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HIGH-LEVEL CONFERENCE ON WORLD FOOD SECURITY: THE CHALLENGES OF CLIMATE CHANGE AND BIOENERGY

Rome, 3-5 June 2008

CLIMATE CHANGE, BIOENERGY AND FOOD SECURITY: OPTIONS FOR DECISION MAKERS IDENTIFIED BY EXPERT MEETINGS

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BACKGROUND

The High-Level Conference was preceded by a series of expert meetings on climate change, bioenergy and food security, which were held in Rome between February and April 2008, with the objective to assemble the state of the art scientific knowledge and to draw upon the experience of relevant networks. A total of about 80 experts serving in their personal capacities, as well as FAO staff, representatives from IFAD, WFP, CGIAR and other partner institutions (i.e. UN-system, intergovernmental organizations, international research institutes) discussed specific themes and agreed on selected options for decision-makers which are compiled in this document. The reports of each expert meeting are made available in the HLC Background Document series. These documents, as well as individual presentations, agenda and list of participants are made available online (www.fao.org/foodclimate).

I. CLIMATE CHANGE ADAPTATION AND MITIGATION

A. INTRODUCTION

1. Climate change will compound existing food insecurity and vulnerability patterns. Communities must prepare themselves for the possibility of food shortages and make appropriate use of resources to protect their livelihoods as well as lives and property. It is imperative to identify and institutionalize mechanisms that enable the most vulnerable to cope with climate change impacts. This requires collaborative thinking and response to the challenges generated by the interaction between food supply, climate change and sustainable development.

B. THE CLIMATE ADAPTATION CONTEXT

2. Vulnerability to food insecurity shocks has grown global. Global and local food security vulnerability patterns will be modified by climate change. Small-scale rainfed farming systems, pastoralist systems, inland and coastal fishing and aquaculture communities and forest-based systems are particularly vulnerable to climate change. Moreover, the urban poor, particularly in coastal cities and floodplain settlements, face increasing risks. It is urgent to build “resilient” communities living off agricultural, forestry and fisheries/aquaculture systems that have high capacity to adapt to stress and disturbances.

3. Attempts to improve resilience to future and uncertain impacts through anticipatory and planned adaptation and innovation will have both immediate and future costs – with trade-offs between optimizing current conditions and minimizing vulnerability to future shocks. For instance, diversifying agriculture may decrease profitability in the short term, but also reduce future vulnerability. Adaptation to climate change must also focus on prevention and removal of maladaptive practices that may do not succeed in reducing vulnerability but, instead, could increase it.

4. Technical adaptation measures range from temporal and spatial variations in production systems (e.g. adjusting planting or fishing dates, rotations, multiple cropping/species diversification, crop-livestock pisciculture systems, agroforestry) to confer better protection against temperature changes, changing rainfall variability and patterns, salinization though sea level rise, and pest attacks - to investing in soil, water and biodiversity conservation and development (e.g. building soil biomass, restoring degraded lands, rehabilitating rangelands, harvesting and recycling water, planting trees, developing adapted cultivars and breeds, protecting aquatic ecosystems) in order to maintain long-term productivity.

5. Adaptation measures also include establishing disaster risk management plans and risk transfer mechanisms, such as crop insurance and diversified livelihood systems. For example, integrated aquaculture-agriculture systems will allow activities to shift in response to changes in the suitability of land and availability of water to produce food. In cases where benefits of diversification are limited, such as those that affect all aspects of the food production systems, social safety nets are required. An important caveat is that there are limits to adaptation. Due to changing climate, the frequency of floods and droughts may increase so much that agriculture, fisheries and forestry are no longer sustainable. Diversification to other economic activities and relocation will need to be considered under such conditions.

C. MITIGATION: NEW OPTIONS FOR CARBON SEQUESTRATION IN AGRICULTURE AND FORESTRY

6. Agriculture and land-use change such as deforestation contributes to, respectively, 13 and 17 percent of total anthropogenic greenhouse gas (GHG) emissions. While carbon dioxide emissions from agriculture are small, the sector accounts for about 60 percent of all nitrous oxide (N_2O, mainly from fertiliser use) and about 50 percent of methane (CH_4, emitted, mainly from natural and cultivated wetlands and enteric fermentation). The GHG impact through radiative forcing of N_2O is 300 times that of CO_2. Methane and nitrous oxide emissions are projected to further increase by 35 to 60 percent by 2030, driven by growing nitrogen fertilizer use and increased livestock production in response to growing food demand.

7. Mitigation of climate change is a global responsibility. Agriculture, forestry, fisheries/aquaculture provide, in principle, a significant potential for GHG mitigation. The IPCC estimates that the global technical mitigation potential for agriculture (excluding forestry) will be between 5 500 and 6 000 Mt CO_2-equivalent per year by 2030, 89 percent of which are assumed to be from carbon sequestration in soils.

8. *Global Soil Carbon Sequestration Initiative*. IPCC estimates that the reduction of agricultural GHG mitigation options are cost-competitive with non-agricultural options for achieving long-term climate objectives. Soil carbon sequestration could in fact take effect very quickly and is very cost-effective in agriculture. A win-win approach could be achieved by paying farmers for carbon sequestration (building soil organic matter) which sets up a scenario where: CO_2 is removed from the atmosphere (mitigation); higher organic matter levels in soil increase agroecosystem resilience (adaptation); and improved soil fertility leads to better yields (production and income generation). However, sequestration of CO_2 in soils is not included in the Clean Development Mechanism (CDM) agreed to in Kyoto. The scope of the successor of the CDM could be enhanced with a view to increase carbon sinks in soil and in above- and below-ground biomass, and thus contribute to removing methodological barriers to operationalising soil carbon sequestration under the Post-2012 climate change regime. FAO should play a leading role in this process, including through the establishment of a Global Soil Carbon Sequestration Initiative entrusted with the promotion of agricultural technologies that restore carbon pools and soil quality (e.g. organic agriculture, conservation agriculture) and to create tools to measure, monitor and verify soil carbon pools and fluxes of greenhouse gas emissions (namely nitrous oxide) from agricultural soils, including croplands and pastures.

9. *Reducing Emissions from Deforestation and forest Degradation in developing countries (REDD).* Since the Eleventh Session of its Conference of Parties (COP) in November 2005, UNFCCC has been exploring the possibility of developing an instrument under the Convention to provide financial incentives for Reducing Emissions from Deforestation and forest Degradation in developing countries (REDD). As the UN agency with the mandate for forestry and a comprehensive programme covering all aspects of forestry as well as agriculture, FAO can play a leading role in: providing technical information and support for the development of methodological and policy options for REDD; strengthening capacity for countries undertaking REDD programmes, including developing systems for monitoring changes in forest carbon; and

addressing underlying causes of deforestation and forest degradation rooted in both the agriculture and forest sectors. In addition, FAO can launch a comprehensive REDD support effort for developing countries.

D. THE KNOWLEDGE BASE

10. *Strengthening IPCC and UNFCCC on agriculture and food-related issues*. IPCC could improve its assessments on the impacts of climate change on food security. The establishment of a Global Food Security Observing System (GFSOS) is seen as an extension of FAO's Global Information and Early Warning System. It is also a technically feasible option to set up permanent monitoring of the effects of current and future climate on food security. Global studies must be complemented by comprehensive national assessments of climate change impacts on agriculture and food security. Local impacts are badly needed to support national and subnational decision-making. While existing studies mainly focus on the effect of down-scaled climate change scenarios on major crops and aquatic species, future studies should look at a wider range of crops and also take into account local farming dynamics and resource base, food marketing chains and delivery systems, the greater international connectedness, food prices, the implications of agricultural policy and possible development pathways. In some regions, such as large parts of Africa, such studies are hampered by highly uncertain trends in rainfall, the insufficient resolution of climate models and the lack of climate observation data.

11. *Improving data collection and impact assessment capacity*. Improving data collection and sharing results at national, regional and international levels will improve local weather forecasts, seasonal climate forecasts, risk and impact assessments. It can also increase the detail of climate impact assessments to a scale that is meaningful for optimizing adaptation and mitigation measures, and operating nearly real-time early warning and hotspots warning systems for food security, agriculture, forestry and fisheries. This refers particularly to the 10 to 15 years time horizon over which the reliability of impact projections is probably acceptable and the planning of responses is probably realistic. Better data will improve access to international funding mechanisms. National extension and agronomic research services have an increased role to play in data collection, analysis and use for decision-making and decentralized service delivery to farmers. There is also a need to include social science research to boost understanding on how people adopt and implement adaptation and mitigation options.

12. A*groecological research.* Research will provide the backbone for adaptation and mitigation methodologies. However, research for a rapidly changing situation is different from research for stable ecological conditions. Traditional knowledge and local biodiversity are a suitable entry points, but likely to be insufficient in a rapidly changing situation. In addition, methodologies, crops and crop varieties need to be developed for future conditions as their applicability cannot be assessed at the location where they may be used in future. This requires strong national and international agricultural, forestry and fisheries research and provides an important role to the Consultative Group on International Agricultural Research (CGIAR) Centres. Research results need to be public in an enabling environment in which methods, germplasm, crop varieties and animal breeds are accessible for use and introduction in adaptation programmes.

E. CLIMATE-RELATED CAPACITIES IN AGRICULTURE, FORESTRY AND FISHERIES

13. Country capacity to assess and apply adaptation and mitigation measures in agriculture, forestry and fisheries is weak at two levels: national institutional frameworks; and adaptive capacity of local populations to climate change and variability. To implement national climate change and food security policies, there is need for in-depth knowledge of appropriate methods and tools as well as awareness of available funding mechanisms, such as the carbon market and adaptation funds established under the IPCC.

14. *Capacity strengthening*. The capacity to identify, collect and share data, use information and methods and build knowledge relevant for climate change adaptation, mitigation and food security is critical because of rapidly changing climatic, environmental and socio-economic conditions. Extension services and mechanisms have been weakened greatly over the last two decades. Extension will need to be strengthened substantially in order to address adaptation and mitigation if it will have to provide an efficient interface between policy-makers and the farming community. Recognizing that climate change will alter many existing equilibriums, socio-economic dynamics must be considered, and the role of all the partners may need to be re-examined or redefined.

