RESPONDING TO CLIMATE CHANGE: SECTOR SCRIPT

SECTOR: AGRICULTURE & RURAL DEVELOPMENT (ARD)

This document provides practical guidance on the links between climate change and a specific sector, together with possible responses to climate-related challenges. Its primary purpose is to support political dialogue on climate change implications between the European Commission, partner governments and other national partners involved in EC development and external co-operation activities. It may also be used to provide inputs for strengthening climate change integration in ongoing and future co-operation programmes and projects, with a focus on developmental benefits for the partner countries.

This sector script is one of a series prepared in a standard format. Key generic aspects common to all sectors are briefly described in the open text sections. Boxes are used to provide sector-specific guidance and illustrative examples. Note that the script is not country- or region-specific, and has been prepared to cover a wide range of possible effects and responses. Users are invited to appreciate which elements, among those proposed, are relevant to their specific needs and circumstances.

Note: This sector script covers a large number of topics but not all those possibly relevant to Agriculture & Rural Development. Related and complementary scripts notably include those on Economic Development, Energy, Environment & Natural Resources, Governance, Infrastructure (incl. Transport) and Water & Sanitation.

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1. How climate change might affect the achievement of sector objectives and results

The first step in responding to climate change involves reviewing its expected effects (manifestations and impacts) in the country concerned – focusing on those that are most likely and most significant to the sector of concern. The identification of potentially significant effects is the starting point for the assessment of risks, opportunities and appropriate responses. Note that some of the "climate change effects" addressed below are not a consequence of climate change alone: they can have other causes, notably the pressures imposed by human activities on natural systems. Climate change sometimes just amplifies existing trends.

In order to determine the extent to which the achievement of sector objectives and expected results may be jeopardised [or possibly promoted] by climate change, the following aspects should be considered:

- *Will sector activities be directly or indirectly exposed to the effects (manifestations and impacts) of climate change?*
- *Does the achievement of sector objectives and results depend significantly on the use of environmental resources, the availability, productivity or regeneration of which may be threatened [or possibly enhanced] by the effects of climate change?*
- *Are sector activities and infrastructure vulnerable to natural or environmental disasters, the frequency and/or severity of which may increase as a result of climate change?*

Generally speaking, the vulnerability of human populations, systems and activities to climate change depends on a combination of: (i) exposure to the bio-physical and socio-economic consequences of climate change (which differs across geographical areas); (ii) sensitivity to these effects (which may vary across and within populations) and ability to adapt (which depends on factors such as wealth, age, gender, education and skills, access to information and technology, "built" infrastructure, "green" infrastructure[1], institutions and social organisation, cultural norms, equity and in general on the "development level").

Box 1: How climate change might affect agriculture and rural development

The *biophysical effects* of climate change most likely to be relevant to ARD include the following:

- changes in (average and/or extreme) temperature and rainfall patterns;
- shifts in seasons;
- increased frequency and/or severity of droughts, floods (including coastal floods), landslides, storms, hurricanes, cyclones, heat waves, wildfires, etc.;
- increased frequency and/or severity of disease and pest outbreaks;
- raised sea levels and increased coastal erosion (in some cases interacting with damage to natural coastal defences such as coral reefs and mangroves);
- river bank erosion;
- seasonal or permanent reduction in the availability of freshwater (e.g. as a result of seasonal or permanent changes in stream flows, reduced precipitation, increased variability in precipitation, melting glaciers, salinity intrusions due to sea-level rise, reduced groundwater recharge rate);

[1] "Green infrastructure" refers to the life-supporting and regulation services (e.g. regulation of hydrological flows) provided by the natural environment and ecosystems.

- decrease in water quality (e.g. increased salinity and increased concentration of pollutants as a result of lower flows, increase in pathogens[2] and disease vectors as a result of higher water temperature);
- loss of habitats and changes in ecosystems, possibly involving loss of biodiversity, accelerated extinction of species, shifts in the range of animal and plant species, and/or changes in the balance/dominance patterns of species.

Among *socio-economic impacts*, those most likely to be relevant to ARD include:

- increased mortality and morbidity[3] as well as malnutrition;
- increased probability and intensity of conflicts related to access to natural resources;
- damage to or destruction of infrastructure;
- human migrations.

Agriculture is generally considered one of the most vulnerable sectors with regard to the effects of climate change. Other sectors that depend on primary production and are directly relevant to rural livelihoods, such as forestry, fisheries and livestock[4], are also seriously impacted by climate change. Rural development is not only about primary sector activities, but it is obviously highly dependent on them. Processing industries which are an element of rural development depend on climate-sensitive primary resources, as well as the availability of infrastructure services. Tertiary sector activities, in turn, depend on the strength of the primary and secondary sectors, as well as the capacity of societies to sustain the functioning of essential infrastructure. All sectors depend on capacity to maintain a degree of social harmony. In the sections below, we review a series of sectors that are relevant to rural development, and also address food security. Note that ecosystems and biodiversity are addressed in the script on Environment and Natural Resources, and issues relating to indigenous people in the script on Governance.

(1) AGRICULTURE

Agriculture is widely recognised as the sector most directly and significantly affected by climate change, due to its sensitivity to climatic factors and dependence on natural resources such as soils and water. Crops are directly affected by temperature and rainfall patterns, droughts, floods, storms, pest outbreaks, changes in the spatial distribution of pests and diseases, freshwater availability, soil erosion, shifts in seasons, shifts in agro-climatic zones, etc. They are also likely to be indirectly affected by the loss of habitats and changes in ecosystems, notably where these changes involve the extinction of species (some of which may be useful to agriculture), shifts in the range of animal and wild plant species, more favourable conditions for the development and spreading of invasive species, and/or changes in the balance/dominance patterns of species. Soil erosion (which can be aggravated by drought episodes as well as heavy rainfall), land degradation, coastal erosion, coastal land salinization and desertification may lead to the loss of arable land.

The main threats associated with these potential effects of climate change are higher yield variability (associated with increased climate variability), reduced crop yields, crop failures, crop destruction by extreme weather events and the loss of arable land – with obvious negative consequences for food security and for the stability of food prices. Smallholders and subsistence farmers are expected to be the most affected, having less capacity and fewer means to adapt. In mid- to high-latitude regions

[2] i.e. disease-producing agents.
[3] i.e. the frequency of occurrence and the prevalence of diseases.
[4] Livestock is important since for many subsistence farmers, it is the only "bank" in which their savings can be invested.
[5] This phenomenon is sometimes referred to as 'carbon fertilisation'.

however, warming (as long as it remains reasonably mild) is likely to have beneficial effects on crop yields, and to lengthen the growing season. It is also recognised that under unstressed conditions, the growth of some plants increases with higher atmospheric concentrations of CO_2.[5]

In addition, agriculture may be indirectly impacted by other consequences of climate change. Damage to transport and storage infrastructure may hinder production (e.g. if essential inputs cannot be delivered in time), prevent the timely transportation of agricultural produce to markets, or prevent adequate conservation of food stocks. Irrigated agriculture, on top of being sensitive to water availability problems (see script on Water and Sanitation), may be affected by damage to rural electricity infrastructure. Conflicts related to access to natural resources or triggered by human migrations may temporarily or more permanently disrupt the sector by preventing the timely seeding/planting of crops and displacing farmers. Increased morbidity and mortality, the increased prevalence of malnutrition, and migrations away from rural areas may negatively impact on agricultural production by reducing the availability and productivity of labour. In the vicinity of cities, migrations encouraged by climate change may lead to urban sprawl and thus the loss of agricultural land.

(2) LIVESTOCK

The same factors that affect crop yields also affect the productivity of grazing lands, and thus their carrying capacity. Changes in the availability of water, as well as increases in waterborne disease vectors, are likely to have a negative impact on livestock productivity. Animals may suffer from heat stress. Pasturelands may be lost to erosion and desertification. Changes in habitats and ecosystems may lead to changes in the prevalence of parasitic diseases. Conflicts between herders (especially nomadic ones), ranchers, farmers and other land users may intensify as a result of the increasing scarcity of “usable” land.

