Assessing, predicting and managing current and future climate variability and extreme events, and implications for sustainable development

<u>Background paper</u>

UNFCCC workshop on climate related risks and extreme events under the Nairobi work programme on impacts, vulnerability and adaptation

Cairo, Egypt
18-20 June 2007

This paper was commissioned by the secretariat of the United Nations Framework Convention on Climate Change and prepared by Dr Anju Sharma

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I. SCOPE AND PURPOSE

1. The United Nations Convention on Climate Change (UNFCCC), under its Nairobi work programme on impacts, vulnerability and adaptation to climate change, is holding a workshop on climate related risks and extreme events in Cairo, 18-20 June 2007.

2. In accordance with the mandate given by the Subsidiary Body for Scientific and Technological Advice (SBSTA), the workshop should explore issues and information relating to:

(a) Experience with assessment and management of current and future climate-related risks and impacts, including those related to extreme events and in specific sectors;

(b) Ability, gaps, needs, opportunities, barriers and constraints to predicting climate variability, impacts and extreme events across regions and hazards;

(c) Contribution of traditional knowledge to understanding and managing climate-related risks;

(d) Implications for sustainable development in relation to a), b) and c) above;

(e) Promoting the understanding of impacts of, and vulnerability to, climate change.

3. The objective of this paper is to provide background information for the workshop and formulate key issues on which to focus the discussions. It presents a general overview of some existing approaches and tools to assess, predict and manage current and future climate related risks and extreme events as part of climate variability and explores insights into risk management approaches and implications for sustainable development, as well as summarises information on needs gaps and concerns.

4. The general concept of climate related risks is very broad. It encompasses:

(a) slow onset events - including climate variability, such as variations in temperature and rainfall and loss of freshwater services, and climate extremes, such as drought;

(b) sudden catastrophic events - such as tropical storms and flooding.

5. The workshop and background paper focus on risks related to climate variability and extreme events and how these will be affected by climate change. This paper suggests issues for consideration and discussion at the workshop. It provides information as relates to prediction, assessment and management and related methods and tools. It explores issues relating to climate-related risks and extreme events in greater detail for agriculture and food security, coastal zones, and health. These sectors have been identified as those of greatest importance from submissions, as well as from three regional adaptation workshops and an expert meeting organised during 2006-2007 by the UNFCCC under decision 1/CP.10 of the Convention. Water related issues are included as a crosscutting theme.

6. Annex I includes a compilation of information on gaps, needs and priorities identified by Parties in their submissions on climate related risks and extreme events, Annex II presents examples of methods and tools to assess climate related risks and extreme events in different sectors. Box 1 provides a clarification of the key words used in the paper and Box 2 provides some examples of potential synergies in managing climate-related risk among activities in different organisations and communities.

7. The following sources were used in compiling this paper:

- Submissions from Parties and organisations on relevant programmes, activities and views on the issues relating to climate[1] (documents FCCC/SBSTA/2007/MISC.4 and Add.1 and MISC.5)

[1] http://unfccc.int/documentation/documents/items/3595.php

- Other relevant UNFCCC documents, including reports from regional workshops under 1/CP.10[2]
- The IPCC Fourth Assessment Report (AR4); The IPCC Third Assessment Report (TAR);
- Information from websites and papers of other relevant organisations and individuals.[3]

Box 1: Definition of key terms

Vulnerability: The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity. The UN International Strategy for Disaster Reduction (ISDR) defines vulnerability as the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.

Risk: IPCC defines risk as a function of probability and consequences of an event, with several ways of combining these two factors being possible. There may be more than one event, consequences can range from positive to negative and risk can be measured qualitatively or quantitatively.[4] ISDR defines risk as the probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable conditions.[5]

Risk assessment: ISDR defines risk assessment as a methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. The process of conducting a risk assessment is based on a review of both the technical features of hazards such as their location, intensity, frequency and probability; and also the analysis of the physical, social, economic and environmental dimensions of vulnerability and exposure, while taking particular account of the coping capabilities pertinent to the risk scenarios.[6]

Climate impact assessment: IPCC defines climate impact assessment as the practice of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems.

Risk reduction: ISDR defines disaster risk reduction as the conceptual framework of elements considered with the possibilities to minimise vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.

