CLIMATE CHANGE AND FOOD SECURITY: A FRAMEWORK DOCUMENT

Summary

INTERDEPARTMENTAL WORKING GROUP ON CLIMATE CHANGE

“Humanity must learn to live with climate change. But we cannot allow climate change to become one more aggravating factor for hunger in the world, one more dividing factor between the rich countries and the poor countries. It is our duty to help the poorer countries and, in those countries, the more vulnerable populations at risk, to deal with this new challenge.”

“FAO is encouraging an approach of adaptation of rural communities, with farmer training, access to credit, investment in the rural economy and support to institutions. If they are carefully planned and formulated, all these strategies could reduce the risk of food insecurity and have a positive impact on the environment.”

Jacques Diouf, Director-General, FAO.

Food and Agriculture Organization of the United Nations

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Summary

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Inside Front Cover – Quote from the statement of Jacques Diouf, Director-General, FAO, on the occasion of the *Conference on Climate Change, Food Security and Poverty Reduction* organized by the Swedish International development Agency, Stockholm, 27-28 September 2007

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DEFINING TERMS

Food Security and Food Systems

Food security 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. To achieve food security, all four of its components must be adequate. These are: availability, stability, accessibility and utilization.

A food system is a set of dynamic interactions between and within bio-geophysical and human environments that influences both activities and outcomes all along the *food chain* (production, storage and processing, distribution, exchange, preparation and consumption).

Food security is the outcome of food system performance at global, national and local levels. It is often directly or indirectly dependent on *agricultural and forest ecosystem services*, e.g., soil and water conservation, watershed management, combating land degradation, protection of coastal areas and mangroves, and biodiversity conservation.

Climate and the Climate System

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location, whereas weather refers to the daily fluctuations in these conditions at the same location. Although climate *per se* relates only to the varying states of the earth's atmosphere, the other parts of the earth system also have a significant role in forming climatic conditions. Earth System dynamics that produce weather are referred to as the *climate system*. The five parts of the earth system are:

- atmosphere (gaseous matter above the earth's surface),
- hydrosphere (liquid water on or below the earth's surface),
- cryosphere (snow and ice on or below the earth's surface),
- lithosphere (land surface of the earth, e.g. rock, soil and sediment)
- biosphere (earth's plants and animal life, including humans).

EFFECTS OF CLIMATE CHANGE THAT ARE IMPORTANT FOR FOOD SECURITY

CO2 FERTILIZATION EFFECTS

- Increase in availability of atmospheric carbon dioxide for plant growth

INCREASE IN GLOBAL MEAN TEMPERATURES

- Increase in maximum temperature on hot days
- Increase in minimum temperature on cold days
- Increase in annual occurrence of hot days
- Increase in frequency, duration and intensity of heat waves

GRADUAL CHANGES IN PRECIPITATION

- Increase in frequency, duration and intensity of dry spells and droughts
- Changes in timing, location and amounts of rain and snowfall

INCREASE IN FREQUENCY AND INTENSITY OF EXTREME WEATHER EVENTS

- Increase in annual occurrence of high winds, heavy rains, storm surges and flash floods, often associated with tropical storms and tornados

GREATER WEATHER VARIABILITY

- Greater instability in seasonal weather patterns
- Change in start and end of growing seasons

RISE IN SEA LEVEL

- Inundation of human habitats
- Saltwater intrusions

Global Warming and Climate Change

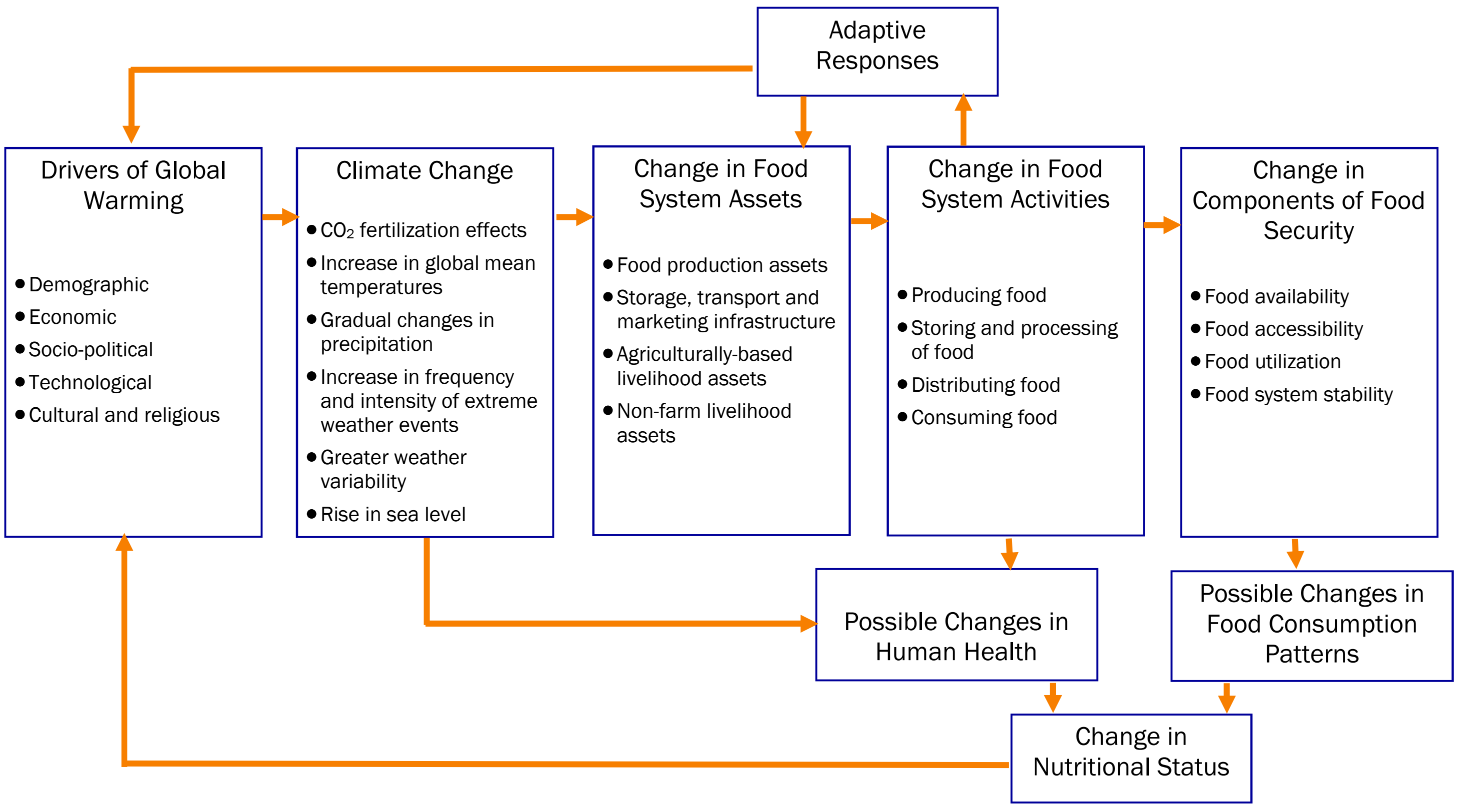
Climate change is a natural process that takes place simultaneously on various timescales – astronomical, geological, and decadal. It refers to the variation over time in the earth's global climate or in regional climates, and it can be caused by both natural forces and human activities. According to the IPCC most of the observed increase in globally-averaged temperatures since the mid-20th century, the phenomenon known as *global warming*, is very likely caused by human activity, principally the burning of fossil fuels and deforestation, which have increased the amount of greenhouse gases in the atmosphere. The warming is in turn producing dramatic changes in climatic conditions such as those shown in the box.

