a way that improves the ability of the system to deal with changes in climate conditions

The effectiveness of integrating climate change adaptation into a national policy relates to:

- how it is incorporated, i.e., the effectiveness of the incorporation of climate change adaptation into the policy itself
- how far the national policy is implemented
- What the role of national policy is relative to other drivers of change in the agricultural system, such as local agents, NGOs, international organizations, etc.

5.2. Potential inclusiveness of climate change policy options in food security and in poverty reduction strategies

Linking climate change and food security vulnerability: the term food security vulnerability usually refers to a specific consequence (such as food shortage or famine), rather than a cause (e.g., drought or climate change). For example, a household in semi-arid Kenya may be vulnerable to food poverty, that is, their current income and assets may be insufficient to avoid hunger if drought triggers a shortfall in production. Second, vulnerability implies an adverse consequence, as opposed to the more neutral term sensitivity. For example, maize yields are sensitive to drought; households are vulnerable to hunger. Societies and regions may be vulnerable to food shortage and hunger, perhaps because their economic systems are sensitive to climate change.

The concept of potential inclusiveness expressed here merges the degree of technical relevance of these policy options within a given policy framework, the chance of effective implementation support and the relevance of institutional and project linkages. For instance policies which require a multi-sector approach involving many ministers are monitored and implemented in a multi-sector framework.

Table 15: Inclusiveness of policy options in food security and poverty reduction strategies

	inclusiveness in food security strategy	inclusiveness in poverty reduction strategy (PRSP)
Adaptation oriented policies		
• Policies to encourage adapted crop development and farming practises	medium	low
• Crop and income loss risk management policies	high	high
• Policies to promote soil conservation and land management	medium	medium
• Irrigation and water resource management policies	medium	medium
• Disaster risk management policies (flood, drought...)	high	high
Mitigation oriented policies		
• Policies to promote conservation agriculture	medium	low
• Options to reduce methane from rice paddies	high	medium
• Watershed management policies	medium	high
• Livestock management policies	high	medium

source: FAO TCA

Food security strategies are usually more global than agriculture policies; they concern different technical ministries and they sometimes face implementation gaps linked with limited inter-ministry coordination and power of implementation. They are more crucial in countries with a high recurrence of serious food crises and which therefore often vacillate between development, emergency and rehabilitation situations.

Poverty reduction strategies have been strongly supported by the IMF, World Bank and other donors (PRSP towards debt annihilation) and have progressively become National Reference Government planning documents driving the use of public funds. As such they remain quite generalized and usually do not allow for the definition of specific sector strategies. Therefore they permit public fund mobilisation but still lack the implementation linkage which is located among the more technical ministries.

5.3. Potential inclusiveness of climate change policy options in agricultural policy or a rural development framework

Most national agriculture policies serve as reference documents which allow for the integration of most proposed climate change policy options. Furthermore they tend to be prepared through a wide participatory process with working groups or consultations involving public and private stakeholders, farmers' representatives and NGO/donor partners.

Table 16: Inclusiveness of policy options in agriculture policies and rural development strategies

	Inclusiveness in		
	agriculture policy[20]	**food security strategy**	**rural development strategy**
Adaptation oriented policy options			
• Policies to encourage adapted crop development and farming practises	High	medium	medium
• Crop and Income loss Risk management Policies	Medium	high	medium
• Policies to promote Soil conservation and land management	High	medium	medium
• Irrigation and Water resource management policies	High	medium	high
• Disaster risk management policies (flood, drought...)	Low	high	high
Mitigation oriented policy options			
• Policies to promote Conservation agriculture	High	medium	medium
• Options to reduce methane from rice paddies	High	high	medium
• Watershed management policies	Medium	medium	high
• Livestock Management Policies	High	high	high

5.4. Direct policy implementation in the formulation of agriculture projects and programmes

Currently the design and formulation of projects and programmes is an opportunity for technical experts within the government, donors and international organisations. They are the ones to negotiate the introduction of innovative ways of working and promoting technology transfers.

Country policy reviews will later be influenced by country success stories from projects, public pilot actions or from NGO initiatives. In other words, what appears successful at the project or programme level could later be scaled up to the policy level (let the risks be taken by the projects, as we can capitalise on their success or learn from their failure).

In chapters 3 and 4, tables of policy options indicate different channels either at producer level, through technical services and projects programmes or through public policies. The proposals regarding the second channel are relevant for direct inclusion in projects.

5.5. Direct implementation through local communities and NGO initiatives

There are now several examples of climate change adaptation being adopted in agricultural communities and regions, including:

- adaptation to droughts in northwest Bangladesh (ADPA, FAO…)
- adaptation to flooding and sea level rise in Southern Bangladesh (CIDA, CARE, etc.)

[20] The concept of potential inclusiveness expressed here merges the degree of technical relevance of these policy options within a given policy framework, the chance of effective implementation support and the relevance of institutional and project linkages

- o adaptation to livelihood risks in Zignasso, Mali (USAID, etc.)
- o adaptation to water resource and coastal hazards in Samoa (SPREP)

Most of these have been successful in demonstrating that adaptations in farming practices, disaster/risk management procedures and livelihood strategies can reduce vulnerability (increase resilience) to climate and weather risks, including those expected to result from climate change.

For example, the ADPC/FAO case study of livelihood adaptation in drought-prone areas of Bangladesh involved collaboration with numerous government agencies, documented vulnerabilities, identified a suite of adaptation options, and a number of short- and long-term measures to facilitate adaptation. Yet the study concludes: *The efforts to mitigate the impact of climate change (ie. adapt to climate change) in drought-prone areas need to be integrated into the long-term planning of national and local institutions. In this context, efforts have been made to involve several national and local-level institutions in the entire process… (Selvaraju et al. 2006).*

Many of the cases mentioned above have involved agencies of national governments in various capacities, but for the most part the initiatives were lead by agencies other than national governments.

5.6. Direct implementation through public/ private service providers

The 'additionality' of climate change has important implications for adaptation. The effects of climate change – both long-term trends in 'norms' and changes in the frequency and severity of extremes – are experienced on top of normal weather variability and together with stimuli relating to other factors – resources, inputs, markets, social conditions, policies, etc. From the practical point of view of a farmer, an extension technician or a farmers' adviser in a developing country, climate change adaptation (even if the person is aware of it and its implications) is one of many external factors affecting agriculture and his/her work.

6. FROM MAINSTREAMING TO IMPLEMENTING ADAPTATION AND MITIGATION OPTIONS IN AGRICULTURE

6.1. A participatory approach involving all stakeholders to ensure ownership and commitments at all levels

Any effective integration of adaptation into policy requires the active participation of those involved and affected by the policy, and by changes to it. This would include those who fund, inform, design, disseminate and implement the policy, and those whose lives and livelihoods are affected by the policy. Such a step would require an efficient communication (media support) and consultative process.

Stakeholder engagement is necessary for policy acceptance, but it is also necessary to ensure that the vulnerabilities addressed are those of direct importance to agriculture and people (not reflecting only the scientists' perspective, for example). To this regard, understanding the various interests and concerns of national policymakers can help ensure that adaptation measures are feasible and beneficial as well as ensure that implementation strategies are practical.

A policy environment in favour of integrating climate change adaptation into national policies is essential. Awareness-raising among key counterparts on the social and economic costs of not addressing climate change is relevant to the policy formulation process because it is one way to create the political will for climate change issues to be placed on the policy agenda. Guidelines for stakeholder engagement are readily available (e.g. UNDP/APF, etc.).

The ultimate beneficiaries of adaptation and mitigation are usually expected to be (current and future generations of) individuals and households, involving agriculturalists, pastoralists, farmers, fishers, etc. Successful adaptation would result in sustainable livelihoods, food security, viable or additional incomes and reduced input costs, particularly in the sense that these goals are resilient or sustainable in the face of a changing global climate. The process (development, modification, dissemination, sponsorship, facilitation, implementation, etc.) can involve any of several categories of participants or stakeholders:

- Individuals and households.
- Groups of households (formal or informal) for input sharing, exchange, marketing.
- Communities (formal or informal), to include facilitating individual actions, and/or implementing community level adaptations (e.g. infrastructure, water management, storing, sharing, insurance).
- Sub-national organizations, e.g. regional bodies, NGOs, businesses.
- National level organizations e.g. government agencies, NGOs, sector organizations, whose common role is facilitate rather than implement adaptations.
- UNFCCC, GEF, UNEP, UNDP, FAO, World Bank, ADB, bilateral agencies, etc.