Risk management: IPCC defines risk management as the culture, processes and structures directed towards realising potential opportunities, whilst managing adverse effects. ISDR defines disaster risk management as the systematic process of using administrative decisions, organisations, 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 activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

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2 see http://unfccc.int/adaptation/adverse_effects_and_response_measures_art_48/items/2535.php
3 References are provided in the footnotes throughout the text
4 IPCC (2007). New Assessment Methods and the Characterisation of Future Conditions. *Fourth Assessment Report*. Chapter draft
5 ISDR (2007). Terminology: Basic Terms of Disaster Risk Management. http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm
6 ISDR (2007). Terminology: Basic Terms of Disaster Risk Management. http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm

II. INTRODUCTION

8. It is now widely recognised that climate-related impacts are not just a future threat. Past and current experiences in dealing with climate variability and extreme events, irrespective of attribution to climate change, hold valuable lessons for reducing vulnerability and enhancing resilience for future climate-related adverse impacts.

9. A strong body of experience in dealing with past and current climate-related risks already exists. The global disaster management community, as well as sectoral communities, are increasingly focusing their efforts on building resilience and adaptive capacity in advance, in order to limit their impacts. This is a shared goal between the disaster management, sectoral and the climate change communities, and both have developed a variety of analytical tools and methodologies to assess risk and vulnerability and to identify opportunities for action.

10. Existing approaches, methods and tools to assess and manage climate related risks long used in the fields of agriculture, forestry, ecology and others, can be of great importance in assessing and dealing with the additional risks posed by climate change. Many methods and tools developed in other disciplines have been "borrowed", adjusted and used in climate change vulnerability and adaptation assessments. Examples include techniques for environmental impact assessment, and agriculture models (where climatic variables have been incorporated into hydrological modelling), and valuation techniques. Some of the examples of methods and tools borrowed from different community areas, including stakeholder participation tools and vulnerability assessments, are given in Annex II.

11. A number of areas of common interest and potential integration between the disaster management community, sectoral communities and the climate change community exist (Box 2) and a great deal of duplication of efforts and lost opportunities will take place unless resources and knowledge are pooled and integrated. For example, improvements in the ability to predict climate variability and extreme events and in assessing vulnerability and risk management interventions could help all communities to be better prepared. Early warning systems, risk sharing mechanisms and traditional knowledge and coping strategies for climate-related variability and extreme events are other areas of shared common interest.

12. Integrating efforts to minimise the impact of climate vulnerability and change into the activities of various developmental processes and creating synergies with existing disaster risk management activities is a considerable challenge. The institutional frameworks, political processes, funding mechanisms, information exchange fora and practitioner communities have developed independently, and to date remain largely separate.[7] Limited interaction between the various institutions and activities and lack of awareness are additional barriers. Issues related to climate variability and change are usually dealt with by environment departments at the national level, which tend to have limited leverage on other key departments that need to be involved in integrated efforts, such as finance, economics and agriculture.

13. Efforts at integration are required at the global, regional and national levels within the context of sustainable development and with the active commitment and participation of national governments (including various departments dealing with development-related issues such as water, agriculture, poverty alleviation, health etc.), the research community, non-government organisations, community representatives and groups, private sector representatives as well as donors working on a wide range of issues, including disaster risk management and sustainable development.

A. Predicting climate variability and extreme events

14. In their submissions, Parties pointed out two major groups of specific issues relating to the prediction of climate variability and extreme events. One group of issues relates to predicting major

[7] Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G., and Rockström, J. (2006). Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters*. Vol. 30 Issue 1. March

events on the global scale, including critical thresholds and abrupt events. Another, larger group of issues encompasses the availability and applicability of existing forecasting for decision-making timeframes at national and local scales.

15. IPCC TAR and AR4 describe a number of methods for providing probabilistic climate change projections, both for global means and geographical depictions. The global climate models provide scenarios that reflect changes in mean temperature and patterns in precipitation. Scientific findings also indicate, with a large degree of certainty that the risk of increased temperature extremes, with more extreme heat episodes in a future climate, as well as risks of increased intensity of tropical cyclones (typhoons and hurricanes) and changes in patterns in precipitation will increase with climate change.