Impacts of Climate Change on Food Security

Significant changes in climatic conditions will affect food security through their impacts on all components of global, national and local food systems. *More frequent and more intense extreme weather events and droughts, rising sea levels, and increasing irregularities in rainy season patterns* are already having immediate impacts on food production, food distribution infrastructure, incidence of food emergencies, livelihood assets and opportunities and human health, in both rural and urban areas. Impacts of *gradual changes in mean temperatures and rainfall* are likely to be disruptive, whether positive and negative, and may include:

- changes in the suitability of land for different types of crops and pasture,
- changes in the health and productivity of forests,
- changes in the distribution, productivity and community composition of marine resources,
- changes in the incidence and vectors of different types of pests and diseases,
- loss of biodiversity and ecosystem functioning of natural habitats,
- changes in the distribution of good quality water for crop, livestock and inland fish production,
- loss of arable land due to increased aridity and associated salinity, groundwater depletion and the rise in sea level,
- changes in livelihood opportunities,
- changes in health risks, and
- internal and international migration.

Climate Change and Food Security



CLIMATE CHANGE AND VULNERABILITY

Climate Change, Agricultural Production and Food Systems

Agriculture, forestry, and fisheries are all sensitive to climate. Therefore their production processes – whether for food, feed, fibre, beverage, energy or industrial crops, or for livestock, poultry, fish or forest products – will be impacted by climate change. In general, impacts in temperate regions are expected to be positive, and those in tropical regions negative, although there is still considerable uncertainty about how projected changes will play out locally, and projected impacts could also be altered by adoption of risk management measures and adaptation strategies that strengthen preparedness and resilience.

Changes in agricultural production patterns will affect food security in two ways:

- *Impacts on the production of food will affect food supply at both global and local levels.* Globally, higher yields in temperate regions could offset lower yields in tropical regions. However, in many low-income countries that have limited financial capacity to trade, and that rely heavily on their own production to cover their food requirements, it may not be possible to offset declines in local supply without increased reliance on food aid.
- *Impacts on all forms of agricultural production will affect livelihoods and ability to access food*. Producer groups less able to deal with climate change, such as the rural poor in developing countries, risk having their safety and welfare compromised.

Besides food and agricultural production, *other food system processes e.g., processing, distribution, acquisition, preparation and consumption are equally important for food security*. Overall, food system performance is much less dependent on climate today than it was two hundred years ago. Now, however, there is an increased risk of storm damage to transport and distribution infrastructure, with consequent disruption of food supply chains. Climate change is likely to make access to food more difficult for many currently vulnerable people and other low-income consumers, whether because of reduced own production, loss of employment opportunities as farm and non-farm production patterns shift, or lower purchasing power due to rising market prices for food. Additionally, the rising cost of energy and the need to reduce consumption of fossil fuels have given rise to a new calculus – that of “food miles” – which should be kept as low as possible in order to reduce emissions. The combination of all of these factors could result in a reversion to more local responsibility for food security in the future.

Who is Vulnerable Now?

Agriculturally-based livelihood systems that are already vulnerable to climate change risk increased crop failure, loss of livestock and fish stocks, increasing water scarcities and destruction of productive assets. They include small-scale rainfed farming systems, pastoralist systems, inland and coastal fishing/ aquaculture communities, and forest-based systems. Rural people inhabiting coasts, floodplains and low-lying river deltas, mountains, drylands and the arctic are most at risk. Moreover, the urban poor, particularly in coastal cities and floodplain settlements, also face increasing risks. Amongst those at risk, pre-existing socio-economic discriminations are likely to be aggravated, causing a deterioration in nutritional status for women, young children, and elderly, ill and disabled people.

Those who are currently vulnerable warrant special attention, but we are all at risk.

Market Uncertainties

Economic growth

All IPCC emissions scenarios assume that, for the world as a whole, economies will continue to grow, albeit at different rates and sometimes with significant regional differences, depending on the scenario. However, it is also possible that the impact of climate change will actually curtail economic growth. If global financial markets are not able to keep pace with continued high rates of loss from extreme weather events, and large numbers of individual households in developed and emerging developing countries experience uncompensated declines in the value of their personal assets and income-generating capacity, global economic recession and a deterioration in the food security situation at all levels is also a possibility.

Food prices

Current projections to 2030 suggest that globally the share of food in average household expenditure will continue to decline. However, recent trends, at least for some commodities, appear to be showing the reverse, with food prices increasing faster than incomes. Growing scarcities of water, land and fuel are likely to put increasing pressure on food prices, even without climate change. Additional pressures on these resources due to climate change, the introduction of mitigation practices that have the potential to create land use competition, and the attribution of market value to environmental services to mitigate climate change, also have the potential to cause significant changes in relative prices for different food items, and an overall increase in the cost of an average food basket for the consumer.

Food supply and food demand

Continued economic growth implies a continued increase in demand for animal protein as average incomes in developing countries rise, and with it, an increase in demand for water and, to a lesser extent, land for livestock production. Assuring an adequate and stable supply of protein will require expansion of intensive agriculture where it is commercially feasible, more efficient agricultural water management, improved management of cultivated land, improved livestock management and use of new, more energy-efficient technologies by agro-industries. Faced with rising prices and increased awareness of the environmental consequences of their food choices, consumers may modify their spending and eating habits, though is it not possible to say at this stage what the precise nature of such changes might be.

Who will be Vulnerable in the Future?

Over time, the geographic distribution of risk and vulnerability is likely to shift. Low-income city dwellers in both developed and developing countries already face risks from the impact of extreme weather events and variable food prices. Those who lack adequate insurance coverage or safety net protection are likely to become more vulnerable with time. Some agriculturally-based livelihoods may benefit from the effects of climate change, while others will be undermined. Also, the livelihood status of agricultural workers will change as centres of agricultural production shift and all wage earners face new health risks that could cause declines in their productivity and earning power. Finally, climate change will impact people differently, based on factors such as land ownership, gender, age and health status.