At the individual or household level, if climate change risks are considered at all, they are necessarily integrated into decision-making. Farmers are aiming to meet immediate needs relating to food, assets, livelihoods or income. Producers think of the challenges from climate and weather in terms of regional variability of climate and water, and impacts from drought. Decisions on the farm are multi-faceted and often take a short-term perspective. “Climate change” appears to be a secondary concern, likely due to the fact that it is seen as an increase of average temperatures in the distant future, unrelated to weather variability and moisture deficits.

Examples of climate adaptation and mitigation activities (floating gardens, livelihood diversification, water capture, crop choice, etc.) all serve core priorities of farm households. Reducing the risk of climate change is rarely, if ever, a key independent driving force. National policies focusing on climate change as independent from the critical considerations of farmers and other resource users are unlikely to be effective.

Key features for integrating climate change adaptation and mitigation into agricultural development initiatives are that they fit within the development priorities and processes of the country (or sector or region) and that they are accepted, supported and promoted by a wide spectrum of stakeholders, including government, decision-makers, civil society organisations, universities and UN agencies. For those policies to be effective in enhancing the adaptive capacity and resilience of agriculture and food systems and communities, it is necessary to involve decision makers in national policy and in agriculture itself.

Ownership of the policy process needs to be ensured through continuous consultation of key stakeholders (both national and international) and the building of partnerships with technical agencies in a policy process that is both participatory and multi-sectoral.

6.2. The role of Government

National government agencies have yet to play a lead role in practical climate change initiatives and climate change has yet to be incorporated into national policies. For effective integration of climate adaptation and mitigation into national policies, the government needs to play a major role in the following:

1. Ensuring commitment and resources: Impediments or constraints to the incorporation of climate change into existing national polices include limited commitment of government agencies to deal with climate change, given other serious and immediate issues and/or lack of financial resources.

2. Building capacity at several levels: The incorporation of climate change adaptation into national policies is also hindered by limited human capacities and institutional weaknesses. Capacity is understood as the ability of people, organizations and society to successfully manage their climate concerns. Based on this, capacity extends over the individual experience, knowledge and technical skills and depends on the organizational environment in which people apply their skills (Fukuda-Parr et al., 2002; OECD, 2006a).

3. Gathering of data to support planning tools and monitoring actions: Policy formulation of climate change adaptation strategies needs to be based on reliable information, such as good quality data, documented vulnerabilities and accurate evidence in order to design targeted climate change strategies and interventions. The government needs to promote efforts to strengthen and improve data collection, analysis and dissemination, and the use of information for policy action.

4. Guaranteeing effective institutionalization and coordination mechanisms: The integration of climate adaptation into policies and effective implementation of those policies are likely to require institutional strengthening and partnerships with other participants (NGOs, international organizations, private sector). Climate change suggests an increased role for the state to ensure successful adaptation and mitigation but whether this will result in a rejuvenation of Ministries of Agriculture or 'more of the same' is not clear. Increased public expenditure in agriculture is required under climate change scenarios.

6.3. The role of donors and funding options

Experience indicates that "climate proofing" a policy is likely to require some stimulus, resources and expertise from agencies or organizations from outside the country. National governments in developing countries invariably have such wide-ranging demands and constraints on agricultural policy development and implementation that mainstreaming climate change rarely becomes a priority. Stimulus and support for adaptation can come from the UN system (via UNFCCC/NAPA or Adaptation Funds, FAO, UNDP, UNEP, etc.), from international development institutions (World Bank, ADB, ADPC, etc.), from bilateral or multilateral development or aid programs (e.g. USAID, DFID, CIDA, SIDA, etc.) and/or from NGOs (e.g. CARE, IISD, IIED, etc.).

In addition to the considerable expertise on climate change adaptation available in international development organizations, there is a growing body of expertise in developing countries, in both governments and NGOs. Several of the small Pacific island states, for example, have government officers with responsibilities around and experience with climate change adaptation. At the same time there are numerous NGOs with considerable expertise in mainstreaming climate change adaptation. This knowledge base should be scaled up in other countries.

Funding for climate change actions in developing countries should be in addition to current ODA. However, synergies and the potential to leverage effectiveness, by combining the two sources of funding, could be considered.

6.3.1. Synergies among financing for mitigation, adaptation, and ODA

Most countries will face both mitigation and adaptation challenges. It is important to assign high priority to mitigation actions that have strong adaptation benefits, for example most agricultural land mitigation activities. Lower priority could be assigned to mitigation activities that have no adaptation benefits. Financing preferences should generally go to the former, but a "top-up" based on the "adaptation asset" value could be considered (FAO, 2009).[21]

Monitoring Reporting and Verification systems to quantify the adaptation asset value, based on mutually agreed accounting units would need to be developed. Combined mitigation and adaptation activities are expected to substantially reduce transaction costs. Funding for climate change actions in developing countries should be additional and clearly separate from current ODA. However, synergies and the potential to leverage effectiveness, by combining the two sources of funding, could be considered.

6.3.2. Establish new financing mechanisms with broader, more flexible approaches

Government and donors could find a way to integrate different funding sources and innovative payment/incentive/delivery schemes to reach producers, including smallholders. A phased approach by aggregating modalities for greater cost-effectiveness, front-loaded payments guaranteed by insurance or performance bonds and/or simplified rules and recognition of community/individual, formal/informal property rights are some design elements that seem to hold promise in this regard.

6.3.3. Funding through Nationally Appropriate Mitigation Action (NAMA)

Agriculture provides an opportunity for Nationally Appropriate Mitigation Actions (NAMA) in developing countries. NAMAs constitute an important entry point through which developing countries could contribute to global mitigation efforts in nationally appropriate ways. For many developing countries, agriculture is a highly climate-sensitive sector, often the main sector of the economy, possessing considerable technical and economic potential to mitigate emissions. In many cases, agricultural mitigation practices have tangential benefits which improve agricultural productivity and resilience and thus contribute to food security, sustainable development and adaptation. For these reasons, mitigation from the agriculture sector is highly relevant to the

[21] FAO, Anchoring Agriculture within a Copenhagen Agreement, A Policy brief for UNFCCC parties by FAO, 2009 http://www.fao.org/climatechange/media/17790/0/0/

development of NAMAs in developing countries. Inclusion of agriculture in developing country NAMAs may also help to balance the exclusion of most forms of agricultural mitigation from the Clean Development Mechanism of the Kyoto Protocol (FAO, 2009).[22]

6.4. A stimulus towards field-based green initiatives and innovations

6.4.1. *A real Innovation-Based Economic Stimulus funding Package for adaptation and mitigation actions*

The request for rapid implementation, the necessity to work simultaneously at different levels (field level with farmers and service providers, local and regional level, national level) and the wide range of stakeholders involved prompt the consideration of an approach which straight away mobilizes all partners. Inspired by the Obama administration's rapid response to the economic crisis, this proposal of an Innovation-based economic stimulus funding package would require both a strong partnership with a donor (6.3.2) and an adequate monitoring system.

On the supply side, the government will provide grants and funds to institutions, companies and service providers to invest in promising existing and new technologies, producing appropriate seedlings and carbon-fixing fertilizer materials and develop training materials. On the demand side, the stimulus package will help farmers and rural micro-enterprises to purchase new green inputs, seed materials and equipment and the municipalities to finance public watershed-land rehabilitation works. The supply side could work as a micro project fund widely open to farmers groups, NGOs and municipalities.

6.4.2. *Scaling up through projects that are launching and on-going*

An additional mechanism to scale up the integration process is to ensure that newly formulated and on going projects are promoting technical adaptation and mitigation options and tools down to farmers and other beneficiary levels. In reality, when adaptation and mitigation options are clearly stated in agriculture policy frameworks, they should also be streamlined as pre conditions for the government approval of any project or programme.

6.4.3. *An ex-ante appraisal tool to assess the mitigation and adaptation potential of proposed actions*

The whole process of selecting and comparing project/micro project proposals in line with mitigation and adaptation will be based on expected performances (ex-ante appraisal). FAO currently works with partners on the development of appropriate appraisal tools which will be available by 2009.