Capacities weaknesses in adaptation development in the food sectors

- vulnerability of infrastructure (e.g. irrigation, means to cope with flood, seawater incursion protection), non-structural measures (e.g. legislation, insurance and capacities to integrate adaptation into development planning at all levels), transportation, food storage and distribution systems to climate vagaries;
- lack of crop varieties, animal and aquatic species breeds, trees and forests adapted to climate change;
- lack of climate-related knowledge in research and extension;
- lack of standard tools to assess main vulnerability patterns that can be tailored to national circumstances;
- lack of monitoring and forecasting of variable food availability;
- insufficient knowledge of rural development and of the roles of markets, trade, migration, refugees, urbanization and their linkage to climate change and food security;
- lack of understanding of social dimensions of vulnerability and resilience, such as how climate change will require shifts in use of, and access to, natural resources (land, water), credit and education;
- insufficient institutional capacities and integration.

15. *Regional cooperation*. Neighbouring countries often share similar problems and solutions. Countries can pool their resources to inventorize and share traditional and innovative solutions. They can also take advantage of developing regionalized markets in order to reduce greenhouse gas emissions and transport costs and increase benefits and rural incomes.

F. POLICY DEVELOPMENT

16. *Integrated climate change strategies*. Climate change strategies and action plans must account for all sectors' specificities. Since food security, sustainable development, and climate change adaptation and mitigation are strongly linked, policies need to be integrated across levels (from people to institutions and ministries) and across sectors. This will avoid later contradictions between local actions and higher decision-making, and ensure that national policies use the benefits associated with the international mechanisms to improve the livelihoods of people. Awareness raising, permanent monitoring of changing vulnerabilities and capacity building are essential components of national climate change strategies.

17. *Increasing resilience of food production systems.* Many countries would benefit from identifying and promoting positive incentives to practices, production systems, and land/aquatic resource-use policies and tenure systems that increase resilience of food production systems. Countries should facilitate the design of new policy tools that consider climate change but also build on already available tools such as early warning systems and disaster risk management. In parallel, negative incentives that encourage harmful practices and production systems and unsustainable land/aquatic resource-use should be identified and removed. Policies to encourage appropriate investments and technology transfer into rural areas should be directed towards reducing long-term negative effects of short-term climate variability on food security. Examples

include crop insurance, policy, legislation and non-structural measures that target vulnerable people.

18. *Land and aquatic resource use planning.* Investments in forest conservation and sound forest management, tree planting, sustainable fisheries and aquaculture development, and improved soil and water management for climate change mitigation and adaptation require addressing tenure constraints and incentives, and managing pressure and conflicts over resources. It is paramount to secure land and resources rights of groups and individuals, facilitate community involvement and establish solid, robust institutions for governance and conflict resolution. Land, water and aquatic resource-use planning and policy measures are particularly essential to: avoid perverse incentives which lead to detrimental land conversion, such as from forest to agriculture; identify measures to reduce pressure on natural resources and promote sustainable land-use systems; avoid encroachment of agriculture and disruption of mobile dryland pastoral systems that are adapted to droughts and irregular rainfall; and manage the consequences of massive migration and refugees.

G. FINANCIAL INSTRUMENTS

19. *More active participation in the international climate change discussions*. Climate variability and change are dominant factors driving food production availability and stability. They also affect, at least indirectly, food accessibility and utilization. Measures aiming at improving food security directly contribute to sustainable development. On the other hand, measures for adapting to climate change or reducing emissions can contribute to food security. The Post-2012 climate change regime that is currently being prepared offers an important window of opportunity to developing countries. Many countries would benefit if the international carbon-related funding mechanisms paid more attention to food security, agriculture and livestock, soil, fishery and rangeland activities, along the lines of REDD (Reducing Emissions from Deforestation and forest Degradation).

II. CLIMATE CHANGE, WATER AND FOOD SECURITY

A. INTRODUCTION

20. Climate change is expected to alter hydrological regimes and patterns of freshwater resource availability, with impacts on rainfed and irrigated agriculture, livestock, inland fisheries and aquaculture.

21. By 2060, projections indicate a general reduction of precipitation in semi-arid areas, higher variability in rainfall distribution, increase in the frequency of extreme events (droughts and foods) and increase in temperature affecting, in particular, agriculture in low latitudes. A significant reduction in river basin runoff and aquifer recharge can be expected to occur in the entire Mediterranean basin and the semi-arid areas of Southern Africa, Australia and part of the American continent. On the other hand, northern temperate latitudes, in which rainfed agriculture is dominant, can expect positive moisture and temperature impacts to boost overall production. Parts of Southeast Asia can anticipate increases in run-off which may allow increased water use, but also exacerbate drainage and water-logging problems.

22. Globally, agricultural production will have to cope with more variability in water inputs and more competition for bulk water[1]. While climate change does not seem to threaten the overall

[1] Other drivers adversely affecting water availability for food production include: rapidly increasing non-agricultural water demand for domestic, industrial and, increasingly, environmental uses; declining water quality levels; and growing water demand for non-food agricultural production.

global food balance during the medium term, food insecure areas dominated by rainfed agriculture (sub-Saharan Africa and peninsular India in particular) may suffer multiple, short-term adverse impacts, especially in densely populated farming systems. These impacts will include reduced production levels, lower agricultural incomes, loss of livelihoods and displacement. It is also anticipated that a combination of reduced river base-flows, flooding and sea-level rise will hit highly productive irrigated systems which currently help maintain the stability of global cereal production. The production risks will be amplified in alluvial plains dependant upon glacier melt (e.g. Punjab) and in lowland deltas in particular (e.g. Indus, Nile, and Ganges).

23. *Alleviating resource pressure*. Pressure exerted on the natural resource base underlying food production is already stretched and many of the large contiguous irrigated areas are operating at their socio-managerial limits. Any further change will exacerbate already existing water scarcity problems. At regional and national level, this will call for efforts to increase water productivity and strengthen resilience in all water dependant food production systems. A careful review of soils, surface and groundwater storages and an anticipation of future needs will be key in building resilience and reconciling competing demands while also maintaining environmental services.

24. *Maintaining production capacity.* Reduced food production capacity in rainfed systems will transmit demand into already tight global commodity markets, destabilizing and driving prices higher, and putting further pressure on irrigated production. Adaptation strategies focusing on improved water infiltration, soil moisture retention and management, water harvesting, supplemental irrigation, and small- and dam-based irrigation development will be required to increase the resilience of these highly vulnerable production systems. Critical water-related actions include:

- promoting technical and management measures to reduce non-beneficial consumptive use in both irrigated and rainfed production systems;
- supporting extension services to promote diversification into crops with higher water productivity to adapt to changing markets, and
- updating land and water management development strategies to take account of anticipated climate change impacts.

25. Ma*instreaming adaptation.* The existing knowledge base is sufficiently precise to warrant mainstreaming. Notwithstanding gaps in data and research, progressive “no regrets” adaptation across land and water systems can provide both a positive response to climate change but also make good environmental and economic sense in its own right. This requires specific national capacity in climate change assessment. In addition, system-based analyses and plans that operate within an integrated water resource management framework need to link with analyses of crops – particularly staples such as wheat and rice – and of ecological regions. At all levels, adaptation and mitigation programmes need to start with an awareness-raising initiative for policy-makers, researchers and opinion leaders focusing on production systems most threatened by climate change impacts. Linking regional centers for water, climate change and food to existing national and international centers of excellence is recommended to support national capacity in copying with climate change. Additional and new financing mechanisms for adaptive water management initiatives will be needed. Farmers access to microcredit has proven to be a positive adaptive strategy. Capacity building must be an integral part of these programs.

B. PRIORITIES AT NATIONAL, REGIONAL AND INTERNATIONAL LEVELS

26. Given the fundamental value of water to all economic sectors, agriculture cannot act alone. Water management actions will need to be focused at national level but supported by regional and international initiatives. Specific options are listed below.

National level

27. Planning approaches:

- Provide support at the national level for collection of data and information for assessing renewable water resources and determining the potential change and impact that could result from climate variability.
- Mainstream adaptation and mitigation measures for agricultural water management into national development plans, employing an integrated water resource management framework.
- Adopt strategic inter-sectoral development planning aimed at increasing resilience, adapting to climate change impacts and maintaining environmental services and biodiversity.
- Update land and water management development strategies and economic plans to account for anticipated impacts of climate change, particularly increased variability and long-term drying or wetting trends.

28. Institutional development:

- Set the conditions for more flexible and responsive service-oriented water management.
- Develop tools for water-related conflict resolution and prevention at local and district levels.
- Develop and implement economic and financial trade instruments to remove distortion in water allocation.

29. Management options:

- Revise operating procedures for water storage systems to accommodate climate change impacts on water supply and demand.
- Promote watershed management and soil moisture conservation practices to increase infiltration and soil water storage.
- Increase surface and groundwater storage options at a range of scales including distributed tank rehabilitation and possible new large-scale impoundments.
- Increase water productivity through measures such as intermittent rice irrigation.
- Promote risk management in national policies through better monitoring networks, risk assessment, early warning, risk sharing and participatory response mechanisms.
- Develop alternative sources of water supply, such as treated wastewater streams for peri-urban agriculture and desalination plants for coastal urban supply.

30. Economic and financial instruments:

- Document and quantify current patterns of water use and water entitlements.
- Develop transparent water allocation mechanisms to protect water use rights while providing greater flexibility to respond to scarcity under anticipated patterns of climate change.
- Develop innovative insurances products.

Regional level

- Develop and strengthen transboundary cooperation and institutional mechanisms to anticipate and respond to climate change impacts on transboundary water resources, including mechanisms to optimize water allocation and manage extreme hydrological events (floods and droughts).
- Standardize climate and hydrological data formats and promote exchange of national data to improve operational hydrological forecasting and regional climate prediction/forecasting.

International level

- Combine global data sets on water resource balances at basin level with production data to track climate change impacts.
- Focus international research agendas on systemic water productivity gains.
- Promote interlinkage between climate change, water and food security needs in global water meetings, such as the World Water Forum.
- Assess the vulnerability of globally-important food production systems and its potential impact on food security for the low-income food-deficit countries.

C. ADDRESSING KNOWLEDGE GAPS

31. There are key gaps in data and research related to climate change and water. Many of these have been stipulated in the Fourth Assessment Report of the Inter-Governmental Panel on Climate Change and the forthcoming Technical Paper on Climate Change and Water. In view of these reports, it is recommended that policy-makers be made aware of current shortcomings and gaps in data and applied research.

32. Quality-assured local and country data are essential to establish overall water supply and demand balances, track climate change impacts and inform responses. Improved national data collection and verification are widespread needs, requiring international support and coordination. Internationally recognized databases such as AQUASTAT and FAOSTAT are important vehicles for standardizing, organizing, and disseminating improved national and basin-level water data. Key areas requiring attention include:

- improved water supply and water use data that consider both quantity and quality;
- improved data on the frequency and magnitude of extreme events;
- improved estimates of exploitable groundwater reserves.