ADAPTATION - MANAGING RISK

What is Climate Change Risk?

Risk exists when there is uncertainty about future outcomes from presently ongoing processes or the occurrence of future events. The more certain we are of an outcome the less risk there is, because certainty allows us to make informed choices and prepare for dealing with climate change impacts.

Climate change is creating increased uncertainty about future temperature and precipitation regimes which makes investments in agriculture and other weather-dependent livelihoods inherently more risky. The risk absorption capacity of poor people is such that they are unlikely to be able to cope with the added risk imposed by climate change. At the same time, there is increasing certainty that extreme weather events are going to increase in frequency and intensity, and the vulnerable locations are known. Because of this, there is growing certainty that asset losses attributable to weather-related disasters will increase. Whether these losses involve productive assets, personal possessions or even loss of life, the livelihoods and food security status of millions of people in disaster-prone areas will be adversely affected.

Risk Management Objectives and Challenges

The objective of managing climate change risk is to reduce risk exposure and reduce negative outcomes. The process entails first risk mapping, which includes the identification of areas, populations and livelihoods at risk, followed by an analysis of the kinds of risks involved and an estimation of the levels of risk exposure of the different areas, groups and livelihoods in terms of size and degree of risk and their risk absorption capacity. From there the process should flag eventual catastrophic outcomes which need to be avoided at all cost and highlight risks that may be avoided or that can be taken on, giving explicit attention to the gender dimension. Typical components of national risk management policies and programmes include:

- infrastructure investments to protect against asset loss,
- minimum recommended density of weather stations world wide and enhanced use of weather and climate information for climate and adaptation modelling,
- climate information and advisory services for agricultural communities,
- reliable and timely early warning systems,
- rapid emergency response capacity, and
- innovative risk financing instruments and insurance schemes to spread residual risks.

An average of 500 weather-related disasters are now taking place each year, compared to 120 in the 1980s, and the number of floods has increased six-fold over the same period. Moreover, population increase, especially in coastal areas where the majority of the world's population now lives, mean that more and more people will be affected when catastrophic weather events take place. The global aid community has developed an immediate response capacity that can limit loss of life, but there is a growing risk that its ability to assist affected to people to replace lost assets and recover livelihoods following climate-related natural disasters will be overwhelmed. Thus investments that will limit these losses should be given highest priority.

Adaptation is about reducing the risks posed by climate change to people's lives and livelihoods.

Promoting Adaptive Management by the Poor

No risk management policy or programme will work unless those at risk feel that it is addressing their needs. Therefore adequate provision must be made for participation of the most vulnerable in deciding on what actions to take to strengthen their own resilience. Participatory approaches to assess vulnerability and needs should involve representatives of all community members in a dynamic process of reflection, planning and action that is livelihoods-based and gender-sensitive, and that draws on local knowledge and priorities.

Strengthening Resilience for Vulnerable People

Actions that strengthen resilience involve adoption of practices that enable vulnerable people to protect existing livelihood systems, diversify their sources of income, change their livelihood strategies, or migrate if this is the best option.

Actions that strengthen resilience for agriculturally-based livelihood systems include:

- *Research and dissemination of crop varieties and breeds adapted to changing climatic conditions:* Use of a variety of indigenous and locally adapted plants and animals as well as the selection and multiplication of crop varieties and autochthonous races adapted or resistant to adverse conditions can enable many existing farming systems to adapt successfully. Breeding plants and animals for tolerance to drought, heat stress, salinity and flooding will also become increasingly important.
- *Effective use of genetic resources:* Genetically diverse populations and species-rich ecosystems have greater potential to adapt to climate change, so effective use of genetic resources can reduce negative effects of climate change on agricultural production and farmer livelihoods. As women in many traditional cultures are the carriers of local knowledge about the properties and uses of wild plants and the keepers of seeds for cultivated varieties, they have an important role to play in protecting biodiversity. Providing appropriate compensation for this service could guarantee a sustainable livelihood to these women, many of whom belong to vulnerable and food insecure groups.
- *Promotion of agro-forestry, integrated farming systems and adapted forest management practices:* Introduction of tree crops can provide food, fodder and energy and enhance cash income, as well as contributing to soil moisture retention and improving land quality. Adjusting forest management can help maintain forest productivity and ecosystem services needed to support local livelihoods in the face of climate change.
- *Improved infrastructure for small-scale water capture, storage and use:* Accessibility to water resources will be a key to future sustainability of many existing livelihood systems, especially those of small-scale farming households.
- *Improved soil management practices:* Improved water infiltration and water retention capacity of soils, maintenance of high levels of soil organic matter and greater water-use efficiency on cultivated lands can increase resilience to both drought and flood by conserving water and reducing risk of soil erosion.
- *Adaptation of farming systems and livelihood strategies to rapidly changing agro-ecological conditions.* Climate change will alter the geographical pattern of comparative advantages for the production of agricultural and environmental goods and services. Technology transfer and innovation should thus be fostered to ease farming system transitions.

ADAPTATION - RESPONDING TO LOCAL NEEDS

Climate and Ecosystem Interactions

To protect local food supplies, assets and livelihoods from the effects of increasing weather variability and increased frequency and intensity of extreme events, adaptation measures will need to respond to a variety of risks, many of which are specific to particular ecosystems. In addition to risk management, climate change also requires adaptive management that focuses on modifying behaviours over the medium-to-long term to cope with gradual changes in precipitation and temperature regimes. The Millennium Ecosystem Assessment report evaluated potential climate change impacts for ten ecosystems. Examples of adaptation responses for each of these ecosystems are shown below.

URBAN ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME Heat and cold waves High winds Storm surges Floods GRADUAL Sea level rise	• Elderly persons (especially women) and others susceptible to temperature extremes • Low-to-medium-income groups (eg. female headed households) who may lose homes, stored food, personal possessions and means of obtaining their livelihood	• Emergency shelters • Adaptive gender sensitive infrastructure investments • Innovative insurance instruments
MARINE ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME More anomalies, both in failures and bonanzas, among multiple species Drastic shift in the areas where small, migrating fish are found GRADUAL Changes in ocean currents Rise in average sea temperature Sharpening of various gradient structures Increased discharge of fresh water into oceans RATCHET-LIKE Eutrophication (increase in chemical nutrients and loss of oxygen in ocean waters) Severe reductions in water quality and in fish and other animal populations)	• Fishers/aquafarmers who suffer diminishing catches from shifts in fish distribution and productivity of aquatic ecosystems	• Shift from dynamic to static fishing technologies that are less wasteful of remaining fish stocks • Occupational training to facilitate search for new livelihood opportunities for both men and women
COASTAL ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME Heavy rains High winds Storm surges Floods GRADUAL Saltwater intrusions Sea level rise	• Fishing communities that depend heavily on coral reefs for protection from natural disasters and food; • Fishers whose infrastructure essential for fishing activities, e.g. port and landing facilities, storage facilities, fish ponds and processing areas, become submerged or damaged • Farmers whose land becomes submerged or damaged by the rise in sea level or saltwater intrusions;	• Coastal defences: ◊ hard – groynes, revetements, embankments ◊ soft – mangroves, coral reefs, wetland conservation • Emergency shelters on high ground, with stocks of food, water and medicine • Relocation of settlements, roads and other infrastructure • Integrated coastal zone management • Desalination plants • Weather-related insurance • Relocation where a rise of sea level is inevitable

Active adaptive management can be a particularly valuable tool for developing strategies that respond to the unique risk exposures of different ecosystems.