[22] FAO, Anchoring Agriculture within a Copenhagen Agreement, A Policy brief for UNFCCC parties by FAO, 2009 http://www.fao.org/climatechange/media/17790/0/0/

7. CONCLUSION

These guidelines have been developed within the quickly changing environment of climate change and development within the context of the preparation of the 2009 Copenhagen Summit and many newly open options on the way to bridging climate change adaptation and mitigation actions to sector development policies and how to fund such actions in developing countries

The magnitude of the challenge to reduce GHG concentrations in the atmosphere makes the contributions of all sectors with significant mitigation potentials imperative. Agriculture is recognized as a sector with such potential and farmers, herders, ranchers and other land users could and should be part of the solution. Therefore, it is important to identify mitigation activities that are easy to implement and cost effective, and which will strengthen the adaptive capacities of local actors to climate change.

Adaptation strategies are aimed at adjusting social and economic systems so that they are less vulnerable, less impacted and/or more resilient to changing climatic conditions. As a significant contributor to greenhouse gases (14%), agriculture has a role to play in mitigation. Some mitigation initiatives may be compatible with adaptation. Invariably, adaptations to climate change in agriculture have not been (and are not likely to be) undertaken in response to climate change alone or in isolation.

Agricultural adaptations are invariably undertaken by individuals or households (private agents at the farmer level), usually autonomously or spontaneously, and often reactively (*ex post*). Public agencies, from community to national levels, can facilitate or constrain adaptations, and they have a role to play in promoting anticipatory or planned (*ex ante*) adaptations. Mainstreaming adaptation will go through different channels, from autonomous adaptation to planned adaptation policies which include adaptation measures undertaken by the government on state-level (e.g. fund research on local climate impacts), policy measures supporting autonomous adaptation at the farm-level: (e.g. strengthen extension services, etc.) and policies indirectly supporting adaptation.

Adaptation policy options have been organized in five components: (i) to encourage adapted crop development and farming practises; (ii) to promote soil conservation and land management; (iii) irrigation and water resource management; (iv) crop and income loss risk management; and (v) disaster risk management (flood, drought, etc.).

Agriculture also contributes to greenhouse gas emissions, and has a role to play in climate change mitigation through emission reductions and carbon sequestration. Many agriculture mitigation options are estimated to also have positive effects on adaptation to climate change, because they increase the resilience of the agro ecosystems to perturbation by climatic variation by increasing nutrient and water retention in the systems and by preventing soil erosion, degradation and flooding. Opportunities for climate change mitigation, including those which are synergistic with adaptation, can also occur via incorporation into national agricultural policies.

Key features for integrating climate change adaptation and mitigation into agricultural development initiatives are that they fit within the development priorities and processes of the country (or sector or region) and that they are accepted, supported and promoted by a wide spectrum of stakeholders, including government, decision-makers, civil society organisations, universities and UN agencies. For those policies to be effective in enhancing the adaptive capacity and resilience of agriculture and food systems and communities, it is necessary to involve decision makers in national policy and in agriculture itself.

However this integration process should be profiled to fit with the choices of the Government in question as well as with the degree of partner mobilisation using the following paths separately or jointly: (i) begin with policymaking as a driver; (ii) Promote local entry points to test and multiply pilot experiences which will help design adequate policies; (iii) encourage or facilitate donor initiatives to propose innovative projects (?); or (iv) simultaneously promote mainstreaming at all levels with synergic effects of self-led dynamic of local initiatives vis-à-vis public policies.

The role of government in implementation will be more with respect to (i) ensuring commitment and resources; (ii) building capacity at several levels; (iii) gathering data to support planning tools and monitoring actions; and (iv) guaranteeing effective institutionalization and coordination mechanisms.

The request for rapid implementation, the necessity to work simultaneously at different levels (field level with farmers and service providers, local and regional level, national level) and the wide range of stakeholders involved prompt the consideration of an approach which straight away mobilizes all partners. Inspired by the Obama administration's rapid response to the economic crisis, this proposal of an Innovation-based economic stimulus funding package would require both a strong partnership with a donor (6.3.2) and an adequate monitoring system.

An additional mechanism to scale up the integration process is to ensure that newly formulated and on going projects are promoting technical adaptation and mitigation options and tools down to farmers and beneficiary levels. The whole process of selecting and comparing project/micro project proposals in line with mitigation and adaptation will be based on expected performances (ex-ante appraisal) and appropriate monitoring.

GLOSSARY

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. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation:

Anticipatory adaptation
Adaptation that takes place before impacts of *climate change* are observed. Also referred to as proactive adaptation or *ex ante* adaptation.

Autonomous adaptation
Adaptation that does not represent or reflect a conscious policy response to climatic stimuli but is undertaken as a natural adjustment in ecological systems and by market or *welfare* changes in *human systems*. Autonomous adaptation can also be referred to as spontaneous adaptation.

Planned adaptation
Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Adaptation assessment
The practice of identifying options to adapt to *climate change* and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.

Adaptation benefits
The avoided damage costs or the accrued benefits following the adoption and implementation of *adaptation* measures.

Adaptation costs
Costs of planning, preparing for, facilitating and implementing *adaptation* measures, including transition costs.

Adaptive capacity (in relation to climate change impacts)
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.

Assets

Capacity building
In the context of *climate change*, capacity building entails developing the technical skills and institutional capabilities in developing countries and economies in transition in order to enable their participation in all aspects of *adaptation* to, *mitigation* of, and research on *climate change*, and in the policy processes.

Carbon dioxide fertilisation
The stimulation of plant *photosynthesis* due to elevated CO_2 concentrations, leading to either enhanced productivity and/or efficiency of *primary production*. In general, *C3 plants* show a larger response to elevated CO_2 than *C4 plants*.

Carbon sequestration
The process of increasing the carbon content of a *reservoir*/pool other than the *atmosphere*.

C3 plants
Plants that produce a three-carbon compound during *photosynthesis*, including most trees and agricultural crops such as rice, wheat, soybeans, potatoes and vegetables.

C4 plants
Plants, mainly of tropical origin, that produce a four-carbon compound during *photosynthesis*, including many grasses and the agriculturally important crops maize, sugar cane, millet and sorghum.

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
Climate change generally refers to change in *climate* over time, whether due to natural variability or as a result of human activity. The United Nations Framework Convention on Climate Change (UNFCCC), 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 anthropogenic climate change and climate variability.

Climate proofing
Climate proofing refers to the process of incorporating or mainstreaming climate change adaptation Into policies, programs, management strategies… in order that the initiatives are resilient (or less vulnerable) to conditions associated with climate change. See also *mainstreaming* or *climate resilient development*.

Disaster Risk Management

Extreme weather event
An event that is rare within its statistical reference distribution at a particular place. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. 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. Food insecurity may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level.

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).

(climate change) Impact assessment
The practice of identifying and evaluating, in monetary and/or non-monetary terms, the effects of *climate change* on natural and human systems.

(climate change) Impacts
The effects of *climate change* on natural and *human systems*. Depending on the consideration of *adaptation*, one can distinguish between potential impacts and residual impacts:

- **Potential impacts**: all impacts that may occur given a projected change in climate, without considering adaptation.
- **Residual impacts**: the impacts of climate change that would occur after adaptation. See also *aggregate impacts*, *market* impacts, and non-market impacts.

Mainstreaming
In the climate change context, mainstreaming refers to the incorporation of climate change considerations into established or on-going development programs, policies or management strategies, rather than developing adaptation initiatives separately. See also *climate proofing* or *climate resilient development*.

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.

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-organisation, and the capacity to adapt to stress and change.

Risk
In the climate change context, risk is the likelihood of loss associated with exposure to a climate-related hazard. Risk is generally measured as a combination of the probability of an event and its consequences, with several ways of combining these two factors being possible.

Risk Management
Strategies, policies and decisions to minimize potential hazards and their detrimental effects. Risk management refers to an ongoing process that starts with coping strategies for current risk, tries to anticipate changes in risk, and seeks to evolve new coping strategies as necessary (World Bank).

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*).