(3) FORESTRY

The productivity of forests is influenced by climatic factors, in particular temperature and rainfall patterns. Prolonged and recurrent droughts increase the risk of destruction by wildfires. Forests may be damaged by storms. Changes in habitats and ecosystems may result in the emergence of new pests, increased vulnerability to existing pests, as well as shifts in the range of specific tree, plant and animal species. Transport infrastructure needed to take timber and other forest products to markets may be damaged or destroyed by extreme weather events (or by a reduction in river flows, where timber floating is used as a means of transportation). As a result of climate change, farmers in search of new land to cultivate, ranchers/herders in search of new grazing lands, and migrants in search of new livelihoods may all exercise deforestation pressures. On the positive side, forestry productivity is expected to increase in some regions (in low latitudes in the short term, in higher-latitude regions in the longer term).

(4) FISHERIES AND AQUACULTURE

Changes in sea surface temperature, in salinity and oxygen levels, in oceanic circulation patterns, in the acidity of oceans may all affect the productivity of fisheries. The ranges of many fish species have already changed and may change further, as planktonic growth is affected by changing conditions. The genetic composition and phenology (i.e. life cycle events) of fish stocks is also affected, and in some areas the development of invasive new species is facilitated by new conditions. The breeding sites of some valued species are threatened by damage to mangrove and coral reefs. Changes in marine ecosystems, combined with unsustainable fishing practices, are likely to result in the accelerated extinction of some species and changes in the balance/dominance patterns of the surviving ones. The productivity of coastal aquaculture operations is likely to be affected by changes in water temperature, acidity and turbidity, as well as changes in the prevalence of pests and diseases.

Freshwater aquaculture operations may suffer from reduced water flows, changes in water temperature, turbidity and biochemical quality, and changes in pest and disease patterns caused by wider ecosystem changes.

More violent and frequent storms may damage or destroy fishing fleets as well as harbour, coastal and aquaculture infrastructure – which is also at risk from rising sea levels. The general pressure on food resources (both marine and land-based ones) may be a source of conflicts, e.g. between local fishermen and external ones, or between established fishermen and new entrants.

(5) EXTRACTIVE INDUSTRIES

Mining operations of all types and sizes may be affected by damage to infrastructure (resulting from extreme weather events) as well as reduced availability of water and power (e.g. reduced hydropower generation associated with a decrease in rainfall). Increased morbidity and mortality, the increased prevalence of malnutrition, and migrations away from extraction areas may reduce the availability and productivity of labour. And of course, conflicts of all kinds may be a threat to both infrastructure and operations.

(6) PROCESSING INDUSTRIES

All the processing industries built around primary production and extractive activities will suffer if the upstream activities on which they depend are negatively impacted by climate change. Damage to industrial and commercial infrastructure, as well as to public infrastructure (transport, energy, telecoms), may disrupt their operations. Increased morbidity and mortality, the increased prevalence of malnutrition, and migrations away from rural areas may reduce the availability and productivity of labour. And of course, conflicts of all kinds may be a threat to both infrastructure and operations.

(7) TERTIARY SECTOR ACTIVITIES, GOVERNANCE AND INSTITUTIONAL DEVELOPMENT

Rural development is also concerned with the development of tertiary sector (service) activities, including (eco)tourism, and institutions at all levels. In this area, climate change-related risks are mostly indirect. Public and private sector operations may be disrupted by damage to infrastructure and conflicts. Increased morbidity and mortality, the increased prevalence of malnutrition, and migrations away from rural areas may reduce the availability and productivity of labour. The long-term development of sectoral institutions may be neglected if more frequent and severe climate-related emergencies result in the slashing of resources available for institutional strengthening, in favour of more immediate but less 'structuring' objectives. Conversely, the emergence of new climate-related challenges may provide the impetus needed to tackle difficult sector organisation issues and strengthen key institutions, such as those in charge of land planning and management and environmental/natural resource management.

(8) SPECIAL FOCUS: FOOD SECURITY

Lower productivity in agriculture, livestock breeding, forestry, fisheries and aquaculture is likely to have negative impacts on food security in many regions, especially where several "shocks" on food production systems combine their effects. The loss of biodiversity is also a threat to food security since it reduces possibilities to diversify food production and switch to species that may be better adapted to the new conditions or more resistant to pests.

2. ADAPTING TO CLIMATE CHANGE

Adaptation to climate change aims to reduce vulnerability both in the short and in the long term. It involves costs, but should also produce social and economic benefits, especially if a medium- to long-term perspective is adopted: the costs of 'no action' may indeed well exceed the cost of action.

Adaptation involves adjustments in practices, processes and infrastructure but also changes in social and institutional structures and decision-making processes. The systemic nature of climate change impacts makes the development of adaptation policies rather complex; systemic, multi-sectoral answers will often be required. Development interventions should aim to increase adaptive capacity which is the ability to anticipate, respond to and learn from disturbance and change. In most cases, measures aimed at reducing poverty, protecting or restoring ecosystems (to ensure the continued provision of ecosystems services), diversifying livelihood strategies and improving access to essential services and resources can be expected to enhance the population's resilience and adaptive capacity – nevertheless this should not be taken for granted: applying a 'climate change lens' to specific policies and planned interventions is needed to avoid 'maladaptation' (i.e. the adoption of measures or the implementation of policies that end up increasing, rather than reducing, overall vulnerability to climate change).

Climate change adaptation measures can aim to offset negative impacts but also to take advantage of positive ones, where they exist. Adaptation should not be seen just as a constraint and an additional financial and economic burden. In almost every sector, climate change intensifies already existing problems. Climate-related concerns may provide the impetus needed to implement many of the environmental and developmental "best practices" previously neglected and in this way make a sector's programmes and projects both more effective and more sustainable. There are many instances in which 'climate change adaptation measures' may alleviate factors that contribute to chronic vulnerability today, enhance equity, reduce poverty, improve management, and generally make a positive contribution to development objectives – regardless of the extent to which the potential effects of climate change ultimately materialise. In the presence of significant uncertainties, 'adaptive management' based on the adoption of 'no regrets' or 'robust' measures[6] is a good starting point.

Across sectors, adaptation to climate change will involve:

- *strengthening systems for data collection and monitoring, knowledge management and sharing;*
- *using tools such as integrated models, GIS and scenarios to predict impacts and support adaptation assessments and interventions;*
- *raising awareness (in the general population and in specific groups) and improving access to information;*
- *building capacities (in the public and the private sector, at the national, regional and local levels), through the education system, the provision of training and advisory services, etc.;*
- *financing research, pilot projects and demonstration activities, as well as the dissemination of research results and the scaling-up of successful initiatives;*
- *strengthening the (public and private, national, regional and local) institutions involved in governance, and fostering cross-sectoral planning, cooperation and response mechanisms.*

[6] 'No regrets' measures are those that are expected to produce net benefits for society even if climate change effects fail to materialise, or are less severe than predicted: no resources are wasted by implementing them. 'Robust' measures are those that produce net benefits across various possible climate change scenarios; they are particularly valuable in the presence of uncertainty about future climate evolution.

Finally, it should be noted that not all proposed measures will be relevant, feasible or appropriate everywhere. Adaptation measures should match:

- *the identified (country- or location-specific) risks & opportunities;*
- *the magnitude and rapidity of expected changes: some proposed measures may work for relatively mild or gradual climatic and environmental changes but become ineffective beyond certain thresholds or in the presence of very sudden changes;*
- *physical limits, economic constraints, available resources and capacities: some options may be affordable and/or technically feasible in some specific contexts but not in others;*
- *other local characteristics, such as political and social limitations, culture and traditions: some proposed measures may be acceptable in some places but not others.*

The application of Strategic Environmental Assessments to policy making in the context of climate change could provide an appropriate framework to identify and respond to the identified issues and constraints. At the project level, financial and economic analysis (if possible including elements of risk analysis) is one of the tools that can be used to determine which adaptation options are the most suitable in a given situation or for a given set of possible scenarios.