INLAND WATER AND FLOODPLAIN ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME High winds Heavy rains Flood GRADUAL Changing water levels	• Low-income groups (such as poor women and men) in drought-and flood-prone areas with poor food distribution infrastructure and limited access to emergency response	• Changes to dam and infrastructure specifications • Storm and flood resilient building codes • Improved river defences • Watershed management, [including no-till farming systems] • Restricting development in high risk (flood, mudslides) zones • Weather-related insurance
FOREST ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME Heavy rains High winds Flood Drought Wildfires GRADUAL Sea level rise Forest dieback Pests and disease	• Low-income forest dependent people • People (eg. vulnerable female headed households) indirectly dependent on forest ecosystem services	• Promotion of (gender sensitive) small-scale forest-based enterprises for local income diversification • Integrated watershed management approaches • Forest conservation • Integrated forest fire management systems • Integrated forest pest management systems • Adjusted silvicultural practices
DRYLAND ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME Drought Flood GRADUAL Changes in rainfall patterns	• Low-income groups in drought-and flood-prone areas with poor food distribution infrastructure and limited access to emergency response • Producers of crops that may not be sustainable under changing temperature and rainfall regimes • Poor livestock keepers where changes in rainfall patterns will affect forage availability and quality	• Improved crop, grassland and livestock management, • Promotion of cropping systems increasing soil organic matter and water infiltration capacity (no-tillage systems). • Research and dissemination of crop varieties and breeds adapted to changing climatic conditions • Introduction of integrated agro-forestry systems • Community grain storage for food distribution • Weather-related insurance
ISLAND ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
Same as coastal ecosystem	Same as coastal ecosystem	Same as coastal ecosystem
MOUNTAIN ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME Flood Landslide	• People indirectly dependent on mountain ecosystem services • Producers of crops that may not be sustainable under changing temperature and rainfall regimes	• Integrated watershed management approaches • Adjusted silvicultural practices • Research and dissemination of crop varieties and breeds adapted to changing climatic conditions
POLAR ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
Not specified	Not specified	Not specified
CULTIVATED ECOSYSTEM		
Nature of risk	**Livelihood groups at risk**	**Adaptation responses**
EXTREME High winds Floods Drought GRADUAL Changing temperature and rainfall regimes	• Producers of tree crops that are susceptible to wind damage • Producers of crops that may not be sustainable under changing temperature and rainfall regimes	• Introduction of cropping systems which do not move and expose soil • Introduction of integrated agro-forestry systems • Research and dissemination of crop varieties and breeds adapted to changing climatic conditions

ADAPTATION - SECURING FOOD SUPPLIES

Intensifying Agricultural Production

To meet the demand for food of a global population that is projected to increase by 2.5 billion by 2050 it will be essential to further intensify production, obtaining more yields per unit of input – whether this be time, land, water, nutrient, plant or animal. Improved land management practices that contribute to soil moisture retention and maintain the amount of nutrients in the soil at appropriate levels can strengthen resilience as well as enhance productivity. Also, maintaining and enhancing plant and animal genetic resources, and managing livestock operations and fisheries more efficiently will be crucial. Above all, however, with a more variable climate and less reliable weather patterns it will be essential to increase the capacity to store water for agricultural use and reduce inefficiencies in its application.

WATER IS KEY

Raised productivity from improved agricultural water management will be key to ensure global food supply and global food security. Increasing water scarcity and more intense rainfall events will characterize changes in the overall pattern of water availability as a result of climate change. These changes pose the main threat to stable agricultural production, particularly for the continuous irrigated areas of the world. A secondary threat is loss of productive land due to increased aridity (and associated salinity), groundwater depletion, and sea-level rise.

Looking ahead to 2030, irrigated areas will come under increasing pressure to raise productivity with respect to water, both to buffer the more volatile rainfed production and also to respond to declining water availability. Managing this production risk in the face of increasing aridity and more variable rainfall events will require both rainfed and irrigated agricultural systems to become much more responsive and flexible in approach.

In the short term, progressive adjustment of the operation of large-scale irrigation and drainage systems will be essential to ensure higher cropping intensities and start closing gaps between actual and potential yields. Key adjustments for maintaining cropped areas in large irrigation schemes include:

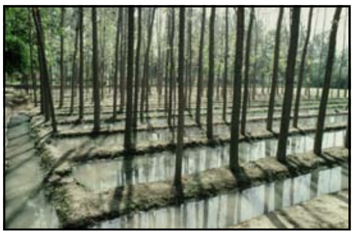
- optimising operational storage and distribution through provision of on-demand water services,
- protecting equipped areas from flood damage and maintaining drainage outlets,
- introducing more water efficient crop management practices, and
- adjusting institutional capacities to ensure scheme performance.

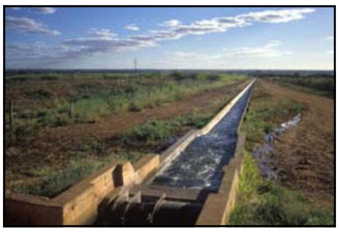
Negotiating allocations and releases of water to agriculture across river basins among competing sectors will be an essential pre-requisite for improved operational performance and productivity gains.

Well targeted investments in small scale water control facilities and the upgrading of larger scale facilities, together with associated institutional reforms, will pay off in the medium term. Other strategies that can be used to increase water productivity directly or that have indirect water-saving benefits include:

- reducing soil evaporation through adoption of conservation agriculture practices,
- planting more water-efficient and/or drought tolerant crop varieties,
- enhancing soil fertility to increase yields per unit of water utilized,
- decreasing runoff from cultivated land,
- reducing crop water requirements through micro-climatic changes, and
- reusing wastewater for agricultural purposes.

Finally, in the longer term, a transition toward more precision irrigated agriculture in water stressed areas needs to be anticipated where commercial agricultural is feasible.





Safeguarding food security also means avoiding disruptions or declines in global and local food supplies due to changes in temperature and precipitation regimes .