16. While remarkable progress has been made in the ability to predict climate variability and extreme events at a local and national scale, especially for a seasonal time frame, challenges still remain. A number of gaps and needs have been identified from submissions by Parties as well as by the UNFCCC regional workshops on adaptation organised in Africa, Asia, Latin America and the expert meeting organised for small island developing States (SIDS) under decision 1/CP.10 of the Convention. The identified gaps and needs include basic requirements for resources to improve climate and weather observations, data collection and vulnerability and adaptation assessments, the need for higher resolution models for weather prediction and assessment methods suited to specific needs.

17. There are many uncertainties in the prediction of climate variability and extreme events. These include the ability to predict the frequency of extreme events as well as the change in behaviour of extreme events over the next century and the mechanisms involved in producing these changes. Mechanisms and tools need to be developed in order to best develop and communicate societal and environmental vulnerability and opportunities to variability and extreme events and improve predictions at different scales.

B. Assessing risks from climate variability and extreme events

18. New methods, frameworks, and guidelines are being developed to facilitate a wider integration of related activities in risk and vulnerability assessments of climate-related impacts. This shift was noted by the IPCC TAR in 2001, which recorded advances from primarily science-driven assessments that estimate potential climate impacts, towards policy-driven interdisciplinary impact assessments that take into account the many interactions of climate change with other stresses on the environment and human populations, and the value of adaptation measures to diminish the risk of damage from future climate change and from present climate variability.[8]

19. In addition to impact -based, adaptation-based, vulnerability-based, and integrated assessment approaches to climate change impacts, adaptation and vulnerability, the IPCC AR4 describes the risk management approach which is designed for decision-making under uncertainty, and includes the use of formalised methods to manage uncertainty, stakeholder involvement, use of methods for evaluating policy options without being policy prescriptive, integration of different disciplinary approaches and mainstreaming of climate change concerns into the broader decision-making context.

20. Examples of assessment methods from the climate community that involve a broad interdisciplinary approach, with greater emphasis on socioeconomic scenarios and wider stakeholder participation, include the UNDP's Adaptation Policy Framework (APF), the UNFCCC 's National Adaptation Programmes of Action (NAPAs), the Assessments of Impacts and Adaptations to Climate Change (AIACC) projects, and the United Kingdom Climate Impacts Programme (UKCIP). These and other assessment methods are described in detail in the UNFCCC Compendium on methods and tools to evaluate impacts of, vulnerability and adaptation to climate change, updated in 2005[9], as well as other sources from different entities, including the World Bank, ISDR and WHO.

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[8] Füssel, H., and Klein, R.J.T. (2006). Climate change vulnerability assessments: An evolution of conceptual thinking.

[9] UNFCCC (2005). Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change. http://unfccc.int/files/adaptation/methodologies_for/vulnerability_and_adaptation/application/pdf/consolidated_version_updated_021204.pdf

21. Parties have highlighted a better understanding of the nature of the impacts of rapid climate change as a research priority in their submissions. The crossing of critical thresholds in the climate system could lead to a rate of climate change that far outstrips societies' ability to implement the adaptation measures necessary to prevent significant societal, infrastructural and economic damage. Credible research and monitoring programmes of critical indicators of change (such as triggers of rapid change) are essential to develop appropriate preparedness strategies and actions designed to enhance the adaptability and resilience of ecosystems and economies.[10]

22. The importance of basing action related to building adaptive capacity and resilience on the solid foundation of community involvement from the very start and at every stage of predicting, assessing and managing climate-related risks has been emphasised by the AR4, at the UNFCCC's regional adaptation workshops, and also by the Hyogo Framework for Action 2005-2015.

23. Traditional knowledge has the potential in some cases to provide valid input into vulnerability and adaptation assessments, and fill gaps where scientific data collection is sparse. The AR4 finds that traditional and community knowledge is an important but under-utilised resource for assessing and managing climate-related risks and extremes, and contributes, from past experiences, to managing climate-related disasters such as droughts, floods and health crises as well as long-terms trends in mean conditions.

24. The Parties' submissions and outputs from the UNFCCC's regional adaptation workshops highlight the need for effective exchange of information among different users of traditional knowledge. Sensitivity will be required in this process however, as intellectual property issues may arise if traditional adaptive capacities are transferred outside the local area or community.