Box 2: Adapting to climate change in the ARD sector

Adaptation measures may have a better chance of success if combined measures are adopted, to take advantage of possible synergies. Given the size and complexity of the challenge, strong rural development institutions, at supra-national, national, regional and local level, will be needed to help rural societies "weather the storm" and adapt to the expected effects of climate change. Collaboration between all levels of government, and between public and private sector organisations, will be required. Finally, attention should be paid to the possible unintended consequences of adaptation measures, e.g. undesirable environmental effects, negative externalities in other locations, or net increase in GHG emissions.[7]

(1) AGRICULTURE

Agriculture has historically been confronted with climate variability (if not the levels of predicted climate change) and has generally shown high levels of adaptability. Many adaptation options are in effect extensions of existing risk management and production-enhancing techniques. Possible adaptation measures include:

- conversion to alternative land uses that may be better adapted to the new climatic conditions;
- adopting new crops and/or varieties that may be more resilient to droughts, floods, high temperatures, emerging pests, soil salinity – or generally better adapted to the new climatic conditions;
- creating or strengthening national centres for the conservation and use of biodiversity in food plant species (e.g. rice, potato, corn) – or participating in international initiatives to this effect;
- adjusting seeding/planting and harvesting periods to take account of new seasonal patterns as well as water efficiency considerations;
- with due regard for environmental sustainability, altering the use of inputs such as fertilisers and pesticides to optimise production under new conditions, and generally improving the effectiveness and sustainability of pest, disease and weed management practices (e.g. Integrated Pest

[7] For instance, the increased use of fertilisers if not very carefully managed may result in increased emissions of nitrous oxide (N_2O), a greenhouse gas, into the atmosphere. Furthermore, the inadequate use of fertilisers is a significant source of water pollution.

Management);

- improving soil moisture retention by the appropriate use of micro-catchments, mulches and soil organic matter management (e.g. crop residue retention);
- where rain-fed agriculture is at risk, developing water-efficient (e.g. drip) irrigation systems (if possible given current and future constraints on freshwater availability); where irrigation is already in place, making more efficient use of water;
- developing rainwater harvesting and storage techniques, and possibly desalination (an environmentally acceptable option only if it is powered by renewable e.g. solar energy);
- promoting water-use efficiency measures and other water management measures, such as water recycling, increased use of water metering and pricing, the development of water markets (to facilitate reallocation of the resource to the most valued uses) – but also any existing indigenous practices for sustainable use of water;
- where irrigated agriculture is not a sound option from an economic or environmental point of view, promoting the substitution of some local productions with imports from regions with better water endowments;
- promoting Integrated Water Resources Management (see script on Water & Sanitation) at the appropriate scales (i.e. those that are most likely to allow effective responses to specified needs);
- adopting cultivation techniques that reduce soil erosion (e.g. reduced tillage or no-till agriculture, planting of hedgerows to prevent soil washout and act as windbreaks), conserve soil moisture (see above) and maintain biodiversity (notably as a natural protection against pest outbreaks);
- developing appropriate defences around cultivated areas and key infrastructure, including human settlements (e.g. dykes, seawalls, embankments, dunes or overflow routes against floods, "green barriers" against desertification, vegetation-cleared firelines against wildfires);
- maintaining a critical mass of (unexploited or sustainably exploited) natural ecosystems including wetlands throughout the territory, in particular in agricultural regions and in coastal areas (to enhance overall ecosystem resilience and ensure the continued provision of essential ecosystem services) (see script on Environment & Natural Resources);
- promoting local electricity generation based on renewable sources, notably to power irrigation pumps (see script on Energy);
- taking account of climate risks in the building of rural transport infrastructure, and in the choice of locations and technical specifications for food storage and other essential rural facilities (see script on Infrastructure incl. Transport);
- promoting diversification of farmers' income;
- strengthening land planning and management institutions, and adopting land reforms that promote sustainable land management (e.g. by clarifying and securing property rights, whether private or collective, or by transferring the ownership and management of some resources to local communities) (see script on Governance);
- in vulnerable coastal and delta areas, adopting 'managed retreat' where coastal protection is not feasible or unaffordable;
- implementing adequate conflict prevention and management mechanisms;
- developing monitoring, information sharing, seasonal climate forecasting and early warning systems (e.g. for droughts, floods, storms, pest outbreaks, environmental changes and consequences such as impending famine);
- developing and testing emergency preparedness plans at various levels;
- promoting farmers' access to training, advisory services and financial services, including insurance or other forms of risk sharing (see script on Economic Development).

(2) LIVESTOCK

Possible adaptation measures include:

- designing and enforcing policies aimed at keeping livestock stocking rates within sustainable limits;
- rotating pastures;
- modifying grazing times;
- altering mixed livestock/crop systems (e.g. adaptation of forage crops, reassessment of fertiliser use to optimise productivity under new conditions while avoiding negative impacts on the environment);
- gradually switching to animal species (e.g. cows, sheep, goats) that are more resilient / better adapted to the new prevailing conditions (including heat, water shortages and diseases); in the case of industrial livestock farms, this may involve re-introducing traditional local species;
- installing or adapting ventilation in buildings that house livestock;
- diversifying sources of forage, partially switching to feed concentrates;
- developing appropriate defences around grazing lands (e.g. “green barriers” against desertification, vegetation-cleared areas against wildfires);
- ensuring adequate supply of water, in quantity and quality (e.g. by developing rainwater harvesting techniques, by fighting parasitic diseases at water points);
- adapting veterinary practices to changes in disease patterns;
- maintaining a critical mass of (unexploited or sustainably exploited) natural ecosystems including wetlands (to ensure the continued provision of essential ecosystem services);
- promoting diversification of herders’ and ranchers’ income;
- adopting land reforms that promote sustainable land management (e.g. by clarifying and securing collective or private property and access rights);
- implementing adequate conflict prevention and management mechanisms;
- promoting herders’ and ranchers’ access to training, advisory services and financial services, including insurance or other forms of risk sharing.

(3) FORESTRY

Possible adaptation measures include:

- for managed forestry, altering the mix of tree species and gradually switching to species that may be more resilient / better adapted to the new climatic conditions;
- modifying rotation periods;
- adopting harvesting techniques that reduce soil erosion and exposure to wildfires, and promote the conservation of biodiversity (e.g. keeping dead timber *in situ*);
- building firebreaks and adjusting/strengthening fire management systems and procedures; this may include, for instance, the use of controlled burning as a protection against uncontrolled wildfires, the installation of surveillance towers and water reservoirs, the provision of better equipment and capacity building for firemen, the development of regional fire control forces equipped for aerial surveillance and interventions, and the integration and coordination of regional, national and international fire-fighting forces; tougher laws and sanctions against arson may also be part of the arsenal of measures;
- improving insect control techniques (with due regard for environmental considerations);
- maintaining a critical mass of diversified, natural forest ecosystems throughout forested regions;
- taking account of climate risks in the building of forest transport infrastructure;

- strengthening land planning and management institutions, and adopting land reforms that promote sustainable land management (e.g. by clarifying and securing private or collective property and access rights);
- implementing adequate conflict prevention and management mechanisms.