Increasing Efficiency in the Livestock Sector

Intensive livestock production is shifting geographically, first from rural areas to urban and peri-urban, to get closer to consumers, then towards the sources of feedstuff, whether these are feedcrop areas, or transport and trade hubs where feed is imported. There is also a general shift towards production of pigs and poultry, mostly reared in industrial units, while the growth of cattle, sheep and goats, often raised extensively, is slowing.

Increasing intensification and industrialization is generally improving efficiency and reducing the land area required for livestock production, but also marginalizing smallholders and pastoralists, increasing water and fossil fuel inputs and increasing and concentrating the pollution of soil and water. Despite an overall intensification trend extensive grazing still occupies vast areas of grassland where degrading issues are often reported. In many grazing systems, improved grazing management practices such as optimizing stock numbers and rotational grazing will improve efficiency and result in substantial increases in carbon pools. Improved pasture management and integrated agro-forestry systems that combine crops, grazing lands and trees in ecologically sustainable ways are also effective ways to conserve the environment and mitigate climate change, while providing more diversified and secure livelihoods for inhabitants.

The sector is an important emitter of greenhouse gases, but has the potential to reduce emissions substantially through improved management practices. Rumination and manure are important sources of methane. Providing a more balanced diet that is not too high in roughage can simultaneously improve productivity and reduce emissions of methane from ruminant species. Management of manure so as to avoid build-up and release of methane is also important: various techniques, including biodigestion, that are efficient and economically feasible exist that could be more widely applied. Improving feed conversion ratios in order to limit expansion of area used for feed crops also bears substantial mitigation potential.

Land use by the livestock sector, including grazing land and cropland dedicated to the production of feed, represents approximately 70 percent of all agricultural land in the world. Current prices of land, water and feed do not reflect true scarcities, leading to overuse of resources, high rates of deforestation, and major inefficiencies. Full-cost pricing of inputs and widespread adoption of improved land and water management practices by both intensive and extensive livestock producers would help to resolve the balance between competing demands for animal food products and environmental services in more sustainable ways.

GLOBAL IMPORTANCE OF THE LIVESTOCK SECTOR

The livestock sector plays a significant and dynamic role in driving global environmental change but its potential contribution to the solution of environmental problems is equally large. Globally, the sector accounts for 40 percent of agricultural gross domestic product. It employs 1.3 billion people and creates livelihoods for one billion of the world's poor. Livestock products provide one-third of humanity's protein intake, and are both a contributing cause of obesity and a potential remedy for undernourishment. Growing populations and incomes, along with changing food preferences, are rapidly increasing demand for livestock products, while globalization is boosting trade in livestock inputs and products. Global production of meat and milk is projected to more than double from 1999/01 to 2050. Thus the environmental impact per unit of livestock production must be cut by half, just to avoid increasing the level of damage beyond its present level.

ADAPTATION - ADJUSTING CONSUMPTION AND PROTECTING HEALTH

Wheat, Maize and Rice

International wheat prices increased sharply in 2007 in response to tightening world supplies, historically low levels of stocks and sustained demand. The combination of higher world market prices and soaring freight rates pushed up domestic prices of bread, flour and wheat-based food products in importing countries, hitting the group of Low-Income Food-Deficit countries (LIFDCs) particularly hard and causing social unrest in some areas. Maize prices were also well above previous levels despite bumper harvests, mainly reflecting continued strong demand from the biofuel industry.

Current projections suggest that, following past trends, global demand for rice will decline relative to wheat as incomes grow and purchasing power increases. However, if there are significant, long-term shifts in the relative prices of these two important staples, it could be that demand for rice will grow more rapidly than the projections currently foresee.

Rice is a highly adaptable staple, with many properties that have not yet been exploited in large-scale rice production systems. It is tolerant to desert, hot, humid, flooded, dry and cool conditions, and grows in saline, alkaline and acidic soils. Yet, at present, of 23 species, only two are cultivated. Science provides the basis for improving the productivity and efficiency of rice-based systems. Improved technologies enable farmers to grow more rice on limited land with less water, labour and pesticides, thus reducing damage to the environment. In addition, improved plant breeding, weed and pest control, water management, and nutrient-use efficiency increase productivity, reduce the cost, and improve the quality of the products of rice-based production systems.

New rice varieties are under development that:

- exhibit enhanced nutritional value,
- produce high yields in dryland conditions,
- minimize post harvest losses,
- require less water,
- have increased resistance to drought,
- have increased resistance to pests,
- have increased flood tolerance, and
- have increased salinity tolerance.

Rice is currently the staple food for more than half of the world population. In Asia alone, more than 2 000 million people obtain 60 to 70 percent of their calories from rice and its products. It is the most rapidly growing source of food in Africa, and is of significant importance to food security in an increasing number of low-income food-deficit countries. Moreover, rice-based production systems and their associated post-harvest operations employ nearly 1 000 million people in rural areas of developing countries. About 80 percent of the world's rice is grown by small-scale farmers in low-income and developing countries. It follows that efficient and productive rice-based production systems are essential for economic development and for improved quality of life of much of the world's population. Rice systems especially in south and east Asia, are coming under increasing pressure because of their high demand for water and role as a source of methane emissions. Therefore new crop management systems that increase rice yield, and reduce production costs, by enhancing the efficiency of input application, increasing water use efficiency, and reducing green house gas emissions are required.

Market forces and voluntary choices will influence individual decisions both about what food to eat and how to maintain good health in the face of climate change.

Changing Food Consumption Patterns and Maintaining Dietary Quality

Changing food consumption patterns	Maintaining dietary qualify
• Shift in staple food preferences; • Reduce livestock product consumption especially red meat in OECD countries; • Shift toward greater proportion of locally produced foods in the diet; • Increase in consumption of new food items; • Reduction in consumption of wild foods; • Reduction in quantities and/or variety of food consumed.	• Protecting biodiversity and exploiting wild foods; • Urban and school gardens; • Promoting greater use of dry cooking methods to conserve water; • Promoting energy efficient and hygienic food preparation practices; • Teaching good eating habits to reduce malnutrition and diet-related diseases.

Responding to New Health Risks

Increased incidence of water-borne diseases in flood-prone areas, change in disease vectors and habitats for existing diseases, and emergence of new diseases will pose new risks for food security, food safety and human health. Vector changes are a virtual certainty for pests and diseases that flourish only at specific temperatures and under specific humidity and water irrigation management regimes. This will expose crops, livestock, fish and humans to new risks to which they have not yet adapted. It will also place new pressures on caregivers within the home, who are often women, as well as challenging healthcare institutions to respond to new parameters. Where such vector changes can be predicted, varieties and breeds that are resistant to the likely new arrivals can be introduced as an adaptive measure. A recent upsurge in the appearance of new viruses may also be climate-related, although this link is not certain. Viruses such as avian flu, ebola, HIV-AIDS and SARS have various implications for food security, including risk to the livelihoods of small-scale poultry operations in the case of avian flu and the extra nutritional requirements of affected persons in the case of HIV-AIDS.