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 cap

REFERENCES

- BANQUE MONDIALE, définition d'un cadre stratégique concernant le changement climatique et le développement pour le groupe de la Banque Mondiale, Note de synthèse, 2008
- BOCKEL L, THOREUX M, SAYAGH S, Resilience of rural communities to climatic accidents: a need to scale up socio-environmental safety nets (Madagascar, Haiti), FAO Easypol Policy Brief, 2009
- BOCKEL L, THOREUX M, SAYAGH S Food Security and Risk Management by Local Communities, Lessons learned and recommendations on development policy (Niger, India), FAO Easypol Policy Brief, 2008
- BOKO ET AL., 2007; Christensen et al., 2007; Cruz et al., 2007; Magrin et al., 2007; Mimura et al., 2007; UNFCCC, 2008
- ELLIS S, The Changing Climate for Food and Agriculture: A Literature Review, Institute for Agriculture and Trade Policy Minneapolis, Minnesota , 2008
- FAO, Anchoring Agriculture within a Copenhagen Agreement, A Policy brief for UNFCCC parties by FAO, 2009 http://www.fao.org/climatechange/media/17790/0/0/
- FAO ,SUSTAINABLE AGRICULTURE AND RURAL DEVELOPMENT (SARD) POLICY BRIEF 7, SARD and Climate change, 2007
- FAO, Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and Priorities, IDWG Climate change, 2008
- FAO, AGRICULTURAL WATER MANAGEMENT AND CLIMATE CHANGE NRLW Draft, 2007
- FAO, Climate change adaptation and Mitigation in the Food and Agriculture Sector-Technical Background Document from the Expert Consultation held on 5-7 March 2008 in Rome
- FAO, Climate change and Food security, a framework document, , Interdepartmental Working Group (IDWG) on Climate Change (Killmann Huddleston), 2008
- FAO, Climate change water and food security, technical background document from the Expert consultation held in February 2008 FAO, ROME
- FAO, Policy Brief: Options for Decision Makers, FAO Expert Meeting on Climate Change and Disaster Risk Management Rome 28-29 February 2008,
- FAO-SEI, Climate Change Adaptation in Agriculture, Forestry and Fisheries: A Strategy and Plan of the Food and Agriculture Organization of the United Nations, IDWG CC Stockholm Environment Institute, 2007
- FARRINGTON J, HOLMES R, SLATER R, Linking Agriculture and Social Protection: Conceptual framework, ODI, 2008 http://www.odi.org.uk/resources/download/3069.pdf
- FRELIH-LARSEN ET AL, Deliverable D11 Climate change mitigation through agricultural techniques Policy recommendations**,** PICCMAT European project, Policy Incentives for Climate Change Mitigation Agricultural Techniques, 2008
- HABIBA Gitay, Adaptation – learning from case studies for adaptation policies and sustainable development, World Resources Institute, 2008

- IIED, Taking steps , mainstreaming national adaptation, IIED Briefing, 2008
- IFAD, Climate change: building the resilence of poor rural communities, IFAD 2008 www.ifad.org/climate/factsheet/climate_brochure_web.pdf
- IISD, Agriculture and Climate Change, A Prairie Perspective Prepared by the International Institute for Sustainable Development and the Institute for Environmental Studies, University of Toronto, 1997
- IISD, Designing policies in a world of uncertainty, change, and surprise, Adaptive policy-making for agriculture and water resources in the face of climate change, International Institute for Sustainable Development, 2006
- IPCC WGII, Summary for Policymakers- Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC Working Group II, 2007
- IPCC Technical Paper VI – Climate change and water - Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds. IPCC Secretariat, Geneva June 2008
- IPCC, Climate change 2007, synthesis report, UNEP-WMO, 2007 http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
- IPCC Climate Change 2007 "Mitigation of Climate Change" Working Group III Report, Contribution of Working Group II to the Fourth Assessment Report of the IPCC , 2007
- IPCC, Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the IPCC
- IRIN, Ethiopia: Safety Nets Help to Climate-Proof the Poor, 2007 http://allafrica.com/stories/200712050944.html
- KLEIN, R. (2007): Adaptation to Climate Change: IPCC Findings and their Implications for Climate and Development Policy. Presentation held at a workshop in Bonn, 20 November 2007 http://www.germanwatch.org/termine/2007-11-20/klein.pdf
- KLEIN, R. ET al. Portfolio Screening to Support the Mainstreaming of Adaptation to Climate Change into Development Assistance, 2007
- MOUNT T D, Climate change and agriculture, a perspective on priorities for economic policy , Department of Agricultural Resource and Managerial Economics, Cornell University, New York, 1994
- NELLEMANN, et Al, The Environmental food crisis, the environment's role in averting future food crisis, a UNEP Rapid response assessmentl, 2009
- NELSON G, Agriculture and climate change, an Agenda for negotiation in Copenhagen, IFPRI, 2009
- PARRY, ET AL (2007) 'Technical Summary' in *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007.*
- PAUSTIAN K, ANTLE M J., SHEEHAN J, Agriculture's Role in Greenhouse Gas Mitigation, Pew Center on Global Climate Change, 2006
- QUAN J, DYER N, Climate Change and Land Tenure , The implications of climate change for land tenure and land policy, NRI FAO, IIED , 2009

- ROUSSET N, ARRUS R, L'agriculture du Maghreb au défi du changement climatique : quelles stratégies d'adaptation face à la raréfaction des ressources hydriques ? LEPII, Groupe Energie et Politiques de l'Environnement (EPE), 2006
- SIETZ D, BOSCHÜTZ M, JT KLEIN, LOTSCH A, , Mainstreaming Climate Adaptation into Development Assistance in Mozambique: Institutional Barriers and Opportunities, World Bank, Policy Research Working Paper 4711, 2008
- SMIT B, SKINNER M W, Adaptation Options in Agriculture to Climate Change: A Typology, Mitigation and Adaptation Strategies for Global Change, 2002
- SMIT, B., AND O. PILIFOSOVA. Adaptation to climate change in the context of sustainable development and equity, 2001
- SMIT, B. AND O. PILIFOSOVA. 2003. From adaptation to adaptive capacity and vulnerability reduction. In J. Smith, R. T. J. Klein and S. Huq (eds.), Climate Change, Adaptive Capacity and Development. London: Imperial College Press, pp. 9-28.
- STERN, N. , The Economics of Climate Change: The Stern Review. Cambridge University Press, Cambridge, 2007
- UNDP , Fighting climate change: Human solidarity in a divided world. Human Development Report 2007/08. New York, 2007
- UNFCCC, Challenges and opportunities for mitigation in the agricultural sector, Technical paper, 2008
- UNFCCC (2006): Technologies for Adaptation to climate change. http://unfccc.int/resource/docs/publications/tech_for_adaptation_06.pdf
- UNFCCC (2007a): Bali Action Plan. Decision 1/CP.13. http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf
- UNFCCC (2007b): Investment and financial flows to address climate change. Background paper.
- UNITAR, NAPA National Adapatation Programme of Action http://www.napa-pana.org/
- WALL E, SMIT B, Climate Change Adaptation in Light of Sustainable Agriculture, Journal of Sustainable Agriculture, Vol. 27(1) 2005
- WASSMANN et Al, Agriculture and Climate Change: An Agenda for Negotiation in Copenhagen Reducing Methane Emissions from Irrigated Rice, IFPRI 2020 Vision , 2009, http://www.ifpri.org/2020/focus/focus16/focus16_03.pdf
- WORLD BANK, Policy and Institutional reforms to support climate change adaptation and mitigation in development programms, a practical guideline, 2008
- WORLD BANK, World Development Report 2008: Agriculture for Development. Washington, D.C.: The International Bank for Reconstruction and Development / The World Bank, 2007

APPENDIX 1. CLIMATE STIMULI FOR ADAPTATION

Excerpt from:
Smit, B. and O. Pilifosova. 2003. From adaptation to adaptive capacity and vulnerability reduction. In J. Smith, R. T. J. Klein and S. Huq (eds.), Climate Change, Adaptive Capacity and Development. London: Imperial College Press, pp. 9-28.

The relationship between a change in average conditions and variability and extremes is also represented in Figure 2b, where drought severity is portrayed as a normal (or Gaussian) distribution. Whereas severe droughts currently occur roughly one year in 20, with the shift in mean (climate change) and with no change in variability (the shape and variance of the distribution remain stable), severe droughts have approximately a 1 in 5 probability of occurring. The main point here is that climate change can alter the frequency and magnitude of extreme conditions, even without a change in variability.

Figure 3 shows that changes in the frequency and magnitude of extreme conditions can also change without a change in average but with a change in variability (Figure 3b) and with changes in both mean and variability (Figure 3c).