(4) FISHERIES AND AQUACULTURE

Coastal fishing communities have a long experience of coping with fluctuations in fish stocks (notably fluctuations resulting from climate variability) and changes in the range of planktonic ecosystems and fish species. They have generally shown high levels of adaptability – although in recent decades this capacity has been tested by a sharp increase in human-induced stresses and pervasive policy failures. Most adaptation options are focused on altering catch size and fishing effort. Possible adaptation measures include:

- implementing policies aimed at keeping fishing fleets and fish catches within sustainable limits, enforcing rules (possibly with the help of new technologies such as GPS-based fishing fleet tracking systems), and in particular enforcing a strict ban on the most damaging fishing practices (e.g. bottom trawling, mercury, explosives);
- mapping changes in the range of fish species and strengthening the monitoring of fish stocks;
- adopting ecosystem-based approaches to fishery management;
- developing a network of marine protected areas where all fishing is banned;
- strictly enforcing the protection of fish breeding areas such as mangroves and coral reefs – and more generally, protecting coastal ecosystems (especially wetlands);
- managing and upgrading coastal infrastructure including "natural infrastructure" to avoid the destruction of fish breeding areas and improve water quality along the coast (e.g. mangrove restoration, development of wastewater treatment facilities);
- where essential infrastructure has to be protected (e.g. harbour infrastructure) and managed retreat is not an option, strengthening natural coastal defences (e.g. mangrove regeneration) and/or building sea defences (with due regard for environmental considerations);
- adopting Integrated Coastal Zone Management practices (see script on Water & Sanitation);
- promoting diversification of artisanal fishermen's income;
- implementing adequate conflict prevention and management mechanisms;
- promoting artisanal fishermen's access to training, advisory services and financial services, including insurance or other forms of risk sharing;
- inland, implementing policies aimed at preserving the quality of freshwater resources used for aquaculture;
- financing research specifically aimed at supporting the sustainable adaptation of saltwater and freshwater aquaculture to the new prevailing conditions.

(5) EXTRACTIVE INDUSTRIES

Possible adaptation measures include:

- making own infrastructure as "climate-resilient" as possible;
- ensuring that the public infrastructure on which extractive industries depend (e.g. transport, energy, water) is gradually made as "climate-resilient" as possible;
- implementing new techniques and upgrading infrastructure to reduce water and energy consumption and diversify energy supply sources;
- developing capacities for integrating climate risk management into overall business strategies.

(6) PROCESSING INDUSTRIES

Possible adaptation measures include:

- making own infrastructure as "climate-resilient" as possible, including in the choice of locations;
- ensuring that the public infrastructure on which transformation industries depend (e.g. transport, energy, telecoms, water) is gradually made as "climate-resilient" as possible;
- adapting storage and distribution systems to reduce vulnerability;
- implementing new techniques and upgrading infrastructure to reduce water and energy consumption and diversify energy supply sources;
- developing capacities for integrating climate risk management into overall business strategies;
- supporting suppliers of key raw materials and inputs in the adoption of practices that enhance resilience to the effects of climate change.

(7) TERTIARY SECTOR ACTIVITIES, GOVERNANCE AND INSTITUTIONAL DEVELOPMENT

Possible adaptation measures include:

- making service enterprises' and public sector infrastructure (e.g. administrative buildings) as "climate-resilient" as possible, including in the choice of locations;
- ensuring that public infrastructure (e.g. transport, energy, telecoms, water and sanitation) is gradually made as "climate-resilient" as possible, including in the choice of locations;
- implementing new techniques and upgrading infrastructure to reduce water and energy consumption and diversify energy supply sources;
- developing capacities for integrating climate risk management into overall business strategies, notably in the (eco-)tourism sector;
- promoting access to financial services, including insurance or other forms of risk sharing;
- supporting awareness raising, knowledge sharing and capacity building among public and private organisations involved in rural development activities;
- promoting disaster preparedness at various levels of government and at community level;
- making the case for institutional strengthening in the context of climate-related challenges, by showing the added value of improved sector management in terms of productivity and resilience.

(8) SPECIAL FOCUS: FOOD SECURITY

The main climate-induced threats to food security are related to:

- lower productivity in agriculture, livestock breeding, forestry, fisheries and aquaculture;
- the loss of biodiversity and the disruption of ecosystems.

There are no adaptation measures really specific to food security. Generally speaking, all measures that effectively contribute to the increased climate resilience of food production, storage and distribution systems also contribute to enhancing food security. National and international efforts to support the conservation of biodiversity in food plant species are particularly necessary and likely to be useful – as are efforts to conserve biodiversity-rich, well-functioning ecosystems. The genetic modification of plants is particularly controversial from an environmental point of view and is generally considered to limit, rather than increase, the range of seed varieties used to grow crops. Nevertheless, some recent advances in the development of food crops engineered to resist droughts and high levels of salinity may in future offer partial solutions in specific contexts.

3. CONTRIBUTING TO CLIMATE CHANGE MITIGATION

Climate change mitigation, i.e. efforts to reduce greenhouse gas (GHG) emissions in order to ultimately stabilise their atmospheric concentration, aims to limit the magnitude of climate change. Although most developed countries, which have the largest GHG emissions per capita, accept that they should make the largest contribution to the mitigation effort, the stabilisation of GHG levels cannot be achieved unless all countries and sectors collaborate. At the moment, developing and emerging countries are not concerned by mandatory emission reduction targets, but as part of the international climate change negotiations, they are increasingly being called upon to start curbing the growth of their emissions. In preparation for the Copenhagen agreement (which is to succeed the Kyoto Protocol when it expires in 2012), the EU calls for developing countries as a group to curb the growth of their emissions by 15-30% by 2020 compared to 'business-as-usual' scenarios – and for all developing countries except the poorest to commit to adopting low-carbon development strategies by the end of 2011.

It is therefore important that development co-operation interventions, as well as other initiatives such as the Kyoto Protocol's Clean Development Mechanism and its successor, help partner countries opt for 'climate-friendly' or 'climate-neutral' development paths – and provide access to the technical and financial resources required for this purpose.

Again, climate change mitigation should not be seen only as a constraint but also as a source of opportunity. While some trade-offs between mitigation and developmental goals are likely to be unavoidable, especially in the short term, in many instances the adoption of mitigation measures may actually make a positive contribution to sustainable development objectives. They may improve financial and economic returns, reduce dependence on imported energy, put partner countries on a more sustainable development path (which is in their short- and long-term interest) – and, in some instances, give them access to additional financial resources (through carbon-finance mechanisms).[8]

As in the case of adaptation measures, it should be noted that not all proposed measures will be relevant, feasible or appropriate everywhere. The application of Strategic Environmental Assessments to policy making in the context of climate change could provide an appropriate framework to identify and respond to the identified opportunities and constraints. At the project level, financial and economic analysis is one of the tools that can be used to determine which mitigation options are the most suitable in a given situation.

Box 3: Opportunities for reducing GHG emissions in the ARD sector

The way in which some key rural development activities are managed can have a significant impact on GHG emissions. Agriculture is an important source of two powerful GHGs: nitrous oxide (N_2O) and methane (CH_4), as a result of the microbial transformation of nitrogen fertilisers in soils, the digestion processes of cattle and other ruminant animals (production of fermentation gases), and the

[8] For generic information on financing opportunities linked to GHG emission reductions and the so-called 'carbon markets', see notably:

- World Bank (2008) – *State and Trends of the Carbon Market 2008*, downloadable from: http://carbonfinance.org/docs/State_Trends_FINAL.pdf;
- Clean Development Mechanism of the Kyoto Protocol: http://cdm.unfccc.int/index.html;
- website of the World Bank's Carbon Finance Unit, which has entered partnerships with other international organisations as well as several EU governments to promote the financing of 'emission reductions cum sustainable development/poverty alleviation' projects in developing countries: http://carbonfinance.org.

storage and spreading of manure. On the other hand, agricultural lands have the potential to store large amounts of carbon dioxide (CO_2), depending on how soils are managed.[9] Forests have even greater potential as "carbon sinks"[10], and generally store carbon more permanently than croplands: they store carbon in tree biomass, and also in the soil's organic matter. On the other hand, deforestation (especially where slash-and-burn techniques are employed, for instance to clear land for agriculture and ranching) releases significant quantities of CO_2. Peatlands are the largest terrestrial store of biomass carbon: they store on average 10 times more carbon per hectare than other terrestrial ecosystems. When they are cleared, drained or burnt to be converted to agricultural or managed forestry uses, they release large amounts of CO_2 into the atmosphere.[11]

According to the 2007 IPCC report[12], agriculture and forestry/deforestation account for, respectively, approx. 13.5% and 17.4% of global anthropogenic emissions.[13] Changes in these two sectors in particular thus have considerable potential to contribute to the global climate change mitigation effort. Curbing deforestation, in particular, is considered one of the most cost-effective ways of reducing GHG emissions: avoiding deforestation could achieve significant emission reductions in the short term, without requiring new technology, and at a low cost in comparison with other mitigation options (even if compensation is offered to cover the opportunity costs of not exploiting forests). The conservation and restoration of peatlands is another extremely cost-effective carbon sequestration technique.