More specifically, climate change is expected to:

- increase mortality from exposure to high or low temperatures,
- increase risk of diarrhoea,
- increase risk of cholera,
- change the pattern of malaria risk,
- affect the incidence of malnutrition,
- increase the number of killed or injured in coastal floods,
- destroy health infrastructure in natural disasters.




ADAPTATION - CREATING AN ECO-FRIENDLY ENERGY ECONOMY

Bioenergy and Climate Change

Three main factors have been driving recent and projected growth in demand for bioenergy:

- rising energy prices, in particular oil,
- a desire in many oil-importing countries to reduce dependency on a few oil and gas exporting countries, thereby increasing energy security, and
- commitments to reduce greenhouse gas emissions to combat climate change.

Across the board estimates of potential greenhouse gas balances and net emission reductions from various sources of bioenergy are currently under extensive research and debate. Assessing carbon emission reductions from crop-based biofuels considers the full life-cycle of the crop, including production activities (choice of feedstock, agricultural practices, land use changes), refining and conversion processes and end-use practices. The analysis is complex because of wide variation in the use of by-products, agricultural practices in growing the feedstocks, and efficiencies in refining, conversion and distribution. Potentials for net emissions reduction must therefore be seen as indicative.

The potential for reducing greenhouse gas emissions from first generation, crop-based liquid biofuels varies widely by region and technology. Of commercial biofuels currently in use, Brazilian sugar-based ethanol produces the largest savings – estimated to be up to 90 percent of emissions compared to fossil fuels. In general, use of biofuels for electricity and heat can generate greater savings than if used to substitute for transport fuels. At present, however, most liquid biofuels are not commercially viable without subsidies, mandates and/or tariff protection. If subsidised production of biofuel from field crops becomes an important factor in global agricultural markets, this will create additional competition for land and water, put upward pressure on food prices, and increase vulnerability and food insecurity for the poor. Biogas from livestock wastes is another source of bioenergy that also has potential to reduce methane emissions. Both small scale units for household consumption and large scale plants producing electricity for the public grid have demonstrated financial profitability.

Developing Second Generation Biofuels

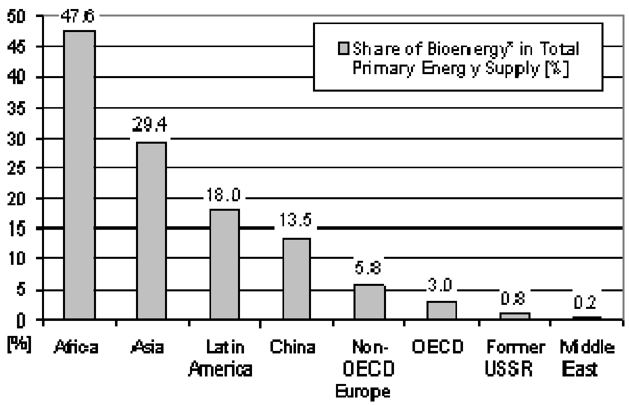
Biomass from woody matter and crop residues is increasingly being used to produce cellulosic ethanol. This is expected to produce significant savings in emissions – possibly of up to 80 percent. Second generation biofuels are expected to be more efficient and create less competition for scarce land and water resources, although competition with grass-based livestock systems may occur locally.

Increasing Wood Fuel Production in Planted Forests

In 2005, planted forests accounted for only seven percent of global forest cover, but over half of global industrial roundwood production. There is significant potential for further expansion of planted forests for bioenergy use on marginal lands or lands released from crop or livestock production. Conversion of native forests and ecosystems of high social and ecological value (including peat swamp forests, which have particularly high carbon contents) to planted forests should be avoided.

Meeting the growing demand for energy is a prerequisite for continued growth and development..
Bioenergy is likely to play an increasingly important role, but its use should not undermine food security.

Share of bioenergy in total primary energy supply in different world regions in 2004



The graph illustrates the importance of traditional uses of bioenergy in developing countries, where fuelwood and charcoal are still widely used for cooking and heating, and demand for fossil fuels for electricity, heat and transport is still relatively low. While the reverse is currently the case in developed countries, this situation is likely to change rapidly with the increased popularity of biofuels.

Improving Energy Security and Food Security Simultaneously at Household Level

Less publicised, but equally important, is the *energy demand of both rural and urban poor.* In many parts of the developing world the poorest people use manure, twigs and low grade biomass for cooking and heating and nothing but human force in their productive activities. As they become less poor and move up economically, they switch to fuel wood moving progressively to charcoal, kerosene, gas and electricity and integrating animals and simple tools. At a certain level of development they will manage to integrate some level of mechanization, irrigation and fertilization that implies a switch to fossil fuels.

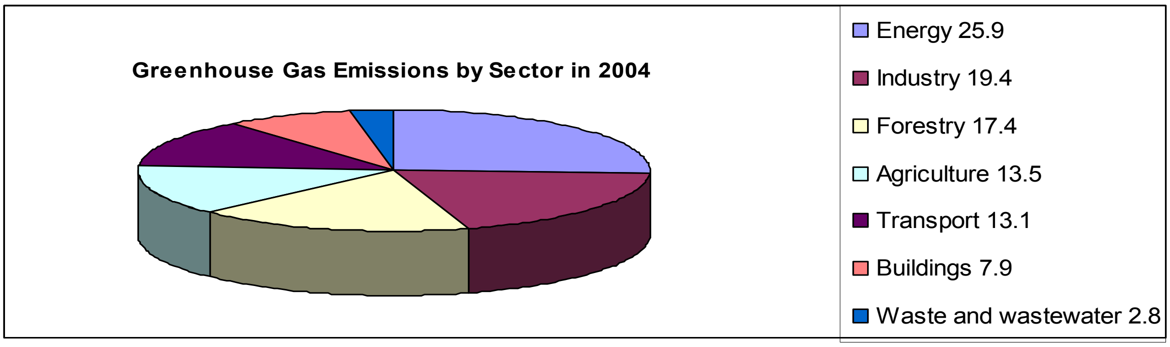
In both household and economic activities the "energy ladder" follows and influences the "economic ladder." Attempts to alleviate hunger and to promote rural development and food security must be accompanied with efforts to promote the role of energy as a key component of those attempts. Many parts of the developing world are suffering from lack of adequate energy/farm power resources for agricultural and food production itself. Better management of biomass sources of fuel for household use is essential to reduce deforestation, control carbon dioxide releases, and address the energy poverty that constrains sustainable development in many parts of the world.