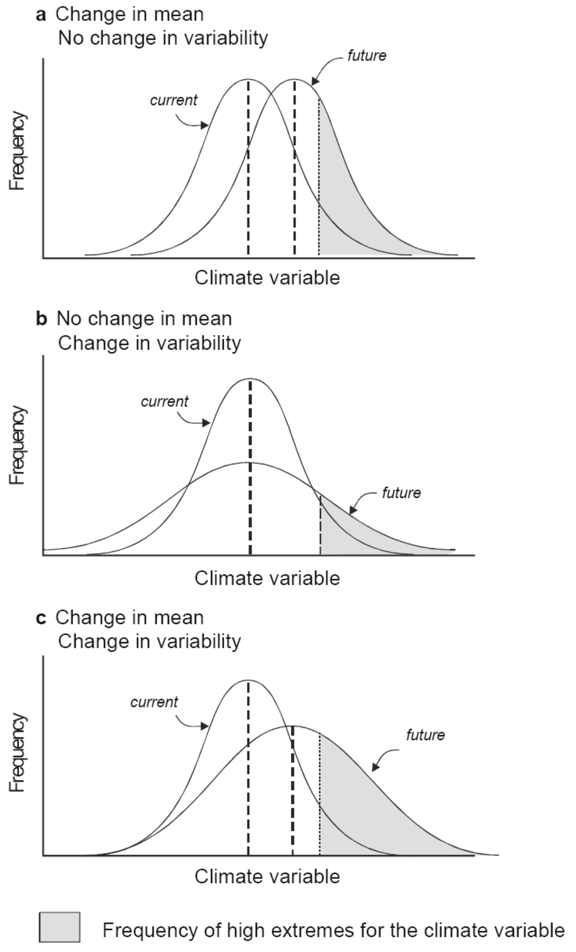


Figure 3. Changes in climate mean and variability (after Hare, 1985; Parry, 1986; Smit et al., 2000)

APPENDIX 2: IMPACT OF CLIMATE CHANGE EFFECTS ON FOOD SYSTEMS AND FOOD SECURITY

A. CO2 fertilization effects				
Impact on food system assets	**Impact on food system activities**	**Impact on food security outcomes**	**Impact on other human well-being outcomes**	**Possible adaptive responses**
Production assets: ▪ Increase in availability of atmospheric carbon dioxide for plant growth	***Producing food:*** ▪ More luxuriant biomass ▪ Higher yields of food and cash crops, mainly in temperate regions	***Food availability (production, distribution, exchange):*** ▪ Increased food production in major exporting countries would contribute to global food supply but diversion of land from food to more economically attractive cash crops could negate this benefit ***Food accessibility (allocation, affordability, preference):*** ▪ Increases in food production would limit price increases on world markets, but diversion of productive assets to other cash crops could cause food prices to rise	***Livelihoods:*** ▪ Increased income from improved food and cash crop performance would benefit commercial farmers in developed countries but not in developing countries	***Policies and regulations:*** ▪ Avoidance of subsidies or other monetary or non-monetary incentives for diversion of food production assets to other uses

B. Increase in global mean temperatures				
Impact on food system assets	**Impact on food system activities**	**Impact on food security outcomes**	**Impact on other human well-being outcomes**	**Possible adaptive responses**
Production assets: ▪ Trend changes in suitability of land for crop and livestock production ▪ Gradual loss of biodiversity ▪ Trend changes in vectors and natural habitats of plant and animal pests and diseases ***Storage, transport and marketing infrastructure:*** ▪ Strain on electricity grids, air conditioning and cold storage capacity	***Producing food:*** ▪ Immediate crop and livestock losses due to heat and water stress ▪ Lower yields from dairy animals ▪ Reduced labour productivity due to heat stress ▪ Trend impacts uncertain, conditional on location, availability of water and adoption of new cropping patterns by farmers ***Storing and processing of food:*** ▪ Upgrade in cooling and storage facilities required to maintain food quality at higher temperatures ▪ Increasing energy requirements for cooling ***Consuming food:*** ▪ Higher intake of liquids ▪ Lower intake of cooked food ▪ Perishable products have shorter shelf life ▪ More need for refrigeration ▪ Heat stress may negatively affect people's ability to access food (no energy to shop or do productive work)	***Food availability (production, distribution, exchange):*** ▪ Reduced production of food crops and livestock products in affected areas ▪ Local losses could have temporary effect on local markets, ▪ Reduction in global supplies likely to cause market prices to rise ***Food accessibility (allocation, affordability, preference):*** ▪ Impacts on incomes, prices and affordability uncertain ▪ Changes in preference uncertain ***Food utilization (nutritional value, social value, food safety):*** ▪ Risk of dehydration ▪ Risk of ill health from eating food that is spoiled ▪ Ability of body to process food reduced due to heat stress or diseases ***Food system stability:*** ▪ Higher cost for storing grain and perishable products	***Livelihoods:*** ▪ Trend changes in vectors and natural habitats of pests and diseases that affect human health and productivity ***Social values and behaviours:*** ▪ Acceptance of a greater degree of risk and uncertainty as a natural condition of life ***National and global economies:*** ▪ Reorientation of public and private sector investments towards mitigating and adapting to climate change	***Policies and regulations*** ▪ Greater reliance on weather-related insurance ▪ Development of risk management frameworks ***Farming, forestry and fishery practices*** ▪ Trend changes in cropping patterns ▪ Development and dissemination of more heat-tolerant varieties and species ***Food processing, distribution and marketing practices*** ▪ Greater use of alternative fuels for generating electricity ***Food preparation practices*** ▪ Greater use of alternative fuels for home cooking

C.1. Gradual changes in precipitation (increase in the frequency, duration and intensity of dry spells and droughts)				
Impact on food system assets	**Impact on food system activities**	**Impact on food security outcomes**	**Impact on other human well-being outcomes**	**Possible adaptive responses**
Production assets ▪ Loss of perennial crops and vegetative cover for grazing and fuel wood due to water stress and increasing fire hazard ▪ Loss of livestock due to water stress and lack of feed ▪ Loss of productive assets due to hardship sales ▪ Loss of buildings, equipment and vehicles and other productive assets due to fire ▪ Changes in rates of soil moisture retention and aquifer recharge ▪ Trend changes in suitability of land for crop and livestock production ▪ Gradual loss of biodiversity ▪ Trend changes in vectors and natural habitats of plant and animal pests and diseases ***Food preparation assets*** ▪ Lack of water for cooking ▪ Lack of vegetation for fuel	***Producing food:*** ▪ Immediate crop and livestock losses due to water stress ▪ Trend declines in yields ▪ Change in irrigation requirements ***Storing/processing of food:*** ▪ Less need for chemicals to preserve stored grain ▪ Scarcity of water for food processing ***Distributing food:*** ▪ Easier movement of vehicles on dry land ***Consuming food:*** ▪ May not be possible to continue growing preferred foods ▪ May be necessary to purchase a larger proportion of foods consumed ▪ Diet may become less varied and / or less nutritious	***Food availability (production, distribution, exchange):*** ▪ Declines in production ▪ Wild foods less available ▪ Pressure on grain reserves ▪ Decrease in food exports / increase in food imports ▪ Increased need for food aid ***Food accessibility (allocation, affordability, preference):*** ▪ Local increase in food prices in drought-affected areas ▪ Loss of farm income and non-farm employment ▪ Preferred foods not available or too costly ***Food utilization:*** ▪ Risk of dehydration ▪ Ability of body to process food reduced due to diseases ▪ Dietary adjustments with different nutritional content ***Food system stability:*** ▪ Greater instability of food supply, food prices and agriculturally-based incomes	***Livelihoods:*** ▪ Decline in expenditure for other basic needs, e.g., clothing, shelter, health, education ▪ Trend changes in vectors and natural habitats of pests and diseases that affect human health and productivity ***Social values and behaviours:*** ▪ Food scarcity strains ability to meet reciprocal food-sharing obligations ***National and global economies:*** ▪ Strain on national budgets and aid resources due to increased need for food safety nets	***Policies and regulations:*** ▪ Greater reliance on weather-related insurance ▪ Development of risk management frameworks ***Infrastructure investments*** ▪ New investment in irrigation for intensive agriculture where water resources permit ***Farming, forestry and fishery practices*** ▪ Trend changes in cropping patterns ▪ Development and dissemination of more drought-tolerant varieties and species ▪ Use of moisture-retaining land management practices ▪ Use of recycled wastewater for irrigation ***Food processing practices:*** ▪ Use of recycled wastewater ▪ Use of dry processing and packaging methods ***Food preparation practices*** ▪ Use of dry cooking methods