Although it supports a 'Land Use, Land Use Change and Forestry' component, the Clean Development Mechanism developed in the framework of the Kyoto Protocol is often perceived as too cumbersome to finance GHG emission reduction projects from agriculture and forestry projects on a routine basis – and it will anyway expire in 2012. It will be essential, however, to monitor the development of new financing mechanisms under the post-Kyoto arrangements (which should in principle be agreed at a major UN gathering to be held in Copenhagen in late 2009), as well as any other new instruments developed to address global deforestation and facilitate North-South financial transfers.

In the meantime, several mechanisms already support the financing of projects by developed countries under both compliance and voluntary emission reduction schemes. The Worldbank's BioCarbon Fund and Forest Carbon Partnership Facility are particularly suitable for activities in agriculture and forestry – but other funds may also be relevant (see http://carbonfinance.org for more information). In future, carbon prices are likely to determine to a large extent which mitigation measures are viable and which ones are not.

Some mitigation options are congruent with adaptation options (especially in agriculture and

[9] Chlorophyllic plants absorb CO_2 through photosynthesis and use the carbon to build organic matter. The richer the soil is in organic matter, the more carbon it stores.
[10] More carbon is stored in forest biomass than in the atmosphere.
[11] The "un-freezing" of peatlands in permafrost regions is also a significant source of methane emissions.
[12] IPCC (2007) – *Climate Change 2007: Synthesis Report*, Fourth Assessment Report, Intergovernmental Panel on Climate Change, downloadable from: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
[13] According to an FAO report, "the livestock sector is […] responsible for 18 percent of greenhouse gas emissions measured in CO_2 equivalent", if one adds up the methane resulting from enteric fermentation by ruminants, the manure-related nitrous oxide emissions and the changes in land uses (primarily deforestation) caused by the expansion of pastures and land cultivated for feedcrops. See FAO (2006) – *Livestock's long shadow: environmental issues and options*, Food and Agriculture Organization, Rome, p. xxi.
[14] Biochar is charcoal produced from biomass using pyrolysis techniques. It can be used as a soil amendment, and has the advantage of allowing the storage of significant amounts of biomass carbon into soils, in a stable form. On top of improving soil quality and reducing irrigation and fertiliser requirements, the use of biochar as a soil amendment has the advantage of reducing emissions of nitrous oxide and methane, two powerful GHGs. (Source: Wikipedia)

forestry), and thus produce a double stream of benefits. Other mitigation options, however, may inadvertently result in increased vulnerability and threaten or cancel out adaptation efforts (e.g. biofuels may have adverse impacts on food security, food prices, water availability and ecosystems) – or even have a negative net impact in terms of mitigation (e.g. increased deforestation to accommodate cropland extension for biofuels). Just as with adaptation measures, it is thus important to carefully consider the pros and cons and possible 'side effects' of any envisaged mitigation measures.

(1) AGRICULTURE

Generally speaking, mitigation measures in relation to agricultural practices are still characterised by many uncertainties (e.g. about the carbon sequestration potential in different conditions, and about the stability and permanence of carbon retention) – and there is no universally applicable list of good practices. Some measures may have a positive net impact on GHG emissions in some locations and agricultural systems but not in others. Some measures involve a trade-off (e.g. reduction in emissions of one greenhouse gas but increase in emissions of another one). It is therefore very important to seek technical or scientific advice before opting for a given mitigation option. Possible mitigation measures include:

- enhancing carbon sequestration in soils by conversion to reduced tillage or no-till agriculture, retaining crop residues (a precursor of soil organic matter), converting drained croplands back to wetlands, restoring degraded lands, converting some croplands to grassland, avoiding bare fallow, growing temporary vegetative cover ("catch crops") between main agricultural crops or between rows of trees and vines, using biochar[14] as a soil amendment, etc.;
- making more efficient use of fertilisers (more efficient delivery of nitrogen to root systems reduces atmospheric emissions of N_2O), and rotating crops with legume crops (to reduce reliance on external nitrogen inputs);
- adopting cropping systems with reduced reliance on fertilisers, pesticides and other inputs (including but not limited to organic farming);
- adopting rice cultivation methods that reduce methane emissions (e.g. more frequent draining of fields, improved water management, composting of residues before incorporation in soils, capture of methane for producing biogas to be used as fuel for energy production);
- avoiding the drainage of organic and peaty soils, protecting and restoring peatlands;
- converting the fossil fuel-based systems used to power the pumps of irrigation systems to renewable sources of energies;
- using crop residues for renewable energy production;
- developing biofuel crops (only to the extent this can be done sustainably and without adversely affecting food production, ecosystems and land rights – see script on Energy), and investing in the development of 'second-generation' biofuels, which will rely on improved conversion technologies and on a wider range of biomass resources (e.g. crop residues, forestry by-products) – thus reducing pressures on food production and ecosystems compared to 'first-generation' biofuels;
- intensifying (in an environmentally sustainable manner) agricultural practices on existing croplands for the purpose of reducing pressure on forest and other natural ecosystems that store carbon;
- reducing the energy consumption associated with processing and transporting agricultural products in/to distant markets; public education campaigns may for instance be undertaken to encourage the consumption of local and regional products where possible;
- integrating climate change mitigation objectives in the design of agri-environmental measures and rural development policies (e.g. creation of incentives to adopt practices that curb emissions and enhance the "carbon sink" potential of agriculture);
- using and enforcing environmental regulation to control some practices that have an impact on climate (e.g. regulation of nitrogen fertiliser use).

(2) LIVESTOCK

Possible mitigation measures include:

- rehabilitating degraded pasturelands (e.g. by alleviating nutrient deficiencies, re-planting grasses);
- making more efficient use of fertilisers, particularly nitrogen;
- maintaining permanent pastures;
- introducing grass species with higher productivity or deeper roots, and introducing legumes in grazing lands;
- reducing the frequency and intensity of fires in pasturelands through improved fire management practices (more effective fire suppression, vegetation management, etc.);
- adopting improved manure management practices (e.g. covered storage of manure; in intensive systems, installation of anaerobic digestion plants for the production of biogas to be used as fuel for energy production; promotion of solid rather than liquid handling of manure);
- modifying ruminant animals' diet and breeding practices to reduce methane emissions per kg of meat produced;
- developing sustainable sylvo-pastoral projects;
- using and enforcing environmental regulation to control some practices that have an impact on climate (e.g. regulation of manure application on crop- and pasturelands).

(3) FORESTRY

The carbon mitigation potential of forests differs significantly across regions. In the short term, reducing the rate of deforestation produces more benefits than afforestation – however, afforestation is a good option in most regions if one takes a longer-term perspective. Sustainable forest management practices that maintain or increase forest carbon stocks while delivering a sustained flow of other benefits (e.g. timber, fuelwood, fibre, other non-timber forest products, biodiversity conservation, water filtering, protection against erosion, balancing of hydrological flows) generally produce the most benefits from a social point of view. Possible mitigation measures include:

- developing sustainable afforestation and re-forestation projects specifically designed to support environmental and poverty alleviation goals as well as carbon sequestration;
- increasing carbon density in forests;
- developing sustainably managed plantations (e.g. as a source of fuelwood, timber or pulp for paper mills) for the purpose of alleviating pressure on natural forests;
- adopting harvesting practices that minimise carbon losses (e.g. maintaining partial forest cover, minimising losses of organic matter, avoiding most slash-and-burn techniques);
- avoiding the drainage of forest soils and in particular peatlands, which should be protected from clearing, burning and exploitation, and restored where they are degraded;
- developing sustainable agro-forestry projects (e.g. in replacement of unsustainable subsistence farming and cattle grazing);
- developing financing mechanisms ("payments for environmental services") to avoid deforestation and promote forest regeneration;
- promoting eco-tourism and recreational uses of forests in order to generate income and thus create an economic incentive for forest conservation;
- adopting fire prevention and fire management good practices;
- strengthening the regulatory and institutional mechanisms required to reduce illegal logging and unplanned deforestation, incl. the definition of forest property rights and of the rights and obligations of forest owners;
- improving the enforcement of legislation aimed at preventing deforestation or unsustainable timber

production activities.