Using Energy Efficiently

Although the debate about biofuel / food security tradeoffs has so far focused mainly on how to manage competing demands on scarce productive resources, it is equally important to focus on energy saving and efficient energy use that will contribute to reduced demand for energy, including bioenergy. Changes in variability of the prevailing weather conditions can shorten available time windows for field work, be it for land preparation, weeding, pest management or harvest. This will create higher demand for human labour, animal traction or mechanized farm power to carry out the respective work in a shorter available timeframe. In mechanized farming systems, shorter time windows result in increasing machinery investments, and may increase demand for fossil fuels. At the same time, the shift from labour to mechanisation will cause some who depended on farm employment to lose their livelihoods, necessitating proactive interventions to aid them to find new livelihood opportunities.

ADAPTATION AND MITIGATION– COMPLEMENTARITIES AND TRADE-OFFS

Mitigation - The Crucial Role of Agriculture



Greenhouse gas emissions from the food and agriculture sector contribute over 30 percent of current annual total emissions (deforestation 17.4 percent, agriculture 13.5 percent). The livestock sector on its own accounts for 18 percent, including over two-thirds of total emissions attributable to deforestation and over one-third of total agricultural releases of methane and nitrous oxide. However, the sector also has significant potential for mitigating climate change. Best practices include:

Reducing emissions of carbon dioxide through:

- reduction in the rate of deforestation and forest degradation,
- better control of wildfires,
- avoiding the practice of burning crop residues after harvest,
- avoiding pasture degradation
- reduction of emissions in arable farming by adoption of no-till systems,
- reduction of emissions from commercial fishing operations,
- more efficient energy use by commercial agriculture and agro-industries.

Reducing emissions of methane and nitrous oxide through:

- improving nutrition for ruminant livestock,
- more efficient management of livestock waste,
- more efficient management of irrigation water on rice paddies,
- more efficient management of applications of nitrogen fertilizer and manure on cultivated fields,
- reclamation of treated municipal wastewater for aquifer recharge and irrigation

Sequestering carbon through:

- afforestation, reforestation and improved forest management practices;
- introduction of integrated agro-forestry systems that combine crops, grazing lands and trees in ecologically sustainable ways,
- use of degraded lands for productive planted forests or other cellulose biomass for biofuels,
- improved management of pastures and grazing practices on natural grasslands, including by optimizing stock numbers and rotational grazing,
- use of techniques such as conservation agriculture to improve soil organic matter management with permanent organic soil cover, minimum mechanical soil disturbance and crop rotation.

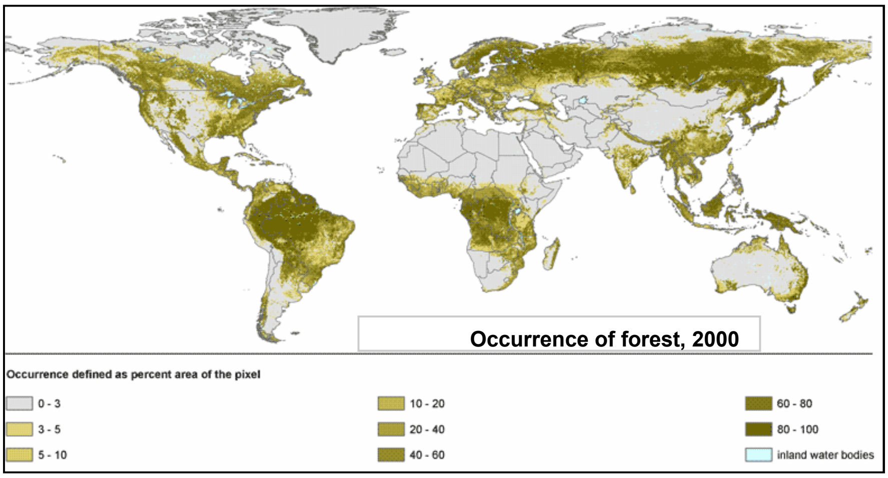
MULTIPLE BENEFITS OF CONSERVATION AGRICULTURE

Conversion of natural systems to cultivated agriculture, using conventional methods, results in loss of soil organic carbon on the order of 20-50 percent compared to the pre-cultivation amount. Application of the zero-till methods of conservation agriculture to all cultivated land could theoretically result in a total sequestration of up to 3 billion tonnes of carbon per year, for about 30 years. This is nearly the equivalent of the annual net increase in atmospheric carbon dioxide of anthropogenic origin that we are currently experiencing. In addition conservation agriculture also saves on fossil fuel and makes a significant difference for efficiency of water use, soil quality and capacity to withstand extreme events.

Mitigation means reducing greenhouse gas emissions and sequestering or storing carbon in the short-term, and even more importantly, making development choices that will reduce risk by curbing emissions over the long-term.

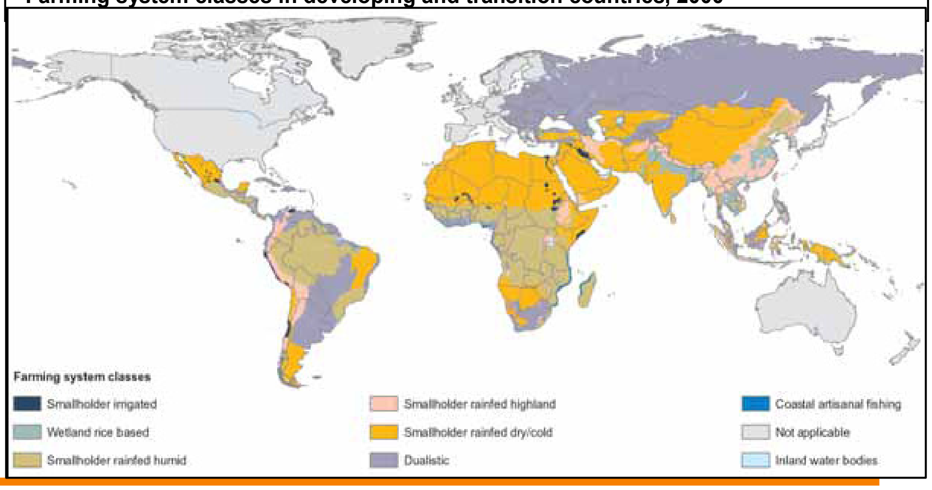
Payments for Environmental Services - Can they Protect Forest-Based Livelihoods and Simultaneously Mitigate Climate Change?