33. Information on water resource status needs to be accompanied by enhanced information on water use in all water-using sectors and on the value and productivity of water in the various agricultural sub-sectors. The latter would include rainfed and irrigated agriculture, fisheries, agro-forestry and livestock, and would assess competition, complementarities and relative contributions to food security.

34. Water management, agriculture and food security databases should be better integrated, with much closer monitoring of irrigated and rainfed production and clearer distinction between the sources of supply (rainfall, surface water, and groundwater). This effort should consider specific food staples, notably rice and wheat, as well as the productivity of water dependent aquatic environments.

35. Integrated assessments of the impact of climate change and variability on food security will be a priority for applied research. These analyses can serve to underpin development of enhanced adaptation methodologies and strategies and should include assessments of the potential impact on water resources of bioenergy production and of mitigation measures such as minimum-tillage and agro-forestry development. Important factors to consider in impact modelling include climate variability, shifts in seasonality, land use changes, yield responses to temperature rise and increased CO_2 concentrations, new crop varieties, and the impact of trade and macro-economic and sectoral policies.

36. Specific research requirements include:

- Determining potential water productivity increases in crop agriculture, taking into account local production environments, livelihood impacts, technological options and environmental impacts.
- Defining methods for improving linkages between remote-sensing information and ground-based data;

- Downscaling climate projections for use in hydrologic modelling and agricultural water management;
- Assessing the potential impact of bioenergy and other mitigation measures on water availability for food production;
- Determining social, economic, institutional and human resource limitations to adaptive capacity and strategies for easing these constraints.

D. ADDRESSING CAPACITY NEEDS

37. Because proactive policy and action responses are typically taken at the national level, the capacity of national systems to generate knowledge, inform decision making, build awareness, transfer knowledge and implement effective action is critical to successful adaptation to climate change.

38. The following immediate steps are required:

- Promoting technical and management measures to reduce non-beneficial consumptive use in both irrigated and rainfed production systems and support extension services to promote diversification from high water-use crop systems into crops with higher water productivity.
- Building skills at the national level in economic planning, demand forecasting, model downscaling and hydrologic impact assessment to supplement current analytical capacities.
- Creating or strengthening regional centers on water, climate change and food, and link them to existing national and international centres of excellence to build local and regional capacity. The centres' key objectives would be producing scaleable solutions to food production under amplified hydrological variability and temperature changes and supporting updated land and water management development strategies to account for anticipated impacts of climate change. Their tasks would include data analysis, research, education, training, policy support and communication.

E. ENABLING FINANCIAL MECHANISMS

39. Implementing the technical options identified above would require opening the investment space for agricultural water management. Specific recommendations include:

- Mobilizing adaptation funds to support developing countries investments to build analytical and management capacity to meet the challenges of water and food security under climate change.
- Funding National Adaptation Programmes of Action (NAPAs) in Least Developed Countries to accelerate adaptation in agricultural water management.
- Encouraging national governments to allocate adequate financial resources for adaptation planning in the field of water management for agriculture.
- Enhancing opportunities for small farmers to develop Clean Development Mechanism (CDM) projects and access funds in post-2012 arrangements.
- Enable adaptation/mitigation financing mechanisms to best practices, such as alternate wet-dry rice production systems.
- Developing implementation mechanisms enabling payment for environmental services in watersheds.

III. BIODIVERSITY FOR FOOD AND AGRICULTURE

A. DEVELOPING THE KNOWLEDGE BASIS TO MONITOR BIODIVERSITY TRENDS AND ASSOCIATED RISKS

40. Analyzing whether climate change may constitute a threat for biodiversity in the future requires understanding the extent and distribution of biodiversity for food and agriculture, and its vulnerability and adaptation patterns. Matching this information with that available from climate change models will be a basic requirement to inform conservation and adaptation strategies. Lack of characterization and evaluation of genetic resources for food and agriculture will be an obstacle in developing adaptation mechanisms to climate change. Evaluation is currently an important bottleneck across all types of genetic resources. Improving information systems for genetic resources and the dissemination of relevant information to users will be an important priority for the future.

41. Suggestions for future action:

- Improve biodiversity national inventories to include relevant spatial information assessing threats caused by climate change to species, populations or genotypes of relevance to food and agriculture.
- Improve knowledge on the genetic processes, such as geneflow, introgression, local populations and extinctions, that allow or undermine species adaptation to climate change of relevant biodiversity for food and agriculture.
- Undertake predictive modelling of future distribution of genetic resources for food and agriculture under different climate change scenarios to inform national strategies.
- Develop biodiversity monitoring plans to analyze changes in delivery of ecosystem services due to climate change in specific farming systems, to inform place-based adaptation strategies.
- Strengthen characterization and evaluation of genetic resources for food and agriculture as a fundamental basis to enable sustainable use.
- Develop or strengthen information systems on genetic resources, including early warning systems.

B. INTER-SECTORIAL COOPERATION AND INTEGRATED PLANNING

42. Biodiversity for food and agriculture and climate change have rarely been discussed in the same context. Previous global assessments on climate change have dealt with possible impacts on food security and on biodiversity, but, so far, there has been no comprehensive analysis at the global level of the threats posed by climate change to the biodiversity most important to food security and on the crucial role biodiversity for food and agriculture can play to respond to climate change. On the other hand, previous global assessments of the status and trends of biodiversity for food and agriculture had limited focus on climate change. Given its potential to contribute to coping with climate change, the sustainable management of biodiversity for food and agriculture should be made a basic component of adaptation strategies.

43. Suggestions for future action:

- Improve cooperation between the United Nations Framework Convention on Climate Change and relevant biodiversity forums, such as the Commission on Genetic Resources for Food and Agriculture, the International Treaty on Plant Genetic Resources for Food and Agriculture and the Convention on Biological Diversity.
- Integrate climate change dimensions into future global assessments on biodiversity for food and agriculture, so that the findings can inform future climate change assessments by incorporating agricultural biodiversity perspectives.
- Develop integrated strategies to tackle climate change adaptation and mitigation, food security and rural development, and the sustainable management of biodiversity. In doing

so, identify opportunities to deliver these triple dividends, but also the trade-offs and conflicts and ways to resolve them.

C. BUILDING ADAPTIVE CAPACITY THROUGH BIODIVERSITY MANAGEMENT IN FARMING SYSTEMS

44. Improving our understanding of the ecosystem services provided by agricultural biodiversity and of how these may be affected by climate change will be a key element in the development of place-based sustainable agricultural responses to climate change. Responses will need to be dynamic given the complex changes occurring at different scales, as explained above. Smallholder and subsistence farmers or pastoralists are likely to suffer complex, localized impacts of climate change. These vulnerable communities are among those most dependent on biodiversity and on the provision of ecosystem services to guarantee their livelihoods and well-being. Farmers and local and indigenous communities adapt to change continuously, and agricultural biodiversity, especially crop and livestock diversity, has traditionally formed an important element of farmer risk management strategies. Strengthening farmer adaptation strategies, their ecological knowledge and local institutions will enable development of more effective adaptation strategies to climate change. It will also allow farmers and rural communities to play a role in climate change discussions and policy. Developing local response strategies will depend on the complementary knowledge of farmers and researchers.

45. Suggestions for future action:

- Identify which agro-ecosystems, components or properties of agricultural biodiversity are most or least sensitive to climatic variability.
- Downscale climate change data to allow informed decisions on biodiversity planning by farmers and rural communities.
- Put in place long-term monitoring of functional agricultural biodiversity in production systems and identify key biodiversity indicators to facilitate such monitoring.
- Promote local institutions to manage agricultural biodiversity and strengthen community capacity to access genetic resources and associated information to cope with climate change.
- Strengthen the dissemination of knowledge, appropriate technologies and tools to improve management practices related to agricultural biodiversity and ecosystem services.

D. DEVELOPING CLIMATE-CHANGE INFORMED PLANS AND POLICIES FOR GENETIC RESOURCES FOR FOOD AND AGRICULTURE

46. Very few national and international programmes on genetic resources for food and agriculture factor climate change into their conservation and sustainable use strategies. Lack of information is currently an obstacle, but available data suggest that there are serious challenges to confront, as climate change is likely to cause a significant and irreversible loss of the genetic diversity that is critical for the sustainability of the food and agriculture sector.

47. Both *ex situ* and *in situ* conservation will need further support to guarantee the availability of genetic diversity needed for future generations to adapt to climate change. *In situ* and on-farm conservation measures will need to guarantee the dynamic evolution of genetic diversity to changing conditions. However, there will be regions and species for which the rate of change caused by climate change may be greater than the natural capacity of certain species and populations to adapt or move, and human intervention will be needed to prevent accelerated genetic erosion, in particular through *ex situ* conservation. However, *ex situ* conservation should be considered a complementary strategy to *in situ* conservation, and not substitute for it. The challenge is how to develop an overall integrated approach to conservation and use which will be

cost-effective and, at the same time, safeguard as much diversity for the future as possible throughout climate change.

48. The sustainable use of genetic resources for food and agriculture is the foundation for many of the climate-change adaptation strategies required in food and agriculture. Farmers and rural communities will require genotypes adapted to multiple new stresses, from drought to new pests and diseases. On-farm management of genetic diversity has traditionally allowed farmers to cope with adversity. Breeding is a long-term process, so preparing to adapt to climate change requires planning. Given that climate change will increase the frequency of extreme climate events, measures should be taken to rehabilitate agricultural systems with locally adapted genotypes after disasters.

49. With climate change, countries will increasingly depend on genetic resources from other countries and regions to adapt their food and agriculture. Loss of genetic diversity at a given place may have negative effects globally as well as locally, as important traits for climate change adaptation may be lost forever. Interdependence between countries with regard to genetic resources for food and agriculture will increase, as will the need to improve the exchange mechanisms for this critical resource. In developing countries, lack of human and financial resources will impede response to climate change through the conservation and sustainable use of genetic resources for food and agriculture. International cooperation, therefore, will be a key element of a long-term strategy to confront climate change in this field.