C.2. Gradual changes in precipitation (changes in timing, location and amounts of rain and snowfall)				
Impact on food system assets	**Impact on food system activities**	**Impact on food security outcomes**	**Impact on other human well-being outcomes**	**Possible adaptive responses**
Production assets ▪ Changes in rates of soil moisture retention and aquifer recharge ▪ Increase in proportion of global population exposed to water scarcities ▪ Changes in locations where investment in irrigation is economically feasible ▪ Trend changes in suitability of land for crop and livestock production ▪ Trend changes in vectors and natural habitats of plant and animal pests and diseases	***Producing food:*** ▪ Trend impacts on yields uncertain, conditional on location, availability of water and adoption of new cropping patterns by farmers ***Consuming food:*** ▪ Changes in consumption patterns may occur, in response to changes in relative prices	***Food availability (production, distribution, exchange):*** ▪ Some local losses virtually certain, but their likely geographic distribution is not known ▪ Likely impact on global supplies, trade and world market prices is not known ***Food accessibility (allocation, affordability, preference):*** ▪ Full-cost pricing for water may cause food prices to rise ***Food system stability:*** ▪ Greater instability of food supply, food prices and agriculturally-based incomes is likely	***Livelihoods:*** ▪ Changes in geographic distribution of vulnerability ***Social values and behaviours:*** ▪ Acceptance of a greater degree of risk and uncertainty as a natural condition of life ***National and global economies:*** ▪ Reorientation of public and private sector investments towards mitigating and adapting to climate change	***Policies and regulations:*** ▪ More aggressive support for efficient water management policies and water use regulations ▪ Full-cost pricing for water ***Infrastructure investments:*** ▪ New investment in irrigation for expanding intensive agriculture where available water resources permit ***Farming, forestry and fishery practices*** ▪ Use of moisture-retaining land management practices ▪ Use of recycled wastewater for irrigation ***Food processing practices:*** ▪ Use of recycled wastewater for plant hygiene ***Food safety and preventive healthcare practices:*** ▪ Use of recycled wastewater for home hygiene

D. Impacts of increase in the frequency and intensity of extreme weather events (increase in annual occurrence of high winds, heavy rains, storm surges, flash floods and rising water levels associated with tornados, tropical storms, and prolonged heavy rains)				
Impact on food system assets	**Impact on food system activities**	**Impact on food security outcomes**	**Impact on other human well-being outcomes**	**Possible adaptive options**
Production assets: ▪ Damage to standing crops ▪ Animals stranded ▪ Increase in water-borne livestock diseases ▪ Damage to buildings and equipment ▪ Loss of stored crops *Storage, transport and marketing infrastructure:* ▪ Damage to roads, bridges, storage structures, processing plants and electricity grids *Non-farm livelihood assets:* ▪ Damage to trade goods *Food preparation assets:* ▪ Loss of household food supplies	*Producing food:* ▪ Possibility of lower yields in flooded agricultural areas ▪ Increased soil erosion reducing future yields *Processing food:* ▪ Pollution of water supply used in processing food *Distributing food:* ▪ Disruptions in food supply chains and increase in marketing and distribution costs *Consuming food:* ▪ Reliance on emergency rations ▪ Possibility that preferred foods will be less available in emergency situations and food variety will decrease ▪ Increased health risks from water-borne diseases may negatively affect people's ability to access food (no energy to shop or do productive work)	*Food availability (production, distribution, exchange):* ▪ Possible decrease in surplus production in flooded agricultural areas ▪ Increased need for emergency distribution of food rations *Food accessibility (allocation, affordability, preference):* ▪ Possible increase in food prices ▪ Possible loss of farm income and non-farm employment, depending on extent of asset loss *Food utilization (nutritional value, social value, food safety):* ▪ Food safety is compromised by water pollution and damage to stored food ▪ Ability of body to process food reduced due to diseases	*Livelihoods:* ▪ Decline in expenditure for other basic needs, e.g., clothing, shelter, health, education ▪ Trend changes in vectors and natural habitats of pests and diseases that affect human health and productivity ▪ Changes in geographic distribution of vulnerability *Social values and behaviours:* ▪ Acceptance of a greater degree of risk and uncertainty as a natural condition of life *National and global economies:* ▪ Reorientation of public and private sector investments towards mitigating and adapting to climate change	*Policies and regulations:* ▪ Development of weather-related insurance schemes for storms and floods ▪ Development of risk management frameworks ▪ Support for resettlement schemes in low-risk areas *Infrastructure investments:* ▪ New investment in flood embankments ▪ Use of wind resistant technologies on new and existing structures ▪ Establishment of emergency shelters on high ground *Farming, forestry and fishery practices* ▪ Use of practices that create more dense root mass to hold soil in place ▪ Development and dissemination of more flood-tolerant varieties and species *Food safety and preventive healthcare practices* ▪ Provision for emergency water supplies

E. Impacts of greater weather variability				
Impact on food system assets	**Impact on food system activities**	**Impact on food security Outcomes**	**Impact on other human well-being outcomes**	**Possible adaptive options**
Production assets: ▪ Change in frequency and extent of pests and diseases	*Producing food:* ▪ Increasing uncertainty ▪ Changing yields ▪ Changing land use patterns ▪ Viability of production systems may be undermined	*Food availability:* ▪ Some local losses virtually certain, but their likely geographic distribution is not known ▪ Likely impact on global supplies, trade and world market prices is not known *Food accessibility:* ▪ Reduced yields may lead to loss of farm income, but this depends on market conditions *Food system stability:* ▪ Greater instability of food supply, food prices and agriculturally-based incomes is likely	*Livelihoods:* ▪ Decline in expenditure for other basic needs, e.g., clothing, shelter, health, education ▪ Trend changes in vectors and natural habitats of pests and diseases that affect human health and productivity ▪ Changes in geographic distribution of vulnerability *Social values and behaviours:* ▪ Acceptance of a greater degree of risk and uncertainty as a natural condition of life *National and global economies:* ▪ Reorientation of public and private sector investments towards mitigating and adapting to climate change	*Policies and regulations* ▪ Greater reliance on weather-related insurance ▪ Development of risk management frameworks *Farming, forestry and fishery practices* ▪ Trend changes in cropping patterns ▪ Changes in water management regimes

APPENDIX 3 : COMPLEMENTARY AGRICULTURE POLICIES WITH CLIMATE CHANGE MITIGATION IMPACT

Mitigating climate change means reducing greenhouse gas emissions and sequestering or storing carbon in the short term, and of even greater importance making development choices that will reduce risk by curbing emissions over the long term. Although the entire food system is a source of greenhouse gas emissions, primary production is by far the most important component. Incentives are needed to persuade crop and livestock producers, agro industries and ecosystem managers to adopt good practices for mitigating climate change.

It is imperative to recognize that agricultural mitigation measures not only offer reductions in GHG emissions but have other social, economic and environmental benefits, particularly as regards sustainable development, food security and making progress towards meeting the objectives of the Millennium Development Goals. Current initiatives suggest that synergies between climate change policies, sustainable development and improvements in environmental quality will most likely lead the way to realize fully the mitigation potential in this sector.

Examples of possible synergies for mitigation measures in the agriculture sector include:

- Cropland management (through management of nutrients, tillage, residues and agroforestry) could improve ground water quality and the environmental health of the cultivated ecosystem, thus offering to local communities sustainable supplies of clean water as well as better soil and air quality;
- Yield improvement measures can enhance food security by increasing productivity while contributing towards a higher income for farmers, and thus helping to alleviate poverty;
- C sequestration combines abatement with climate change adaptation in vulnerable smallholder farming systems, thus enhancing sustainable land management and reducing poverty in rural areas of the developing world (Verchot et al., 2007).

Reforestation and afforestation

Reforestation involves planting new trees in existing forested areas where old trees have been cut or burned; afforestation involves planting stands of trees on land that is not currently classified as forest. Sustainable forest management requires that a new tree be planted for every tree cut down by logging, fuel wood gathering or land clearing activities. At the global level, however, meaningful carbon sequestration through reforestation and afforestation would require that more new trees be planted each year than were lost to deforestation in the previous year.