(4) EXTRACTIVE INDUSTRIES

Possible mitigation measures include:

- adopting less energy-intensive technologies and investing in energy-efficient equipment, rolling stock and facilities;
- switching to cleaner sources of energy.

(5) PROCESSING INDUSTRIES

Possible mitigation measures include:

- using wood waste (e.g. sawdust, wood chips, bark) from sawmills, paper mills and other wood processing industries to generate electricity and heat;
- using crop residues and biomass wastes from agriculture and agro-food businesses (e.g. beet and sugarcane bagasse) to generate electricity and heat;
- producing wood products to displace more fossil-fuel intensive construction materials such as concrete, steel, aluminium, plastics;
- adopting less energy-intensive technologies and investing in energy-efficient equipment, rolling stock and facilities;
- switching to cleaner sources of energy.

(6) TERTIARY SECTOR ACTIVITIES, GOVERNANCE AND INSTITUTIONAL DEVELOPMENT

Possible mitigation measures include:

- investing in energy-efficient equipment, rolling stock and facilities;
- switching to cleaner sources of energy;
- developing capacities to implement mitigation activities and take advantage of opportunities arising from the development of carbon markets.

4. ILLUSTRATIVE EXAMPLES

Illustrative example 1: Bangladesh – Enhancing adaptation capacity of coastal communities

Communities living in the coastal areas of Bangladesh are increasingly exposed to the effects of climate change (salinity intrusions, tidal and storm surges, erosion, water logging), with adverse consequences for their livelihoods. Coastal agriculture, fisheries and generally the livelihoods of the poor are considered extremely vulnerable to the effects of climate change; increased water salinity is also a threat to the health of coastal populations.

A project managed by Caritas Bangladesh, started in July 2008, aims to enhance the adaptive capacities and resilience of coastal communities by directly involving 250 poor households from small coastal communities in a variety of complementary actions, on a pilot basis. The households involved live in three villages in the Satkhira district, in the vicinity of the mangrove forest. They belong to various occupational groups and were selected on the basis of their socio-economic and livelihood conditions. Project activities include:

- an environmental school programme, which will deliver training to school teachers on the impacts of climate change and sea-level rise and thus participate in awareness raising and capacity building;
- the (re-)excavation of ponds and canals to improve freshwater supply;
- mangrove plantation on river banks to increase protection from erosion and cyclones;
- diversification of agriculture (notably by promoting salt-tolerant high-yielding rice varieties);
- home-based horticulture and vegetable cultivation;
- the development of brackish water fish species in aquaculture;
- the promotion of alternative livelihoods (e.g. crab fattening, plant nursery for mangrove regeneration);
- awareness raising on climate change impacts/risks/vulnerability, and institutional strengthening of community-based organisations.

Learning from the project is to be shared at the local, regional and national level and will hopefully allow the replication and scaling-up of successful coping strategies in future.

Illustrative example 2: Eritrea – Adapting livestock management to climate change

Livestock breeding accounts for a significant share of rural incomes and subsistence in the north-western lowlands of Eritrea. However, this activity is increasingly threatened by changes in land and groundwater use, as rangelands are converted to rain-fed and irrigated croplands. The process of confinement of livestock to marginal areas is aggravated by a desertification process that is converting perennial grasslands to more arid savannah. These pressures are and will be increasingly exacerbated by climate change. Livestock production systems already exceed carrying capacities; the related livelihoods are considered highly vulnerable to climate change effects in the long term, as significant rises in temperature are expected. The frequency of droughts has already increased, leading to lower water availability, reduced vegetation productivity, changes in ecosystem services and heat stress. Livelihoods diversification should be promoted, but is hindered by lack of access to credit and markets, lack of information and lack of skills.

To address this situation, a joint UNDP-GEF project is being designed to enhance the resilience of pastoral communities to climate change and climate variability. It focuses in particular on the development of water harvesting for the purpose of improving rangeland productivity. The project, expected to start in 2008, will: (i) support national research capacity; (ii) promote institutional and human resource capacity development; (iii) develop a financing framework aimed at making water provision, maintenance and extension services financially sustainable; and (iv) promote evidence-based adaptation of policies and regulations related to land use and pastoralism. On top of providing training and extension services in relation to land and pasture management and climate risks, the capacity development component will support the development of an early warning system, of participatory resource use and management plans, and of land use and natural resource planning guides.

Illustrative example 3: Moldova – Soil conservation projects

Moldova is an agrarian country with sizeable areas of degraded and eroded agricultural lands. This results in low agricultural yields as well as frequent landslides. Afforestation and reforestation are

two effective ways of addressing this problem, since they allow a stabilisation of landslides while promoting land regeneration.

With the help of the Prototype Carbon Fund[15], a soil conservation project was designed to re-plant degraded pasturelands with shrubs and tree species adapted to poor soil conditions. The project's primary objective is to conserve and restore the soils on thousands of hectares of degraded, severely eroded and unproductive lands. In so doing, the project generates many benefits for the local population, such as increased availability of fuelwood, timber and non-timber forest products, reduced damage from landslides, improved productivity of neighbouring fields (thanks to reduced wind erosion and improved hydrological balance), the development of community-based participatory forest management practices, and positive biodiversity effects (through the reintroduction of native species and semi-naturalised species).

By promoting the development of tree vegetation, the project also sequesters considerable amounts of carbon, making it eligible to receive revenue from the sale of carbon credits to the Prototype Carbon Fund. Carbon financing is a key element for the financial sustainability of the project.

Further to the introduction of this "prototype" project, Moldsilva (the State Forestry Agency) has developed other soil conservation projects based on afforestation and reforestation, which also generate significant benefits for local communities while contributing to carbon sequestration and thus to the overall objective of reduction in greenhouse gas emissions. These projects are supported by the BioCarbon Fund.[16]

Illustrative example 4: Brazil – Sugar bagasse co-generation projects

Sugar bagasse is a fibrous by-product of sugarcane processing. The State of Sao Paulo in Brazil accounts for 70% of Brazil's sugar production; sugarcane mills in this region generate large quantities of bagasse every year. Many Brazilian sugarcane mills burn this by-product in boilers for the purpose of generating electricity and heat to power their own operations; however, the energy production processes used so far have not been very efficient, notably because there was no possibility for sugar mills to sell the extra power they generated to the national grid and so no incentive to invest in generating capacity beyond their own needs.

Thanks to changes in electric sector legislation, electricity purchase from independent power producers is now possible. With some support from the World Bank-managed Prototype Carbon Fund, the Alta Mogiana sugar mill in the State of Sao Paulo is implementing a project to significantly upgrade its energy generation capacities. The company is re-furbishing existing pressure boilers and investing in new equipment to move to high-efficiency co-generation of steam and power. This allows the extraction of much more energy from the residual biomass of sugar and ethanol production activities. The extra power generated is sold to the national grid, on a commercial basis. Furthermore, being located in an industrial region, the new facilities reduce energy losses from transmission by supplying power closer to where it is consumed. Overall, the project thus contributes to enhancing

[15] The Prototype Carbon Fund (PCF) supports pilot projects aimed at reducing GHG emissions while promoting sustainable development. It notably supports the development of methodologies for accounting for and monitoring emission reductions, in order to facilitate the sale of certified emission reductions under the Clean Development Mechanism of the Kyoto Protocol or other similar schemes. The PCF is a partnership between 17 companies and 6 governments, and is managed by the World Bank.