Around 13 million hectares of forests are being lost annually through deforestation, mainly due to conversion of land for agricultural use. Climate change will also affect the health of forests through an increase of forest fires and pests and diseases. Without economic or other incentives and political will, it will be difficult to stop deforestation and forest degradation. One relatively new incentive mechanism is *payments for environmental services* where farmers and communities are compensated for the climate change mitigation benefits they generate. Besides carbon sequestration, other services that have so far qualified for such payments include biodiversity conservation, management of protected areas, and watershed protection (maintaining quantity and quality of water). If well designed, environmental service payments could increase the capacity of small-scale forest-dependent households to insure against risk by diversifying income sources, and also potentially increase employment opportunities for women and youth. These households, which include many of those belonging to the smallholder rainfed humid and smallholder rainfed highland farming systems shown in the maps, could be more inclined to invest in inputs, needed for adapted land and forest management practices, if their incomes were more secure. This increased demand would in turn inspire the private-sector input-supply chain to make the required equipment and inputs available in the local markets. Nevertheless, designing effective payment schemes that lead to a change in farmers' practices is not an easy task. The design of cost-effective programmes requires careful analysis of the specific biophysical and socio-economic contexts and consideration of the poverty impacts programmes may have.



In many instances known good practices for sustainable agricultural and rural development (SARD) have both mitigation and adaptation benefits. For example, reducing deforestation and forest degradation could not only have significant impact on climate change mitigation, but may result in important co-benefits, including poverty reduction, conservation of biodiversity and watershed protection. On the other hand, some mitigation strategies may threaten adaptation efforts. For example, liquid biofuels production, a mitigation activity, could increase the risk of deforestation and loss of biodiversity and reduce access of rural communities to these resources as a coping mechanism to deal with external shocks like climate change. Among people who currently rely on forest resources as a source of livelihood, land conversion for biofuel crop production may also lead to socio-economic marginalization, particularly of women.

Farming system classes in developing and transition countries, 2000



THE WAY FORWARD

From a food security perspective, the most immediate risks arising because of climate change are from extreme events. As storms, floods and droughts become more frequent and intense the magnitude of asset losses that impact on agricultural production and purchasing power of low-income consumers is also increasing. Managing these risks is an imperative necessity for many countries, particularly developing countries where insurance cover is limited. At the same time, it is equally urgent to begin now to adapt to foreseeable shifts in agro-climatic zones, availability of water and related changes in species composition and disease vectors have to be anticipated, since it will take time for appropriate adaptive practices to take effect. In many parts of the world, there is still considerable uncertainty about how these more gradual changes are actually going to play out, so there is also a fundamental need to improve the information base for selecting appropriate adaptation options in the face of these uncertainties.

Mitigation is also a major concern in the sense that, if we do not get global warming under control, we could face large-scale disruption of food systems down the road that could be beyond our ability to manage. Moreover, in view of the important contribution of the agriculture sector to emissions, and its equally important potential contribution to emissions reduction and carbon sequestration, mitigation merits greater attention than hitherto. However, mitigation in the food and agriculture sector will make more gains if coupled with adapted agricultural practices and aligned with farmers'interests.

Importance of Innovation

Food and agriculture practices that would provide environmental services and/or reduce emissions or sequester carbon in developing countries represent good adaptation options for vulnerable livelihood systems. However, adaptation is more than this. In many instances, technological or institutional innovation may hold the key. Just as industrialization has speeded up the process of climate change, so too has it speeded up human capacity to innovate. Often, the best adaptation options will involve innovative modifications of known good practices rather than completely new solutions.

In many situations, institutional weakness rather than lack of appropriate technologies has been the main obstacle to adoption of sustainable agricultural and rural development practices in the past. Therefore adaptation of institutions, including customs and behaviour patterns as well as laws, regulations and formally-constituted structures, may be the priority in many situations where the impacts of climate change call for adaptive responses. Incentives to make the adoption of good mitigation and adaptation practices attractive are often lacking. Improved information, technology transfer and favourable regulations as well as both positive and negative monetary incentives, including polluter and user pays principles and getting rid of perverse incentives (e.g subsidies to production), are all options. Devising innovative financial instruments for environmental services payments will also be important.

Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity, and attitudes to risk.

Accessing Funds

There are several funds within the UN system that finance specific activities that are aimed at reducing greenhouse gas emissions and increasing resilience to negative impacts of climate change. As the financing mechanism of the UNFCCC, the Global Environment Facility (GEF) supports adaptation measures that generate global benefits through the GEF Trust Fund. The GEF secretariat also administers two funds under the UNFCCC that focus on development – the Special Climate Change Fund and the Least Development Countries Fund. The projects supported by these funds emphasize agriculture and food security, health, water resources and disaster prevention in developing countries.

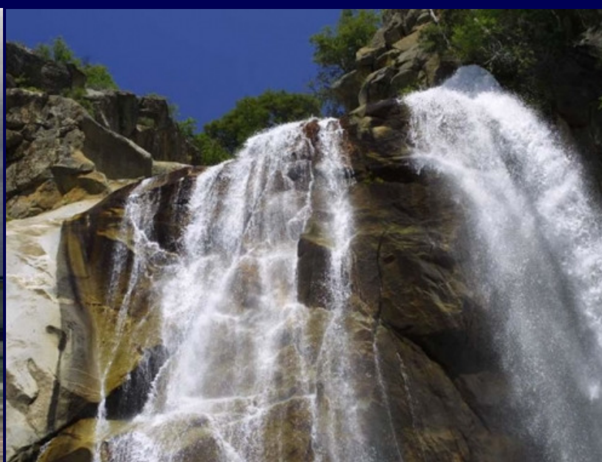
The Clean Development Mechanism (CDM) allows developed nations to achieve part of their emissions reduction obligations under the Kyoto Protocol through projects in developing countries that reduce emissions or sequester carbon. It is recognised that other forms of land use besides forestry are integral to the carbon cycle; however, only afforestation and reforestation activities are eligible for credits under the CDM.

As climate change rises to the forefront of political attention in more and more countries, bilateral donors and international financial institutions are becoming more important as funding sources.

FAO's Role

A main role of FAO is to assist member countries to identify potential adaptation options and help local people understand which ones are most applicable to their particular circumstances. FAO provides practical information to countries through: (i) global data sets, (ii) analytical tools and models, (iii) crop forecasting and impact monitoring, (iv) assessments of scientific evidence, and (v) information dissemination. FAO also assists countries mainstream climate change responses in food and agricultural policies and programmes. In countries with a National Programme for Food Security (NPFS) and also a National Adaptation Programme of Action (NAPA), FAO will facilitate inclusion of appropriate actions from the NAPA in the NPFS. Where there is no NAPA, FAO will provide necessary support for incorporating priority adaptation measures in the NPFS. FAO will also provide assistance to countries in integrating forest-related climate change mitigation and adaptation measures into their NAPAs and into their national forest programmes (NFPs) and other forest policy and planning processes.

The ultimate goal is not to enforce a pre-selected mitigation practice or adaptation option on any impacted community or population group, but rather to inform and promote local dialogue about what the impacts of climate change are likely to be and what options exist for reducing vulnerability and providing local communities with site-specific solutions. Thus the final word on the relationship between climate change and food security will be written, not by FAO experts, but rather by the people themselves whose lives are most immediately affected and whose choices will determine whether their future will be more or less food secure.



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