Farmers, commercial logging companies, industrial roundwood producers and fuelwood plantation managers all have the possibility to plant large numbers of new trees as part of their normal operations. Public sector programmes to replant forested areas that have been destroyed by wildfires or arson can also be managed so that they add to the global carbon sink reserve.

Areas that have been intentionally converted from forest to other land uses need to be transformed into stable agricultural areas as quickly as possible, so they are not left in the vulnerable transition period for too long. Cleared land is at high risk of erosion and loss of soil moisture, so fast-growing cover crops should be planted as soon as possible after clearing, even if they are subsequently replaced by something else. In addition to reducing the risk of erosion, these crops will absorb some CO_2 and can later be ploughed under to enhance the fertility and water-retention capacity of the soil.

Rehabilitation of degraded grasslands

Overgrazing, reduction of fallow, water scarcity and cutting of trees for fuel and timber are degrading land, creating energy scarcities and increasing the prevalence of poverty and food insecurity for many rural people.

Improved grassland management through the incorporation of trees, improved species, fertilization and other measures can reverse carbon losses, lead to net sequestration and yield additional benefits, particularly by preserving/restoring biodiversity. Among the many other technical options are fire management, protection of land and set-asides and enhancement of grassland production, such as through the introduction of deep-rooted/legume species.

Lal estimates the eco-technological scope for soil carbon sequestration in dryland ecosystems to be about 1 billion tonnes of carbon per year, but realization of this potential would require a "vigorous and a coordinated effort at a global scale towards desertification control, restoration of degraded ecosystems, conversion to appropriate land uses, and adoption of recommended management practices on cropland and grazing land" (Lal, 2004b).

Dryland conditions offer very few economic incentives to invest in land rehabilitation for agricultural production and government institutions required to implement such schemes often have insufficient strength and capacity.

Rehabilitation of cultivated soils

The relatively low CO2 emissions from arable land leave little scope for mitigation, but there is great potential for net sequestration of carbon in cultivated soils. According to Lal, the carbon sink capacity of the world's agricultural and degraded soils is 50 to 66 percent of the total carbon loss since 1850 (Lal, 2004b).

Under conventional cultivation practices, the conversion of natural systems to cultivated agriculture results in soil organic carbon losses of about 20 to 50 percent compared with pre-cultivation stocks in the surface metre (Paustian *et al.*, 1997). Non-conventional cultivation practices allow soil quality to improve and soil organic carbon levels to increase. Such practices can be grouped into three classes: agricultural intensification, conservation agriculture and erosion reduction. Sustainable intensification practices include improved cultivars, well-managed irrigation, organic and inorganic fertilization, management of soil acidity, green manure and cover crops in rotations, integrated pest management, double cropping and crop rotation. Increased crop yields result in more carbon accumulation in crop biomass, or alteration of the harvest index.

Although technological improvement may have very significant effects, transfer of these technologies is a key requirement for these mitigations to be realized. For example, the efficiency of N use has improved over the last two decades in developed countries, but continues to decline in many developing countries due to barriers to technology transfers (International Fertilizer Industry Association, 2007).

Promoting conservation agriculture

Carbon sequestration in soils or terrestrial biomass has a maximum capacity for the ecosystem, which may be reached after 15 to 60 years, depending on management practice, management history and the system (West and Post, 2002). However, sequestration is a mitigation option which can be deployed both rapidly and cheaply, until more capital-intensive developments and longer-lasting actions become available. (Caldeira *et al.*, 2004; Sands and McCarl, 2005).

Conventional tillage involves the use of mechanical implements to break up the soil. The simplest such implement is the hand hoe. Mechanized soil tillage allows higher working depths and speeds and involves the use of such implements as tractor-drawn ploughs, disk harrows and rotary cultivators. This initially increases fertility because it mineralizes soil nutrients and makes it easier for plants to absorb them through their roots. **In the long term, however, repeated ploughing and mechanical cultivation breaks down the soil structure and leads to reduced soil organic matter and loss of soil nutrients. This structural degradation of soils results in compaction and the formation of crusts, leading to soil erosion. This process is dramatic under tropical climatic situations**, but can also be noticed all over the world. The heavy machinery used for tillage in intensive crop agriculture has particularly detrimental effects on soil structure.

The logical approach to this is to reduce tillage. Movements promoting conservation tillage, especially zero-tillage, first emerged in southern Brazil, North America, New Zealand and Australia. Over the last two decades, the technologies have been improved and adapted for nearly all farm sizes, soils, crop types and climatic zones. Experience is still being gained with this new approach to agriculture, which FAO has supported for many years.

Conservation agriculture is based on enhancing natural biological processes above and below ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum, and external inputs such as agrochemicals and nutrients of mineral or organic origin are applied at optimum levels.

Conventional practice	Recommended practice
Plough tilling	Conservation tilling or zero-tillage
Residue removal or burning	Residue return as mulch
Summer fallow	Growing cover crops
Low off-farm inputs	Judicious use of fertilizers and integrated nutrient management
Regular fertilizer use	Site-specific soil management
No water control	Water management/conservation, irrigation, water table management
Fence-to-fence utilization	Conversion of marginal lands to nature conservation
Monoculture	Improved farming systems with several crop rotations
Land use along poverty lines and political boundaries	Integrated watershed management
Draining wetlands	Restoring wetlands

Source: FAO. 2004a.

Agricultural practices for enhancing productivity and increasing the amount of carbon in soils

Under an incentive-based system such as a carbon market, the amount of money farmers receive is not the market price, but the market price less brokerage cost. This may be substantial, and is an increasing fraction as the amount of carbon involved diminishes, creating a serious entry barrier for smallholders. For example, a 50 kt contract needs 25 kha under soil carbon management (uptake ~2 tCO_2 ha/yr). In developing countries, this could involve many thousands of farmers.

FAO is also working with partners that are developing tools to measure, monitor and verify soil carbon pools and fluxes of greenhouse gas emissions from agricultural soils, including cropland, degraded land and pastures. Incentives for sequestering carbon and for reducing greenhouse gas emissions (GHG) from agricultural soils coupled with support by Governments and development partners, would encourage smallholders at subsistence level as well as larger commercial farmers and herders to adopt improved management practices and in so doing enhance their productivity while contributing to reversing degradation and desertification, conserving biodiversity and mitigating and adapting to climate change.

By 2030, the global technical mitigation potential of agriculture, excluding fossil fuel offsets from biomass is estimated to be 5.5–6 Gt CO_2 eq per year. About 89 per cent of this potential can be achieved by soil carbon (C) sequestration through cropland management, grazing land management, restoration of organic soils and degraded lands, bio-energy and water management.

APPENDIX 4: Climate change Impact by regions

Effects of climate change will vary according to the sensitivity of the resource base, types of farming, financial and human capital endowment, institutional arrangements and so on. Implications of climate for agricultural productivity and food security over broad regions of the globe have been estimated by FAO and IIASA. [Quote from Action Aid – p7] [FAO/IIASA]

The UNFCCC has summarized the main types of climate change impacts in developing countries, showing how those in "agriculture and food security" relate to other sectors (Table 2, 3, 4 and 5).

Table 2: Climate change impacts and vulnerabilities- **Small Island Developing States**

Climate Effects	Impacts and Vulnerabilities
Temperature – All Caribbean, Indian Ocean and North and South Pacific small island States will experience warming. Warming will be lower than the global average. **Precipitation** – Decrease in summer rainfall in the Caribbean in the vicinity of the Greater Antilles. – Increase in annual rainfall in the equatorial Pacific and in the northern Indian Ocean, in the Seychelles and the Maldives. – Decrease in rainfall in the vicinity of Mauritius, in the Indian Ocean, and east of French Polynesia, in the Pacific. **Extreme Events** – Increasing intensity of tropical cyclones, storm surge, coral bleaching and land inundation.	**Water** – Water sources seriously compromised due to rising sea level, changes in rainfall and increased evapotranspiration, e.g. in the Pacific, a ten percent reduction in average rainfall (by 2050) would lead to a twenty percent reduction in the size of the freshwater lens on the Tarawa Atoll, Kiribati. **Agriculture and food security** – Agricultural land and thus food security affected by sea-level rise, inundation, soil salinization, seawater intrusion into freshwater lenses, and decline in freshwater supply. – All agricultural production affected by extreme events. – Fisheries affected by increasing sea surface temperature, rising sea level and damage from tropical cyclones. **Health** – Increases in the intensity of tropical cyclones increase risks to life. – Heat stress and changing patterns in the occurrence of disease vectors and climate sensitive diseases affect health. **Terrestrial Ecosystems** – Replacement of local species and colonization by non-indigenous species. – Forests affected by extreme events are slow to regenerate. Forest cover may increase on some high latitude islands. **Coastal Zones** – Most infrastructure, settlements and facilities located on or near the shore and will be affected by sea-level rise, coastal erosion and other coastal hazards, compromising the socio-economic well-being of island communities and states. – Accelerated beach erosion, degradation of coral reefs and bleaching will all have impacts on incomes from fishing and tourism. – Habitability and thus sovereignty of some states threatened due to reduction in island size or complete inundation

(Boko et al., 2007; Christensen et al., 2007; Cruz et al., 2007; Magrin et al., 2007; Mimura et al., 2007; UNFCCC, 2008).