50. Suggestions for future action:

- Analyze the effects of climate change, in particular in centres of origin and diversification of genetic resources of relevance to food and agriculture, to inform national conservation strategies.
- Improve monitoring methods of genetic resources being managed *in situ*, to increase understanding of threats and vulnerability due to climate change.
- Promote the collection and *ex situ* conservation of genetic resources for food and agriculture most threatened by climate change, and most potentially useful in adaptation.
- Develop robust programmes and strategies for sustainable use of genetic resources for food and agriculture, so that breeders, farmers and rural communities can have available a wide range of genetic diversity to adapt to climate change.
- Support farmers to continue developing locally adapted genotypes through on-farm management.
- Improve rehabilitation strategies after climate-change related disasters to ensure that locally adapted genotypes are re-introduced.
- Integrate climate change dimensions into the relevant international policies and programmes for the conservation and sustainable use of genetic resources for food and agriculture, and the fair and equitable sharing of the benefits arising out of their use.
- Strengthen international cooperation to build capacities in developing countries to conserve and sustainably use genetic resources for food and agriculture to respond to climate change.

IV. CLIMATE-RELATED TRANSBOUNDAY PESTS AND DISEASES

A. INTRODUCTION

51. The movement of animal and plant pests and diseases,[2] and invasive alien aquatic organisms across physical and political boundaries threatens food security and creates a global public concern. Countries have always allocated extensive resources to maintain animal and plant health services and to limit the spread and control, for example, avian influenza, foot-and-mouth disease and locusts. They also have cooperated regionally and globally for prevention, early warning and control of pests and diseases.

52. Trade, traffic and travel, the traditional drivers of spread, are joined by climate change which is adding to the distribution, incidence and intensity of animal diseases, plant pests and invasive alien aquatic species. Climate change is also creating new ecological niches that allow the entry, establishment and spread of pests and diseases into new geographical areas and from one region to another.

B. IMPACTS ON TRANSBOUNDARY PESTS AND DISEASES

53. Climate change will be especially important to vector-borne diseases and macroparasites of animals and may also result in new transmission modalities and changes in host species. Changes in species composition and interactions will augment the emergence of unexpected events, including the emergence of new diseases and pests. While most developing countries are already subject to an enormous disease burden, both developing and developed countries will be subject to newly emerging diseases. Temperate countries will be particularly vulnerable to invasions by exotic arthropod-borne virus diseases and macroparasites.

Contributors to transboundary pests and diseases

Factors that affect the entry, establishment and spread of transboundary pests and diseases include:

- globalization;
- human population growth;
- ecosystem diversity, function and resilience;
- industrial and agricultural chemical pollution;
- land use, water storage and irrigation;
- atmospheric composition, CO_2 and oceanic acidification by carbonic acid;
- species interactions with hosts, natural enemies and competitors; and
- trade and human movements.

These factors are not independent of each other and climate change interacts with each of them.

[2] Transboundary pests and diseases refer to animal and plant pest and diseases and relevant aquatic organisms that spread across national or geographical (physical) boundaries, indicating that disease or pest events in one country may have direct effects in another country.

Transboundary Animal Diseases (TADs) are defined by the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization of the United Nations (FAO) as epidemic diseases that are highly contagious or transmissible and have the potential for very rapid spread, irrespective of national borders, and can have serious socio-economic and public health consequences.

Transboundary plant pests refer to quarantine pests. These include pests of potential economic importance to the area endangered, even if they are not yet present, as well as pests that are present but not widely distributed and that are officially controlled, and to migratory pests, in particular locusts, which have the ability to change from individual behaviour to collective behaviour in swarms that easily cross boundaries.

54. *Animal threats.* Bluetongue and Rift Valley fever, as well as tick-borne diseases, are examples of animal diseases whose distribution will be strongly influenced by climate change. After introduction in Europe, bluetongue virus is now transmitted by temperate autochtonous midge vectors. Rift Valley fever is a mosquito-borne animal and human disease in which the vectors are influenced by climate.

55. *Plant threats.* Change in plant pests is driven by increases in temperature, variability in rainfall intensity and distribution, drought, CO_2 concentration in the atmosphere and extreme events such as hurricanes or storms as well as intrinsic characteristics of pests (e.g. diapause, number of generations, host interaction), hosts and ecosystems (e.g. monoculture, biodiversity, natural enemies) characteristics. For example, the expansion of maize production in response to climate change will make more areas vulnerable to entry, establishment and spread of the corn root worm (Diabrotica) while climate change will considerably alter the range of fruit flies which have a high potential to affect international trade.

56. *Forest threats.* Mountain pine beetle (Dendroctonus ponderosae), a pest of North American forests, has shown decreases in generation time and winter mortality which increases the risk of range extension into vulnerable ecosystems. Conversely, some pests will be less damaging because of decreasing climate suitability or changes in interactions with natural enemies and plant defenses.

57. *Aquatic threats.* Aquatic animals are very vulnerable because water is their life-support medium and their ecosystems are fragile. Epizootic ulcerative syndrome (EUS), a fungal disease that affects more than 60 host species of cultured and wild fish in fresh and brackish water throughout Asia, recently expanded its distribution to southern Africa. Temperature and rainfall are critical ecological factors for the disease. Perkinsus olseni, a major mollusc pathogen, affects more than 100 host species and is temperature dependant. Many susceptible hosts are major food commodities. Red tides (harmful algal blooms) are influenced by climate change and spread into new locations through ballast water from ships.

58. Production of crops, livestock and aquatic animals will vary according to their exposure to climatic hazards such as droughts, floods, extreme temperatures, oceanic acidification and rises in sea level. The sensitivity of each production system to those hazards will notably depend on the breed or variety of the animal or crop, the pest or disease species involved, and the geographical location. Response options will be determined by the local biodiversity which can act, to varying degrees, as regulators of pest populations.

59. There is a need for a better impact assessment of climate change on animal and plant pests and diseases and invasive alien aquatic species. In the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, these risks are not addressed sufficiently.

60. The application of risk analysis to assess risks of entry, establishment and spread of threats within the context of climate change is resource intensive and requires more reliable data. In addition, risk analyses must be re-evaluated and updated as climate continues to change. Limited resources demand cost effective approaches to risk analysis that exploit minimum data sets. Generic modelling tools that are needed to answer questions related to numerous pests and diseases should be applicable on a global scale.

C. IMPACT ON FOOD SECURITY

61. Animal diseases, plant pests and invasive aquatic species reduce the availability of food of appropriate quality from domestic production and imports. Although quantification of losses and potential losses due to these transboundary pests and diseases is limited, historically, animal disease and plant pest entry, establishment, emergence and outbreaks have resulted in major food problems either directly through yield reductions of food crops and losses in animal production, or indirectly through the reduction of yields of cash crops through, e.g. rinderpest, potato blight or

locusts. Climate change will increase production volatility, bringing additional crises to local agricultural and aquatic production. Although specific consequences will vary according to socio-economic groups and gender, small farmers and those involved in subsistence agriculture and aquaculture will be particularly affected.

62. Plant and animal pest and disease regulations are designed to facilitate trade while reducing the risk of international movement of restricted organisms whose introduction could require expensive eradication or control operations. Transboundary pests and diseases affect food access through reduction in yields of food and cash crops, reduction in forest productivity and changes in aquatic populations as well as the reduction of income from animal production and increased costs of control. They also may have a substantial effect on the stability of food supply through direct losses as well as through the reduction of income. The need for quarantine of animal diseases or plant pests has an indirect effect on access to international markets.

63. Food-borne zoonoses, unacceptably high levels of pesticide residues and veterinary drugs due to increased and inappropriate use, and presence of mycotoxins may make food unsuitable for human and animal consumption. National regulations set maximum residue levels for national production and for import. Changes in rainfall, temperature and relative humidity will result in further spread of zoonoses and the outbreak of plant diseases that produce mycotoxins in crops such as groundnuts, wheat, maize, rice and coffee, and also may increase pesticide residues.

D. POLICY AND IMPLEMENTATION FRAMEWORKS AT NATIONAL, REGIONAL AND INTERNATIONAL LEVELS

64. Management of transboundary animal and plant pests and diseases and invasive alien aquatic species has three components: prevention, early warning and early control through eradication or containment. In case eradication or containment are not feasible, then further actions may be required to adapt to the new situation. Additional research is required to provide the scientific underpinning and tools for all components.

65. National animal and plant protection infrastructure is often unable to execute the range of activities required to prevent and control transboundary animal and plant diseases and pests, particularly in developing countries. Climate change effects will further strain these systems.

66. Learning and sharing lessons from failures as well as from successes is important. When governments reduce funding in the absence of new pest and disease occurrences, they usually suffer later from having failed to maintain capacity.

67. Legislation and national systems that prevent the entry and establishment of invasive alien aquatic species and aquatic diseases exist in only a limited number of countries. There is great concern over the largely unregulated movement of ornamental fish species and aquatic organisms that spread disease or become pests that impact aquatic systems.

68. The introduction of diseases and pests will result in higher costs to the food industry of affected countries in relation to inspection, treatment and compliance to the obligations of importing trading partners. WTO trade disputes could become more frequent. Investment in early control and detection mechanisms will undoubtedly be valuable in avoiding the higher costs of eradication and control.

69. Information-exchange mechanisms exist at global and regional levels. In addition to government databases, many national databases are maintained by non-governmental organizations (NGOs) and universities. Data are, however, of varying quality and are often incomplete or out of date.

70. The existing regional and global regulatory frameworks and standard setting mechanisms provide the structure to serve also under climate change scenarios; but regional frameworks need

strengthening in many aspects and the global framework is inadequate to address invasive alien aquatic species.

E. REQUIREMENTS FOR CAPACITY BUILDING

Insufficient legislation and resources at national level

At present, most countries have insufficient enabling legislation and resources allocated to:

- surveillance and monitoring;
- border control and inspections;
- risk assessment capability;
- diagnostic tools for early detection;
- expertise in diagnosis (taxonomy);
- data collection and access to information;
- tools for rapid response to entry, establishment and spread; and
- control measures at the source.

71. Strengthening of national veterinary and plant health services and systems is the top priority for dealing with animal and plant pests and diseases. This requires targeted legislation and enforcement as well as capacity building in diagnostic expertise and providing for adequate infrastructure, surveillance, border control and emergency preparedness. In addition, response to movements of pests and diseases requires rapid diagnostic tools and forecasting models as well as establishment and maintenance of expertise. Investment in capacity building will contribute to reduction of emerging animal and plant pests and diseases at the source, and benefit importing countries.

72. This indicates that governments should: give highest priority to basic sciences such as climate change science, taxonomy, modelling, population ecology and epidemiology; and legislate and seek to establish capacity to implement systems to prevent the entry and establishment of invasive alien aquatic species and aquatic animal diseases.

73. At the same time, national strategies should: seek to capture synergies across the agencies responsible for managing animal and plant pests and diseases; and consider moving toward biosecurity approaches.