[16] The BioCarbon Fund was set up by the World Bank to support projects that sequester or conserve carbon in forests and agro-ecosystems while promoting other sustainable development goals, notably biodiversity conservation and poverty reduction.

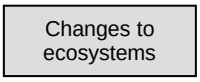
energy efficiency and the productivity of agricultural land.

The sale of electricity to the grid would not on its own be sufficient to justify the investment involved. However, the project also contributes to a reduction in greenhouse gas emissions by substituting electricity produced by fossil-fueled thermal power plants with electricity from a renewable source. In recognition of this, it receives revenue from the sale of verified and certified emission reductions under the Clean Development Mechanism (CDM) of the Kyoto Protocol. This extra source of income makes the project financially sustainable. Several similar projects are being implemented in Brazil and in other sugar-producing countries.

5. ILLUSTRATION OF LINKAGES

Below are a few illustrations (in a format that was voluntarily kept simple[17]) of the linkages between biophysical effects of climate change, potential socio-economic consequences and possible adaptive responses. They are provided to help visualize some important cause-effect relationships and how adaptive responses relate to the identified manifestations and impacts of climate change.

Legend:

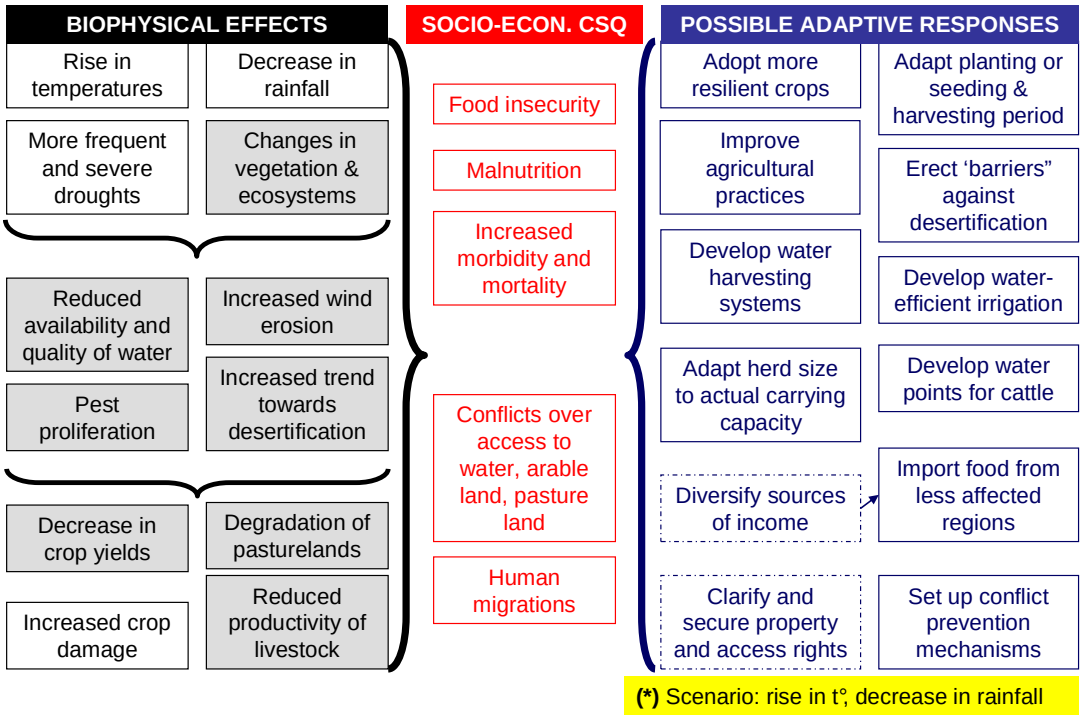


Grey boxes show biophysical impacts that are not exclusively or even primarily caused by climate change – but are also significantly influenced by other pressures resulting from human activities.

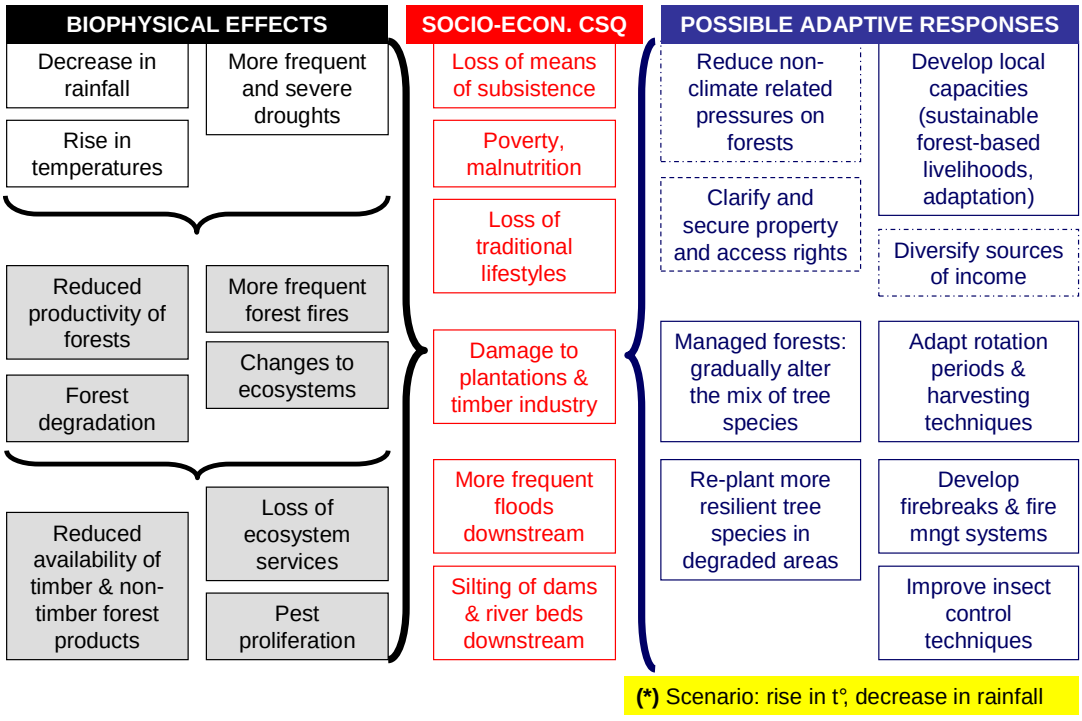
Boxes framed with a dotted line show possible responses that are in principle not under the direct control of the concerned sector authorities – but depend on the development of a cross-sectoral coordinated response.

[17] These illustrations are not meant to be comprehensive, or to be universally applicable; the simple format retained does not allow showing the multiple systemic interactions (including feedback loops) between various elements.