In Africa, by 2020, between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change. Agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020 (IPCC 2007)

Table 3: Climate change impacts and vulnerabilities - **Africa**

Climate Effects	Impacts and Vulnerabilities
Temperature – Higher warming (x1.5) throughout the continent and in all seasons compared with global average. – Drier subtropical regions may become warmer than the moister tropics. **Precipitation** – Decrease in annual rainfall in much of Mediterranean Africa and the northern Sahara, with a greater likelihood of decreasing rainfall as the Mediterranean coast is approached. – Decrease in rainfall in southern Africa in much of the winter rainfall region and western margins. – Increase in annual mean rainfall in East Africa. – Increase in rainfall in the dry Sahel may be counteracted through evaporation. **Extreme Events** – Increase in frequency and intensity of extreme events, including droughts and floods, as well as events occurring in new areas.	**Water** – Increasing water stress for many countries. – 75–220 million people face more severe water shortages by 2020. **Agriculture and food security** – Agricultural production severely compromised due to loss of land, shorter growing seasons, more uncertainty about what and when to plant. – Worsening of food insecurity and increase in the number of people at risk from hunger. – Yields from rain-fed crops could be halved by 2020 in some countries. Net revenues from crops could fall by 90% by 2100. – Already compromised fish stocks depleted further by rising water temperatures. **Health** – Alteration of spatial and temporal transmission of disease vectors, including malaria, dengue fever, meningitis, cholera, etc. **Terrestrial Ecosystems** – Drying and desertification in many areas particularly the Sahel and Southern Africa. – Deforestation and forest fires. – Degradation of grasslands. – 25–40% of animal species in national parks in sub-Saharan Africa expected to become endangered. **Coastal Zones** – Threat of inundation along coasts in eastern Africa and coastal deltas, such as the Nile delta and in many major cities due to sea level rise, coastal erosion and extreme events. – Degradation of marine ecosystems including coral reefs off the East African coast. – Cost of adaptation to sea level rise could amount to at least 5–10% GDP.

(Boko et al., 2007; Christensen et al., 2007; Cruz et al., 2007; Magrin et al., 2007; Mimura et al., 2007; UNFCCC, 2008).

In the Sahel region of Africa, warmer and drier conditions have led to a reduced length of growing season with detrimental effects on crops. In southern Africa, longer dry seasons and more uncertain rainfall are prompting adaptation measures.

At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1–2°C), which would increase the risk of hunger. Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes.

Asia: Glacier melt in the Himalayas is projected to increase flooding, and rock avalanches from destabilised slopes, and to affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede. Freshwater availability in Central, South, East and Southeast Asia is projected to decrease due to climate change which could adversely affect more than a billion people by the 2050s. It is projected that crop yields could increase up to 20% in East and Southeast Asia while they could decrease up to 30% in Central and South Asia by the mid-21st century.

Table 4: Climate change impacts and vulnerabilities- **Asia**

Climate Effects	Impacts and Vulnerabilities
Temperature – Warming above the global mean in central Asia, the Tibetan Plateau, northern, eastern and southern Asia. Warming similar to the global mean in Southeast Asia. – Fewer very cold days in East Asia and South Asia. **Precipitation, snow and ice** – Increase in precipitation in most of Asia. Decrease in precipitation in central Asia in Summer. – Increase in the frequency of intense precipitation events in parts of South Asia, and in East Asia. – Increasing reduction in snow and ice in Himalayan and Tibetan Plateau glaciers **Extreme Events** Increasing frequency and intensity of extreme events particularly: – droughts during the summer months and El Niño events; – increase in extreme rainfall and winds associated with tropical cyclones in East Asia, Southeast Asia and South Asia; – intense rainfall events causing landslides and severe floods; and – heat waves/hot spells in summer of longer duration, more intense and more frequent, particularly in East Asia	**Water** – Increasing water stress to over a hundred million people due to decrease of freshwater availability in Central, South, East and Southeast Asia, particularly in large river basins such as Changjiang. – Increase in the number and severity of glacial melt-related floods, slope destabilization followed by decrease in river flows as glaciers disappear. **Agriculture and food security** – Decreases in crop yield for many parts of Asia putting many millions of people at risk from hunger. – Reduced soil moisture and evapotranspiration may increase land degradation and desertification. – Agriculture may expand in productivity in northern areas. **Health** – Heat stress and changing patterns in the occurrence of disease vectors affecting health. – Increases in endemic morbidity and mortality due to diarrhoeal disease in south and Southeast Asia. – Increase in the abundance and/or toxicity of cholera in south Asia. **Terrestrial Ecosystems** – Increased risk of extinction for many species due to the synergistic effects of climate change and habitat fragmentation. – Northward shift in the extent of boreal forest in north Asia, although likely increase in frequency and extent of forest fires could limit forest expansion. **Coastal Zones** – Tens of millions of people in low-lying coastal areas of south and Southeast Asia affected by sea level rise and an increase in the intensity of tropical cyclones. – Coastal inundation is likely to seriously affect the aquaculture industry and infrastructure particularly in heavily-populated megadeltas. – Stability of wetlands, mangroves, and coral reefs increasingly threatened.

(Boko et al., 2007; Christensen et al., 2007; Cruz et al., 2007; Magrin et al., 2007; Mimura et al., 2007; UNFCCC, 2008).

Table 5: Climate change impacts and vulnerabilities- **Latin America**

America Climate Effects	Impacts and Vulnerabilities
Temperature – Warming above the global mean is predicted in most of Latin America. – In southern South America warming similar to global mean. **Precipitation, snow and ice** – Decrease in annual precipitation in most of Central America and in the southern Andes, although large local variability in mountainous areas. – Increase in winter precipitation in Tierra del Fuego. – Increase in summer precipitation in south-eastern South America. – Uncertain rainfall changes over northern South America, including the Amazon forest. – Increasing reduction and disappearance of Andean glaciers. **Extreme events** Increasing frequency and intensity of extreme events, many related to ENSO, particularly: – intense rainfall events causing landslides and severe floods; – dry spells and drought, such as in northeast Brazil; – heat waves, with particularly major effects in megacities due to heat island effects; – Increase in intensity of tropical cyclones in the Caribbean basin.	**Water** – Increase in the number of people experiencing water stress – likely to be 7–77 million by the 2020s. – Runoff and water supply in many areas compromised due to loss and retreat of glaciers. – Reduction in water quality in some areas due to an increase in floods and droughts. **Agriculture and food security** – Reductions of crop yields in some areas, although other areas may see increases in yields. – By the 2050s, 50% of agricultural lands are very likely to be subjected to desertification and salinization in some areas. – Food security a problem in dry areas where agricultural land subject to salinization and erosion reducing crop yields and livestock productivity. **Health** – Risks to life due to increases in the intensity of tropical cyclones. – Heat stress and changing patterns in the occurrence of disease vectors risk to health. **Terrestrial Ecosystems** – Significant habitat loss and species extinctions in many areas of tropical Latin America, including tropical forests, due to higher temperatures and loss of groundwater with effects on indigenous communities. **Coastal Zones** – Impacts on low lying areas, such as the La Plata estuary, coastal cities and coastal morphology, coral reefs and mangroves, location of fish stocks, availability of drinking water and tourism due to sea level rise and extreme events.

(Boko et al., 2007; Christensen et al., 2007; Cruz et al., 2007; Magrin et al., 2007; Mimura et al., 2007; UNFCCC, 2008).