F. PRIORITIES FOR NATIONAL, REGIONAL AND INTERNATIONAL ACTION

74. Impact assessment and cost-benefit analyses at national and regional levels and methods that take a wide range of factors into account should be developed and used in strategic planning.

75. Coordinated research, including the Consultative Group on International Agricultural Research (CGIAR) programmes related to climate change and food security, will be needed to improve the range of options available to countries. Better accessibility and analysis of existing historical data and more detailed data for all regions in relation to different climate change scenarios will improve the baselines needed for adaptation.

76. Global data exchange mechanisms that cover the distribution of diseases, pests, invasive alien aquatic species and correlated ecological conditions including climate will be needed to enable risk assessment, prevention, monitoring and control.

77. Formulation of local, national and regional strategies for adaptation to animal and plant diseases and pests, under climate change scenarios should consider the general adaptation measures listed in the Fourth Assessment Report of the IPCC. Early detection and identification, including genotypic characterization and preparedness for and rapid response to new and emerging pests, are critical elements.

78. In forestry, adaptation responses will need to take a long-term ecological view and increase monitoring to cover the lag phase in pest population growth after initial establishment. They also should include data sharing, enforcement of wood packaging standards, funding for emergency control operations, control of pest or disease spread after introduction, and capacity building for better compliance by trading partners. Particular risks associated with plants for planting pathways should be addressed generically.

79. Countries should consider mechanisms to make full use of synergies among national infrastructures involved in animal health, plant health and invasive alien aquatic species management. In addition, where nonexistent, countries should establish legislation and national mechanisms to prevent the entry and establishment of alien aquatic species and fish diseases.

80. Information exchange should be improved. This will require increasing cooperation among national, regional and global organizations, and specifying the data required and the safeguards that should be applied to protect national interests. Government agencies and relevant stakeholders should come together and discuss specifications and sustainable systems for practical use.

81. Climate affects ecosystem processes and production at local and regional scales. As many threats are transboundary, countries will not be able to address these issues individually. Regional cooperation is a high priority for risk analysis, standard setting, exchange of information and coordinated action. Countries should examine and, where appropriate, strengthen their regional organizations and cooperation on topics dealing with animal and plan.

V. CLIMATE CHANGE AND DISASTER RISK MANAGEMENT

A. INTRODUCTION

82. Climate variability will result in more frequent and extensive disasters – with the most severe consequences on the food security and livelihoods of agriculture-dependent populations in vulnerable countries. Changing climate patterns have increased the urgency to invest in disaster risk reduction, preparedness and management activities, above and beyond other efforts directed toward climate mitigation and adaptation.

83. The UN ISDR defines disaster risk management as “the systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activity, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards”. In the context of climate change, disaster risk management refers to systematic processes to lessen the impacts of climate-related hazards.

84. The expert meeting considered the cross-sectoral linkages of climate change, disaster risk reduction and management, with a particular focus on the implications for agriculture and food security. The scope of the expert meeting concentrated on those aspects of climate change related to increasing frequency and intensity of extreme climate events such as droughts, floods, windstorms and wild fires. The meeting did not address projected longer term impacts of gradual climate changes such as glacier melt, sea level rise and ecosystem stress.

B. CONTEXT

85. Climate-related disasters are increasing. The number of reported disasters related to hydro-meteorological hazards (e.g. droughts, floods, wind storms, forest fires, landslides) significantly increased from 1987 to 2006 – from an average of 195 per year from 1987 to 1998 to an average of 365 per year from 2000 to 2006. Such a dramatic increase in the number of reported disasters is *also* related to improvements in reporting of smaller scale disasters[3]. Of the more than 230 million people affected annually by disasters between 2000 and 2007, about 98 percent were due to weather and climate-related hazards, predominantly floods and windstorms, followed by droughts[4].

86. According to the IPCCC, climate change is altering disaster risk patterns in three primary ways:

- increase in frequency and intensity of extreme events, such as more frequent extreme temperatures and heavy precipitation, more intense tropical cyclones and expanded areas affected by drought and floods[5];
- changes in geographical distribution of areas affected by hazards; and
- increase in vulnerability of particular social groups and economic sectors due to sea level rise, ecosystem stress and glacier melt.

87. Hazardous events do not in themselves determine disasters; disasters also depend on human vulnerability. Human vulnerability is determined by physical, social, economic and environmental factors or processes, such as precarious settlements, dependence on fragile ecosystems, unsafe buildings and uncertain livelihood options. Disaster hotspots are characterized by exposure to recurrent hazards in combination with high numbers of people living in vulnerable conditions. Negative impacts on food and livelihood security are characterized by more than increases of hazardous climate events. They are affected by cumulative effects of multiple shocks, such as climate, market and health, in combination with governance issues, socio-economic factors and environmental degradation. Mortality risk due to climatic hazards is highly correlated to low levels of human development and large rural populations, indicating that economic and social development is a key element of risk reduction. The poorest developing countries are particularly at risk because of their geographic exposure, low incomes and greater reliance on climate-sensitive sectors, particularly agriculture. Of the 262 million people affected annually by climate disasters between 2000 and 2004, more than 98 percent lived in developing countries, the vast majority dependent mainly on agriculture and fisheries for their livelihoods. In OECD countries, one person in 1 500 was affected by a climate-related disaster while the figure for developing countries was one in 19[6].

88. Although hazards are increasing, capacities to cope with disaster risk have improved. Disaster occurrence in the past 30 years has increased much faster than the numbers of deaths, which have remained relatively constant[7]. Thus, pro-active strategies are essential if vulnerable countries are to avoid large-scale loss of life and destruction of the environment and infrastructure, as well as deterioration of food security, livelihoods and nutrition.

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[3] Center for Research on the Epidemiology of Disasters (CRED)/ISDR, *Annual Statistical Review: Numbers and Trends, 2006*, Brussels 2007.

[4] *CRED Crunch*, Issue No 12, April 2008.

[5] By 2020, between 75 and 250 million people are projected to suffer increased water stress in sub-Saharan Africa. More than 20 percent of the world population live in river basins expected to be affected by floods by 2080.

[6] UNDP, *Human Development Report 2007/2008*.

[7] UN, *Disaster Risk Reduction Global Review 2007*.

C. DEVELOPING THE KNOWLEDGE BASIS

89. The potential linkages between evolving disaster risk patterns and the likely impacts of climate change are complex, non-linear and only partially explored. The instruments available to explain global trends and advocate for global action are not detailed enough to inform national planning and policy-making. Thus, to improve understanding of local and national risk profiles and advance risk reduction and response planning, it is necessary to combine downscaled climate models that focus on projected changes with local-level vulnerability assessments that focus on current threats. Only such integrated assessments will allow for improved understanding of who is vulnerable and how vulnerability patterns will change over time. Analysis needs to be conducted through the use of disaggregated data that differentiates levels of vulnerability according to age, gender, social and poverty groups, ethnicity and other socio-economic factors that influence people's resilience.

90. Climate change is occurring in parallel with rapid changes in global economy, communications and social support structures that generate additional threats but also opportunities for climate risk reduction and response. To date, the focus has been mainly on analysing the impacts on food production. However, more focused attention on the complex interactions of these factors is necessary to understand the present and longer term impacts on livelihoods and food access, stability and use. A number of tools have been developed within the humanitarian community to measure (quantitatively and qualitatively) the impact of disasters on food security and livelihoods. Baseline livelihoods profiling and analysis, and food security assessments in areas at high risk are useful to increase understanding of post-disaster needs, measure progress in adaptation and risk reduction, and ensure that development programming considers the needs of the most vulnerable groups. This should be combined with improvements in statistical disaster data collection and analysis at country level.. In fact accurate disaster data relating to mortality is available at the national and international levels. Although improving, data on economic losses remains limited and often unreliable. Local-level losses and impacts on livelihoods, particularly of the smaller scale recurrent hazards, are systematically under reported.

91. Adverse impacts of future climate change mostly will be an intensification of current hazards in places where they already occur as well as extension to new areas. As most countries and communities have adapted to climate variability over centuries, capacities developed to cope with existing climate threats can be used for adapting to future threats. There is a need to learn more about current coping strategies including how to improve them in the face of more frequent and intense shocks. This is important to ensure that development programmes and aid support, rather than undermine, positive local resilience strategies of the vulnerable. For example, it is important to know what happens when pastoralists migrate to urban areas during times of extreme drought. Do they stabilize in urban areas, do they migrate abroad, do they diversify into other agricultural activities, move into business, invest in education? There is also a need for science-based research to address current threats, such as improvements in long-lead forecasting, development of resistant crop varieties, and water conservation technologies.

D. CLIMATE CHANGE AND DISASTER RISK MANAGEMENT ARE CLOSELY LINKED

92. Disaster risk management and climate change adaptation are ultimately about reducing the risk posed by climate change to the lives and livelihoods of vulnerable people and therefore are key tools for protection of food security.

93. There are two major linkages between climate change and disaster risk management:

- climate change will increase the number and scale of disasters that need to be managed and modify local vulnerability to shocks; and

- existing institutional structures, technologies and tools to manage disaster risk are natural entry points for reducing losses to current threats and thereby would enable longer term adaptation.

94. At the same time, with regard to reducing vulnerability to climate risks, two distinct communities of practice have evolved: those focusing mainly on longer term global climate change research and modelling; and those focusing on national and local-level management of hazards and disasters. Disconnection between these two communities, in terms of their distinct conceptual and institutional frameworks and funding approaches, has often resulted in local-level failure to reduce vulnerability. Increasing efforts to bring the two communities together are, to a great extent, informed by the principle of addressing vulnerability to existing shocks while developing sufficient flexibility to adjust to uncertain future scenarios (i.e. tackling gradual changes as well as new hazards).

E. CLIMATE CHANGE AND DISASTER RISK MANAGEMENT NEED TO BE INTEGRATED INTO DEVELOPMENT PLANNING AND HUMANITARIAN ASSISTANCE

95. Climate-related disasters can reverse development gains by undermining livelihood and food security, damaging infrastructure, increasing exposure to disease and eroding ecosystems. At the same time, unsustainable development augments climate risk through increasing greenhouse gas emissions and exacerbating physical and socio-economic factors of vulnerability such as unregulated urbanization, natural resource degradation and unequal access to information. There is general agreement that disaster risk management and climate change should be embedded in development and relief planning to avoid increasing risk through inappropriate development and to ensure the structural factors of vulnerability are systematically addressed.