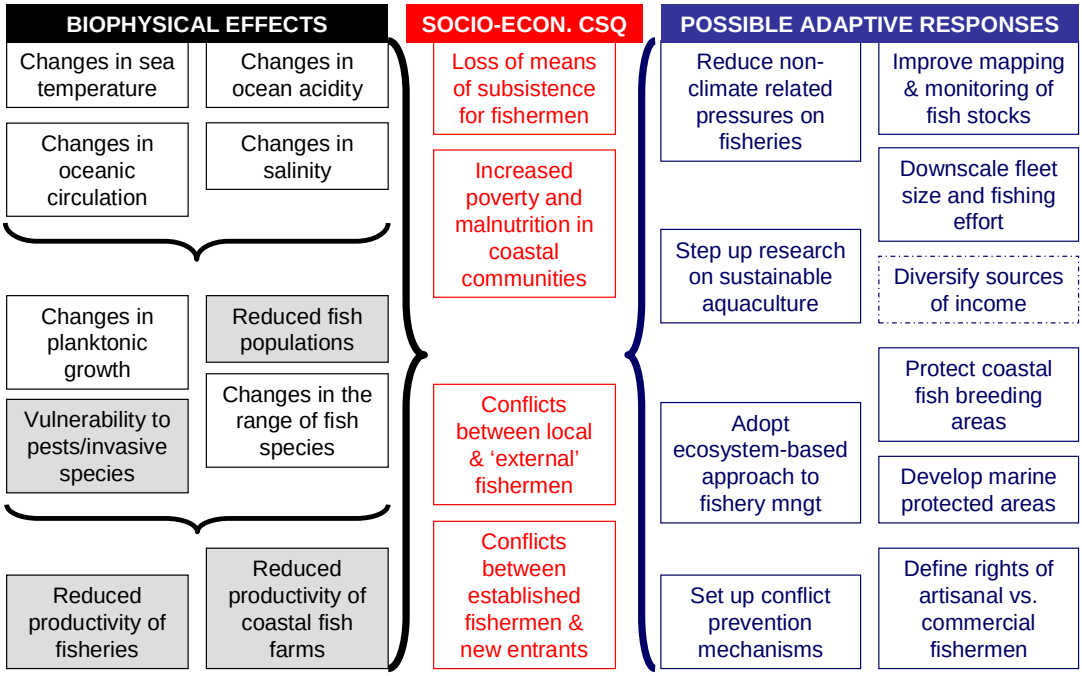
Climate change: Cause-effect-response linkages A&RD – Illustrative ex. (agriculture, semi-arid region) (*)



Climate change: Cause-effect-response linkages A&RD – Illustrative ex. (forests, forestry) (*)

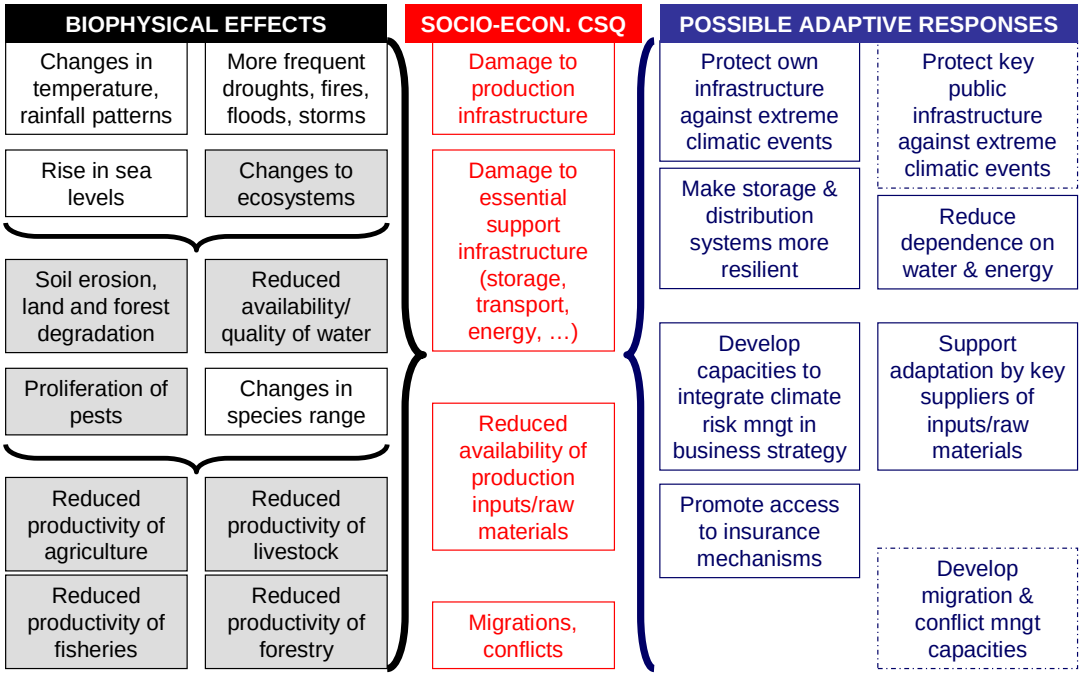


Climate change: Cause-effect-response linkages A&RD – Illustrative ex. (fisheries, fish farms)



3

Climate change: Cause-effect-response linkages A&RD – Illustrative ex. (processing industries)



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6. REFERENCES

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(1) IPCC (2007) – *Climate Change 2007: Synthesis Report*, Fourth Assessment Report, Intergovernmental Panel on Climate Change. Available on: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

(2) IPCC (2007) – *Climate Change 2007 – Impacts, Adaptation and Vulnerability*, contribution of Working Group II to the Fourth Assessment Report, Intergovernmental Panel on Climate Change/Cambridge University Press. Available on: http://www.ipcc.ch/ipccreports/assessments-reports.htm (see in particular Chapter 3 on "freshwater resources and their management", Chapter 4 on "ecosystems, their properties, goods and services", Chapter 5 on "food, fibre and forest products", Chapter 6 on "coastal systems and low-lying areas, and Chapter 7 on "industry, settlement and society")

(3) IPCC (2007) – *Climate Change 2007 – Mitigation of Climate Change*, contribution of Working Group III to the Fourth Assessment Report, Intergovernmental Panel on Climate Change/Cambridge University Press. Available on: http://www.ipcc.ch/ipccreports/assessments-reports.htm (see in particular Chapter 8 on "agriculture" and Chapter 9 on "forestry")

(4) FAO (2006) – *Livestock's long shadow: environmental issues and options*, Food and Agriculture Organization, Rome

(5) EC (2008) – *Climate change: the challenges for agriculture*, Fact Sheet, European Commission, Directorate-General for Agriculture and Rural Development

(6) EC (2007) – *Forests and Climate Change*, Background Note, European Commission, EuropeAid

(7) EEA (2008) – *Impacts of Europe's changing climate – 2008 indicator-based assessment*, European Environment Agency/EC Joint Research Centre/World Health Organization. Available on: http://www.eea.europa.eu/themes/climate (see in particular sections 5.4 on "marine biodiversity and ecosystems", section 5.7 on "terrestrial ecosystems and biodiversity", section 5.8 on "soil", and section 5.9 on "agriculture and forestry")

(8) UNEP-GEF-GEC-WI (2007) – *Assessment on peatlands, biodiversity and climate change*, Executive summary, UN Environment Programme/Global Environmental Fund/Global Environment Centre/Wetlands International. Available on: http://www.gecnet.info/index.cfm?&menuid=48

Illustrative example 1

(9) http://www.southsouthnorth.org/ (Project Portfolio – Adaptation projects – Bangladesh_Project_Satkhira.pdf)

Illustrative example 2

(10) http://www.undp-adaptation.org/project/livestock

(11) http://www.adaptationlearning.net/downloads/ALM_Profile_UNDPEritrea.pdf

Illustrative example 3

(12) Prototype Carbon Fund project:
http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=9612

(13) Other projects supported by the World Bank's BioCarbon Fund::
http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=26320
http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=35579

Illustrative example 4

(14) Alta Mogiana project: http://carbonfinance.org/Router.cfm?Page=Projport&ProjID=9618
http://cdm.unfccc.int/Projects/DB/TUEV-SUED1134666922.78

(15) http://cdm.unfccc.int/Projects/index.html for other similar projects (type "bagasse cogeneration" in the "project search" box)

7. FURTHER INFORMATION AND SUPPORT

AVAILABLE SECTOR SCRIPTS

- Agriculture & Rural Development (ARD)
- Economic Development *(April 2009)*
- Education
- Energy
- Environment & Natural Resources (ENR) *(April 2009)*
- Governance *(April 2009)*
- Health
- Infrastructure (incl. Transport)
- Solid Waste Management
- Water & Sanitation

For further support in relation to the use of sector scripts, including the identification of sources of information on climate change projections in specific regions, you may contact the team in charge of providing advisory services for environmental integration in EC development/external co-operation:

c/o Agreco, Avenue Louise 251/box 23, B-1050 Brussels, Belgium
e-mail : hde@agreco.be, tel. (+32-2)626-3320, fax (+32-2)646-3502
Website : www.environment-integration.eu