96. This said, no matter how much is invested in risk reduction, poor and marginalized people with limited assets will fall back on humanitarian assistance, increasing the demand for national and international emergency response. Climate change will have major implications for humanitarian approaches, the logistical problems of managing an increasing number of smaller scale disasters and “mega-disasters” simultaneously, and financing. Finance, in particular, needs flexibility to allow for support to local and national emergency systems, investment in preparedness and enhanced linkages with development activities.

F. IMPLICATIONS FOR MAINSTREAMING AT DIFFERENT LEVELS

97. *Local level*

Local institutions are the backbone of disaster risk management and will be the primary interface for community-level efforts in adaptation to climate change, as risk reduction and response occur primarily at the local level. More than 80 percent of disasters are managed through local and national institutions. Practically all immediate life-saving actions and initial emergency support in the first few days after the 2004 Indian Ocean earthquake and tsunami (and weeks in some cases) were provided by local people, often assisted by national institutions. However, capacities to absorb new skills and technology are limited and local institutions tend to suffer from additional mainstreaming demands driven by donors. Support to improve understanding and management of climate risk needs to be channelled through: existing formal and informal institutions such as places of worship , extension services and health points; and programmes such as food security, water and sanitation, and rural development. These support efforts also need to recognize that communities normally address climate risk through a multi-hazard perspective focusing on immediate threats. Potentially, extension services can play a key role in delivering advisory services for climate risk reduction but this will require enhanced collaboration with national research institutes and regional and international organizations and training of staff. Most disaster risk management functions benefit from devolution of responsibilities (following the principle of subsidiarity), ideally combining both “top-down” and “bottom-up” approaches.

98. *National level*

Consideration of evolving climate risks, particularly their likely impacts on agriculture, fisheries, forestry and food security issues, requires enhanced collaboration that brings together:

- disaster risk management institutions: normally housed within the ministries of interior or civil protection, with strong linkages to the international humanitarian community;
- climate change focal points: normally housed in the ministries of environment or meteorological services with strong linkages to national and international research institutes;
- food security focal points and advocacy groups: to ensure that food security and livelihoods protection are addressed in climate adaptation and risk management strategies;
- resource management agencies (departments of agriculture, livestock, fisheries, forestry, land , water): to integrate climate change and disaster risk management into resource management planning;
- research institute: for modelling, forecasting, crop research and technology development.

99. Having this broad-based collaboration in place will serve to ensure:

- agriculture, environment and food security departments are represented in national, provincial and local disaster risk management committees;
- risk reduction and climate change adaptation focal points or teams are appointed and trained within food security, agriculture, fishery and forestry line departments;
- cross-sectoral or multi-stakeholder platforms are established to identify risk reduction and climate- change adaptation priorities and ensure involvement of research institutions, civil society and the private sector;
- sector-specific (multi-hazard) risk reduction strategies, such as national strategies for risk reduction in the agriculture sector, or cross-sectoral hazard management plans, such as national and local drought management plan, are developed and implemented; and
- vulnerability assessments are integrated in Poverty Reduction Strategies and national and local development plans.

100. *Regional and international levels*

Climate hazards affect communities across national borders. For example, flood management in Mozambique relies heavily on the watershed management practices of upstream bordering countries; traditional drought coping strategies in the Sahel are being hampered by restrictions on cross-border migration. Regional cooperation frameworks are essential to manage transboundary issues. Such frameworks are becoming key instruments for enhancing national preparedness and contingency-planning capacities.

101. At national and international levels, the UN ISDR Hyogo Framework of Action (2005-2015) provides a valuable framework to set priorities for action. It serves as a platform to operationalize linkages among disaster risk management, climate change and development. Post-Kyoto negotiations should allow for stronger emphasis on food security and livelihoods protection in the context of climate change adaptation, including mechanisms to support and fund local-level adaptation with additional resources mobilized in recognition of industrialized countries responsibilities.

102. Climate risk management also should be integrated into international agencies' strategic plans and become a theme for enhanced UN agency collaboration, particularly though the UN Development Assistance Framework (UNDAF) processes. FAO should be encouraged to assume a more proactive role in facilitating collaboration among the Rome-based UN agencies on issues relating to the agriculture and food sectors and to enhance linkages among research, policy-making and local-level institutions for climate risk management.

103. Relevant information on climate risk often has been unavailable, inaccessible, not usable or not understandable by end users. More emphasis on networks – consisting of national line departments, research institutes, civil society and regional and international organizations – is needed at all levels for raising awareness, sharing information and communication.

G. PRIORITIES FOR ACTION

104. *Systematic national and local risk assessment* combining downscaled climate models that focus on projected changes with local-level vulnerability assessments that focus on current threats, particularly to coastal, riverine and drought-prone areas in order to increase understanding of climate impacts on food security, access to natural resources, agriculture, fisheries and forestry. This will require:

- reviewing climate risk information available at national level;
- determining capacities for data collection and use; and
- undertaking country-wide risk profiling with a focus on vulnerable areas, sectors and groups.

105. *Integration of risk mitigation and climate change adaptation* in climate-sensitive sectors through:

- adapting agriculture, fisheries and forestry practices through, for example, adjustment of crop and fishing calendars, and introduction of climate-resilient crop and tree varieties;
- climate proofing of post-harvest management practices such as storage, drying and processing;
- improving fishing craft design and enhancing safety at sea through traning and equipment;
- improving sustainable natural resource management to increase resilience of food production systems[8];
- increasing afforestation and agroforestry;
- investing in infrastructure and hazard proofing critical facilities[9];
- diversifying livelihoods through decreasing dependence on climate-sensitive farming activities, and increasing small-scale enterprise development and off-farm activities.

106. *Improved use of climate information* which requires more investment in networks of climate stations, capacity building for interpreting information, user-friendly forecasting tools and products, linkages between service providers (researchers and hydro-meteorological services) and service users (humanitarian actors and climate-sensitive sectors), and production of impact outlooks for specific audiences.

107. *Enhanced people-centred early warning systems and mechanisms to allow for early alerts to trigger early action* taking into consideration issues of trust and differences in access to information because of gender, social status or age and people mobility potential.

108. *Strengthen preparedness for effective response* through:

- expanded contingency planning, especially in areas prone to flood, windstorms or drought, that considers new and evolving risk scenarios and integrates “build back better” principles to induce prevention and adaptation in rehabilitation;
- more flexible funding mechanisms at the international level that allow development and humanitarian resources to be invested in preparedness;

[8] Sustainable natural resource management strategies (soil, land, water, fishery, forestry, etc.) are a prerequisite for risk reduction climate adaptation. Inappropriate ecosystem management practices increase vulnerability to climate change.

[9] Investment in large-scale infrastructure requires accurate cost/benefit analyses. However, a number of small-scale, relatively low-cost measures can be promoted at local level, such as raised seed beds, wind and fire breaks, and routine drainage canal clearing.

- preparedness for diversified livelihoods response options combined with social protection measures (household, national and international level).

109. *Increase resources* considering the high profile of the current debate on climate change as an opportunity to increase political commitment and resource allocation to vulnerability reduction. A number of new and traditional funding instruments can be used to address climate risks and food security consequences. They range from microfinance tools that support ex ante disaster risk management activities at the community and household levels to adaptation funding through UNFCCC processes and new funding windows for least developed countries such as the World Bank Global Facility for Disaster Reduction and Recovery.

VI. CLIMATE CHANGE, FISHERIES AND AQUACULTURE

A. INTRODUCTION

110. From local to global levels, fisheries and aquaculture have very important roles for food supply, food security and income generation. Some 42 million people work directly in the sector, with the great majority in developing countries. Adding those who work in associated processing, marketing, distribution and supply industries, and the sector supports several hundred million livelihoods. Aquatic foods have high nutritional quality, contributing 20 percent or more of average per capita animal protein intake for more than 2.8 billion people, mostly from developing countries. They are also the most widely traded foodstuffs and are essential components of export earnings for many poorer countries. The sector has particular significance for small island states.

111. Climate change is projected to impact broadly across ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries and aquaculture sector. Food quality will have a more pivotal role as food resources come under greater pressure, and the availability and access to fish supplies will become an increasingly critical development issue.

112. The fisheries sector differs from mainstream agriculture and has distinct interactions and needs with respect to climate change. Capture fisheries have unique features of natural resource harvesting linked with global ecosystem processes. Aquaculture complements and increasingly adds to supply and, though more similar to agriculture in its interactions, has important links with capture fisheries.

113. The demands of growing populations will require substantial increases in aquatic food supply in the next 20 to 30 years, during which climate change impacts are expected to widen and increase. In the face of these impacts and the existing development and management constraints, the primary challenge for the sector will be to deliver food supply, strengthen economic output and maintain and enhance food security while ensuring ecosystem resilience. This will require concerted, collaborative and determined action across all stakeholders, linking private sector, community and public sector agents.

B. DEVELOPING THE KNOWLEDGE BASE

114. The existing pressures of demand, and anticipated challenges, will require better multi-scale understanding of the impacts of climate change and of the interacting contribution of fisheries and aquaculture to food and livelihoods security. Climate change will increase uncertainties in the supply of fish from capture and culture. Such uncertainty will impose new challenges for risk assessment, which is commonly based on knowledge of probabilities from past events. Data for determining effects of past climate change at best cover no more than a few decades, and may no longer be an adequate guide to future expectations.

115. This means that in the future, planning for uncertainty will need to take into account the greater possibility of unforeseen events, such as the increasing frequency of extreme weather

events and "surprises". However, examples of past management practices in response to existing climate variability and extreme events relating to different regions and resources can provide useful lessons to design robust and responsive adaptation systems, even though they will have to be placed in context of greater uncertainty.

116. While current knowledge is adequate in many instances to take appropriate action, better communication, application and feedback will be essential in knowledge-building. Action in the following areas will be needed to support mitigation and adaptation policies and programmes in fisheries and aquaculture:

Estimate production levels. Projections of future fisheries production levels at the global and regional scales will be driven by medium- and long-term probabilistic climate change predictions in the context of substantial ecological and management uncertainties.

Forecast impact levels. Detailed impact predictions on specific fisheries and aquaculture systems will be required to determine additional net positive or negative consequences for vulnerable resources and regions. This is particularly important for semi-arid countries with significant coastal or inland fisheries, as they are among the most vulnerable to climate change.

Develop tools for decision-making under uncertainty. Adaptive tools for the fisheries and aquaculture sectors will need to be refined, developed and implemented to guide decision-making under uncertainty and address important cross linkages among the relevant sectors. The uncertainties decision-makers will face include i) the responses and adaptations of marine and freshwater production systems to gradual climate change, including critical thresholds and points of no return, ii) the synergistic interactions between climate change and other stressors such as water use, eutrophication, fishing, agriculture, alternative energy, and iii) the ability and resilience of aquatic production systems and related human communities to adapt and cope to multiple stresses.

Expand societal knowledge. Better knowledge will be required of who is or will be vulnerable with respect to climate change and food security impacts, how this arises and how it can addressed. In this regard, gender and equity issues will need to be carefully considered.

C. POLICY, LEGAL AND IMPLEMENTATION FRAMEWORKS AT NATIONAL, REGIONAL AND INTERNATIONAL LEVELS

117. Addressing the potential complexities of climate change interactions and their possible scale of impact requires mainstreaming of cross-sectoral responses into governance frameworks. Responses are likely to be more timely, relevant and effective if they are brought into the normal processes of development and engage people and agencies at all levels. This requires not only the recognition of climate-related vectors and processes, and their interaction with others, but also availability of sufficient information for effective decision-making and approaches that engage public and private sectors. All of these elements will be vital in providing the best possible conditions in which the aims of food security – quantity and timing of food supply, access and utilization – can be met.

118. *National*

Action plans at the national level can have as their bases the Code of Conduct for Responsible Fisheries and related International Plans of Action (IPOAs), as well as appropriately linked policy and legal frameworks and management plans. Responses will need to employ integrated ecosystem-based approaches to fisheries and aquaculture (EAFs and EAAs) for the national fisheries and aquaculture sector throughout the entire resource extraction, supply and value chain. The future implications of climate change will intensify the justification for finding policy consensus to reform capture fisheries while respecting national sector characteristics.

Requirements include:

- Actions will be needed that focus on key issues such as adjusting fleet and infrastructure capacity and flexibility, identifying management systems that offer negotiated balances between efficiency and access, and creating alternative employment and livelihood opportunities.
- Policy and legal regulatory frameworks will be required for aquaculture to expand along sustainable and equitable development paths.
- Links will need to be improved among fisheries, aquaculture and other sectors that share or compete for resources, production processes or market position, in order to manage conflicts and ensure that food security aims can be maintained.
- Links will be required among national climate change adaptation policies and programmes as well as national cross-sectoral policy frameworks such as those for food security, poverty reduction, emergency preparedness and response, insurance and social safety schemes, agricultural and rural development, and trade policies.

119. *Regional*

The potential for spatial displacement of aquatic resources and people as a result of climate change impacts, and the greater variability characteristics of transboundary resources will require existing regional structures and processes to be strengthened or given more specific focus. Policy and legal mechanisms that address these issues will need to be developed or enhanced. Regional market and trading mechanisms are also likely to be more important in linking and buffering supply variability and maintaining sectoral value and investment. Requirements include:

- Regional fisheries organizations and other regional bodies should be strengthened. They should place climate change awareness and response preparedness clearly on their agendas and link more closely with related regional bodies.
- Fisheries and aquaculture will need to be addressed adequately in cross-sectoral and transboundary resource use planning and in intra-regional markets and trade. In this vein, the potential effects of climate change stressors on regional issues will have to be considered as part of any provisions for action.
- Common platforms are needed for research and data gathering approaches, sharing of best practices in identifying and responding to climate change-related impacts and developing response mechanisms.

120. *International*

As sectoral trade and competition issues link with climate change mitigation and adaptation activities, they are likely to become more important, with the potential to define many areas of economic potential and constraint. As a small and often politically weak sector, fisheries and aquaculture may be particularly vulnerable in such competition and conflicts. This increases the importance of having fishery sector representation in policy and legal development processes related to climate change mitigation and adaptation.

Requirements include:

- Fisheries and aquaculture need to be adequately addressed in climate change policies and programmes dealing with global commons, food security and trade.
- Common platforms are needed for international data and research approaches, sharing best practices in identifying and responding to climate change-related impacts and developing response mechanisms.
- Fishery sector responses should be incorporated into processes and decisions related to climate change in the other major sectors (e.g. water) to which fishery issues are linked.
- International fishery agreements and conventions should be more vigorously applied, and strengthened if necessary, to accommodate and support climate change-related activities.
- Cooperation and partnerships should be enhanced for dealing with NGOs, civil society organizations, intergovernmental organizations, including the 1-UN approach, and donor co-ordinated initiatives.

D. CAPACITY BUILDING: TECHNICAL AND ORGANIZATIONAL STRUCTURES

121. Policy-making and action planning in response to climate change involves not only the technically concerned line agencies such as departments responsible for fisheries, interior affairs, science and education, but also those for national development planning and finance. These institutions, as well as community or political representatives at subnational and national levels, should also be identified to receive targeted information and capacity building. Partnerships would also need to be built and strengthened among public, private, civil society and NGO sectors.

Requirements include:

- Nationally, information gaps and capacity-building requirements need to be identified and addressed through networks of research, training and academic agencies.
- Internationally, networks should be created or developed that encourage and enable regional or global exchanges of information and experiences, linking fishery issues with other those of other sectors such as water management, community development, trade and food security.
- Existing management plans for the fisheries and aquaculture sectors, coastal zones and watersheds need to be reviewed and, if needed, further developed to ensure they cover potential climate change impacts, mitigations and adaptation responses. Connections to wider planning and strategic processes also need to be identified and adjusted.
- Communication and information processes that reach all stakeholders will be essential elements in sectoral response. This will require focused application by communication specialists to ensure that the information is accessible and usable –presenting diverse and complex issues in a form that is targeted and understandable for each audience.

E. ENABLING FINANCIAL MECHANISMS: EMBODYING FOOD SECURITY CONCERNS IN EXISTING AND NEW FINANCIAL MECHANISMS

122. The full potential of existing financial mechanisms will be needed to tackle the issue of climate change. Innovative approaches may also be needed to target financial instruments and create effective incentives and disincentives. The public sector will have an important role in leveraging and integrating private sector investment, interacting through market mechanisms to meet sectoral aims for climate change response and food security. Many of these approaches are new and will need to be tested in the sector.

123. *At the national level:*

- Producers, distributors and processors should be able to increase self protection through financial mechanisms. This is particularly relevant for aquaculture (e.g. cluster insurance) but financial services could also be used to promote emergency funds more widely through the sector.
- Investment in the sector, especially in infrastructure, will need to consider climate change which will require developing better information on the costs and benefits of protection.
- Transfer or spread of sector-related risk – from individuals and communities to the state through contingency plans – will be based on specific fiscal provisions but also may be tied to innovations in resource management through which the insured accept responsibilities in exchange for protection.
- Financial instruments that can promote risk reduction and prevention practices include initiatives such as relocation allowances from low lying areas and disincentives for misuse of water in aquaculture.
- Existing and new initiatives for improving equity and economic access, such as microcredit, should be linked to climate change adaptation responses such as livelihood diversification.

- Mitigation options can include fiscal incentives for reducing the sector's carbon footprint, developing more efficient processes and sector agreements, and providing payment for environmental services, particularly offering additional livelihood options to poorer communities.

124. *At the international level:*

- Funding agencies can "climate proof" their approaches and, at the same time, take advantage of new opportunities in the fisheries and aquaculture sector by jointly promoting food security, reducing negative impacts of climate variability and change, and improving resource management.
- Donors should be made more aware of the importance of the fisheries and aquaculture sector in terms of food security and its sensitivity to climate change, and of effective ways in which the sector could become part of cross-sectoral investment strategies.
- Private sector investors should be encouraged to incorporate "climate proof" approaches into international sourcing, trade and market development, and into broader corporate responsibility areas, including delivery of local benefits and inclusion of smaller scale producers.

VII. BIOENERGY POLICY, TRADE AND MARKETS AND FOOD AND FUEL SECURITY

A. INTRODUCTION

125. The combined expert group meeting covering *Bioenergy policy, markets, trade and food security* and *Global perspectives on fuel and food security* focused on the current situation and future prospects for biofuels. Participants identified priority action areas that address the impacts of climate change and biofuel production on food security and identified the potential opportunities that biofuel production presents for agricultural and rural development, which they summarized in a set of twelve key messages[10].

126. Dramatic growth in world population during the last half-century coupled with rising lifestyle expectations are two of the main drivers increasing demand for food and other agricultural commodities. These demands signify long-term trends that will continue to be important until at least 2050. They are expected to put increasing pressure on natural resources such as land, water, natural forests and biodiversity. At the same time, industrialization, commercialization and globalization of economic activity have increased pressure on natural resources, since natural resources and ecosystem services traditionally have been undervalued or underpriced by the market and, hence, overused. Climate change and the expansion of biofuel production as a possible source of clean energy will place the earth's natural resource base under additional, possibly significant, pressure.

127. Reliance on fossil-based energy is not sustainable, according to the International Energy Agency (IEA), either in terms of security of supply or environmental impact. Bioenergy, in its various forms, has potential to help meet, at least in part, growing energy demands. Under foreseeable technological scenarios, it is recognized that the amount of biomass required to produce biofuel will be able to supply only a fraction of what is currently obtained from fossil fuels. Nevertheless, bioenergy production significantly affects commodity markets and trade, and developments in technology may alter the extent and nature of these impacts.

[10] Although this document is built around those messages, these can be accessed through the website http://www.fao.org/foodclimate

B. TRENDS

128. The following trends reflect the current understanding of the context that links biofuel, climate change and food security:

- Accelerating investments in biofuels are set against changes in rural sectors of developing countries that are driven by trade integration and rapid food price increases projected to continue at levels 30 to 50 percent above previous equilibrium levels.
- Expanding biofuel production is currently driven mainly by policy measures adopted to promote farm incomes, energy security, climate change mitigation and rural development, mainly in OECD countries.
- Rising costs of both food and oil (now more than US$100 per barrel) are causing financial stress to poor households. Notably, most of the FAO designated food insecure countries are also net food and oil importers.
- Growing attention to climate change, greenhouse gas (GHG) emissions, land-use changes and linked environmental issues such as nitrogen loadings have focused attention on whether biofuels are a solution to these problems or are contributing to them.
- Rising costs of oil contribute to rising costs of commodities, especially food. In addition, as oil prices go higher, it becomes cost effective for biofuel producers to expand production and pay more for agricultural feedstocks. Competition for feedstocks raises their prices and, indirectly, the prices of other commodities, including food, and ultimately increases their costs to consumers.

C. POLICY ISSUES

129. The following policy issues reflect the current understanding of the context that links biofuel, climate change and food security:

- Cellulosic feedstocks based on non-food crops have received attention as potential alternatives for biofuel production, especially in relation to GHG emissions. However, cellulosic biofuels are not currently commercially viable and may not be for many years to come. Building policy on technological assumptions that have not yet been fulfilled is risky.
- Subsidy “stacking”, such as combining production subsidies, tax exemptions and border tariffs for biofuels, has led to unintended side-effects and contradictions, including implicit subsidies to gasoline consumption, exactly the opposite of what was intended.
- Environmental impacts of biofuels, according to modelling results, will alter land use in substantial ways, including land and forest clearing. This may lead to increased GHG emissions. Life-cycle analysis of these impacts is urgently needed.
- In view of climate change impacts, such as increased frequencies of extreme weather events, increased biofuel production may aggravate negative impacts on the environment and on food security, especially in sub-Saharan Africa and parts of South Asia. Even in environments with good water supply, such as the Mississippi basin and the Gulf of Mexico, nitrogen loadings from expanded row-crop production will harm water quality.
- Biofuels pose potential challenges to trade policy, not only because of the tariff protection afforded them, but in terms of their classification under various WTO modalities, including treating them as agricultural, industrial goods or environmental goods. Trade treatment of biofuels is often overshadowed by domestic concerns with energy self-reliance.

D. POLICY CHALLENGES

130. Notwithstanding significant concerns about the impact of biofuels, biofuel development, potentially based on both first and second generation biofuel technologies, could present new opportunities for agricultural and rural development in a number of developing countries, particularly those where physical and institutional infrastructures are reasonably well developed. The challenge will be to develop national and global policies that will provide incentives for investments that take advantage of these opportunities while also taking into account the need to

minimize risks to food security for the poor, address environmental concerns, protect the rights of indigenous peoples and achieve a net reduction in emissions.

131. The current framing of the policy issue as one of potential tradeoffs between food and fuel security pits proponents of biofuel production against those most concerned about food security. There is a need to link food and fuel policies, so as not to compromise food security or to deprive poor farmers of potential gains from biofuel development.

E. RESPONSE OPTIONS

Improving the knowledge base

132. The biofuel industry was a minor consumer of grains and oilseeds from the 1970s until the end of the century. Data and research into biofuels and their effects on markets, trade and food security reflect the relatively recent emergence of the industry. The fact that neither the impacts of this growth nor of current biofuel policies are fully understood indicates an urgent need for further analysis of land use changes, investment patterns, GHG emissions, trade flows, environmental impacts and food security. Additionally, there is a need for a common methodology for life-cycle analysis of GHG emissions that recognizes the importance of emissions from direct and indirect land-use change. Rather than being analyzed in isolation, biofuels need to be put in the context of the total energy mix, including other renewable energy sources and energy efficiencies.

133. In order to make this happen, high priority needs to be given to research on the following issues:

- determine the impact of policies for biofuel development on: food and energy security at national and global levels; agricultural and rural development for different country situations; and the wellbeing of vulnerable and food insecure people;
- calculate agricultural investment options at different scales based on cost-benefit analyses;
- develop methods for life-cycle analyses of biofuels that include direct and indirect land-use effects in the calculus of net greenhouse gas emissions;
- undertake trade-off assessments of alternative policy options that can be used as a basis for developing an integrated policy approach.

134. Considerable relevant data have been assembled, spatial analyses have been conducted and models built that pertain to these issues. However, this work has been done using a variety of methods at different levels of aggregation in ways that do not permit easy communication and application of the results for decision-making at national and local levels. Therefore, the group stressed the importance of ensuring that large models and remote-sensed data are compatible with results from existing local studies, to the extent feasible. Many existing data sets could be better linked and integrated across countries, agencies and sub-agencies. There is a need for expansion of the knowledge base, which requires making analysis of data sets more widely available, linking and integrating aggregated and disaggregated models so that a coherent set of policy-relevant messages can be produced.

135. At the international level, FAO and governments should undertake technical reviews in terms of food insecurity, subsidy stacking and the environmental impacts of biofuel expansion. Especially where assessments are global or transboundary in nature, multilateral review by FAO, OECD, WTO and other groups such as UNEP may be appropriate. It would be useful for FAO and OECD to develop some type of globally-based information and data clearinghouse on biofuels and the issues and challenges they pose.

Building capacity

136. The technical and organizational challenges many developing countries face on questions of biofuels are daunting. Developing countries lack the ability to pay large biofuel subsidies yet many, such as Angola, Malaysia and Thailand, are encouraging ethanol and biodiesel production from sugar cane, oil palm, sugar and cassava. Many others are considering how they can be part

of the biofuel boom and whether the employment and rural development opportunities are worthwhile to convert land to grow feedstocks and produce biofuels. In Malaysia and Indonesia, for example, substantial land clearing is underway to plant oil palm for biodiesel, which can be used in-country or exported as a feedstock to the EU.

137. With respect to food security, there are serious reservations about the current effect of biofuels. Fuel and food prices have moved higher together and the rapid growth of biofuel feedstock demand is the principal *new* factor in the rise of world food commodity prices to record levels, as higher feedstock prices have had knock-on effects on other commodities. Food price inflation has risen in almost all countries, and is particularly problematic in those countries where high shares of income are devoted to food expenditures. The food import bill of developing countries increased 10 percent from 2005 to 2006 and by an estimated 33 percent from 2006 to 2007.

138. Decisions need to be made on the basis of the best available knowledge. Tools such as scenario and risk analysis can guide decisions. Strategies can be formulated that strengthen resilience against a range of possible future events or developments. Uncertainty should not be used as an excuse for delaying the assessment of options and making decisions about policies or investments that could promote future food and energy security.

139. Sharing knowledge: need to make existing knowledge available to developing countries. This issue is not just about compiling knowledge. It is about transforming knowledge into a form that offers meaningful guidance at the application level. Institutional structures should be identified that allow information to be shared widely and used by those in a position to take appropriate action.

140. Offering guidance: need for guidelines for developing and developed countries on the estimation and reporting of GHGs, compliance with WTO rules, and avoidance of trade barriers related to biofuels. In addition, development of certification and compliance regulations and the cost of their application needs to recognize national differences in priorities and levels of development, especially for developing countries.

141. Agreeing on terminology: need for more precise terminology for the emerging bioenergy and biofuel sectors. Even among experts, terms are not always used in the same way, which can lead to public misunderstanding of the issues and increase uncertainty about the implications of alternative development pathways.

Investing in innovation

142. Technological innovation, crucial to achieving long-term food and fuel security, requires significant new investment in research and development (R&D) programmes. R&D can improve technical efficiencies and identify strategies and opportunities for coping with scarcities and adapting to climate change (see guiding principle C in final section of this paper).

143. Objectives should be to:

- improve physical and economic efficiencies of feedstock production and biofuel conversion processes;
- conduct careful economic analyses of second generation biofuel technology in different socio-cultural contexts;
- clarify the meaning of the term “marginal lands” and assess their potential for production of second generation biofuels;
- breed a new generation of high-yielding crops, including those providing feedstock for biofuel, and animals adapted to anticipated changes in climatic conditions;
- identify new technologies and practices for adaptation to climate change in the agriculture, energy and transport sectors.

Getting national and international policies right

144. Most countries' biofuel policies have multiple objectives, in particular energy security, climate change mitigation, and agricultural and rural development. These goals are not always compatible with other objectives, and there is increasing recognition of trade offs with food security and the sustainable use of natural resources.Policies are required that help achieve goals efficiently, while recognizing also their impact on international markets.

145. At the national and subnational levels, the policy instruments underlying the biofuel industry include: mandates, tax rebates, direct production subsidies, tariffs, distribution and transport subsidies, and research and development. All have encouraged rapid expansion in biofuel production, sometimes leading to imbalances of supply and demand due to engineering and availability constraints. This, together with rising input costs, may put the entire industry at risk. There is a need to develop policies that will guide coherent investments in food or biofuel within the context of overall agriculture and food security policies, considering differences in national needs and contexts, and international spill-over consequences.

146. Policy priorities need to be identified that will guide public sector investment in infrastructure and encourage private sector investment in productive activities in the food or biofuel subsectors, avoiding inefficient policies that help neither food nor energy security.

147. Both developed and developing countries will need to ensure environmental sustainability of biofuel development by adopting policies through which biofuels impart a positive impact on the CO_2 balance, protect land and water resources from depletion and environmental damage and prevent excessive new loadings of pollutants. To support such policies, there is an urgent need for internationally agreed standards that can address the global environmental implications of bioenergy production.

148. In general, there is a need for national policies, institutions and investments to:

- ensure that food security is not compromised, particularly for the most vulnerable;
- contribute to continued improvement of productivity in the agriculture sector and the equitable and sustainable development of the rural economy;
- support options for natural resource conservation and agricultural and rural development with low carbon pathways;
- minimize negative environmental externalities and provide environmental services to society in general;
- assist those who are adversely affected by climate change and the impact of biofuel production expansion.

149. In addition there is a need for:

- policy-makers to provide for the integration of local, regional or international policies that affect the agricultural sector and the rural economy; and
- integration and coherence of policies between national and global levels and between public and private sectors, in order to avoid policy instruments that have the potential to create undesirable and conflicting outcomes.

150. A the international level, policies are needed to integrate biofuel production and food security, taking account of:

- types of energy: fossil, non-bio-renewable, bio-renewable, food;
- levels: global, regional, national, local;
- sectors: agriculture, energy, environment, industry, transport, trade, finance, infrastructure investment, service provision;
- national demographics: more vulnerable and less vulnerable countries and population groups under different long-term trend scenarios;

- capacity-building: across sectors and levels, to enable developing countries to make the most benefit from opportunities for biofuel production.

151. International policies need to promote biofuels within sustainable development pathways, through, where appropriate, international cooperation and policy frameworks.

152. Policy priorities should be guided by the following four interdependent principles.

A. Outward looking and market oriented: there is a need for policies to be more market-oriented and outward-looking to reduce existing distortions in biofuels and agricultural markets and avoid introducing new ones.
B. Environmentally sustainable: there is a need for policies to strive to make biofuels sufficiently 'net CO_2 positive', protect land and water resource from depletion and environmental damages, and prevent excessive new loadings of pollutants.
C. Growth-enabling: there is a need for policies to promote R&D with the objectives of improving economic and physical efficiencies of the feedstock production and biofuel conversion processes and adaptation to climate change.
D. Protective of the poor and the food insecure: there is a need for priority to be given to the problems created by food deficits and dependence on oil imports for the poor and hungry. Potential opportunities to improve food security and the rural economy from current developments should not be overlooked.