25. A methodology for incorporating traditional knowledge into national assessments and eventually into adaptation on the ground would be extremely beneficial. Existing resources to document community adaptation projects include the UNFCCC database on local coping strategies[11] and the GEF-funded UNDP projects on Community-Based Adaptation Programme and Adaptation Learning Mechanism.

C. Managing climate-related risks

26. The submissions made by Parties to the UNFCCC secretariat indicate that the focus still largely remains on assessment and prediction of climate-related risks, while management, especially as relates to climate change related risks, is in many cases at a preliminary stage, both in developed and developing countries. Management measures can include early warning systems and risk sharing mechanisms such as insurance.

27. Early warning systems are an essential element to reduce the impact of disasters, and have been recognised as such in major international agendas including the Yokohama Strategy, the Barbados Plan of Action for Small Island Developing States, the Johannesburg Plan of Implementation, the Mauritius Strategy and the meeting of G8 ministers in Gleneagles as well as major multilateral environmental agreements including the UNFCCC and the UNCCD. Many countries in Europe now have early warning systems for climate-related threats such as heat waves and floods.

28. However, a global survey of early warning systems undertaken after the 26 December 2004 tsunami found that while some warning systems are well advanced, there are numerous gaps and shortcomings, especially in developing countries and in terms of effectively reaching and serving the needs of those at risk.[12]

29. The survey noted that to be effective, early warning systems must be people-centred and must integrate four elements - knowledge of the risks faced; technical monitoring and warning service;

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[10] Alley, R. B., Marotzke, J., Nordhaus, W. D., Overpeck, J. T., Peteet, D. M., Pielke Jr., R. A., Pierrehumbert, R. T., Rhines, P. B., Stocker, T. F., Talley, L. D., Wallace, J. M. (2003). Abrupt climate change. *Science*. 28 March. Vol. 299. no. 5615, pp. 2005 – 2010

[11] see http://maindb.unfccc.int/public/adaptation/

[12] ISDR (2007). http://www.unisdr.org/ppew/iewp/

dissemination of meaningful warnings to those at risk; and public awareness and preparedness to act. All four elements are equally important and failure in any one can result in the failure of the whole early warning system. However, progress on each of the four components in existing early systems has been mixed. The weakest elements in both developed and developing countries concern warning dissemination and preparedness to act - warnings may fail to reach those who must take action and may not be understood or address their concerns. The causes identified for these failures include inadequate political commitment, weak coordination among the various actors and lack of public awareness and public participation in the development and operation of early warning systems.[13]

30. Examples of national early warning systems include the Community Based Flood Early Warning System (CBFEWS) in the Philippines, which aims to help local communities prevent losses from increasing floods. The lessons learned from the CBFEWS can be replicated for many community-based adaptation activities and include the importance of involving grassroots organisations, transferring decision-making power to local communities; and combining advanced technologies with indigenous knowledge.[14]

31. Financial risk management tools such as insurance schemes could provide an incentive for initiatives to reduce vulnerability before an event occurs, as well as provide economic relief after an event occurs.[15] Other financial risk management tools that are being considered include commodity price hedging; economic shock funds; commodity price insurance; alternative risk transfer; hedge funds; alternative risk financing; structured risk financing mechanisms; effective use of developed captive insurance; credit and political risk coverage; hybrid insurance products; and catastrophe bonds.

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[13] UN 2006. *A global survey of early warning systems*. http://www.unisdr.org/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf

[14] UNFCCC (2005) Report of the Asian Regional Workshop on Adaptation. http://maindb.unfccc.int/library/view_pdf.pl?url=http://unfccc.int/resource/docs/2007/sbi/eng/13.pdf

[15] SIDS Workshop on Insurance and Climate-Related Extreme Weather Events, November 28, 2003. Workshop Report. http://www.field.org.uk/PDF/FIELD.UNDPNov2003%20Final.pdf

Box 2: Potential synergies in activities on managing climate-related risks

The **International Strategy for Disaster Reduction** (ISDR) submission points out that the *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters* makes a much-needed link between climate change adaptation and disaster risk reduction activities, and has already resulted in reviews of national plans and strategies for disaster management. The Hyogo Framework for Action aims for *substantial reduction of disaster losses in lives and in the social, economic and environmental assets of communities and countries.*

A number of areas of possible collaboration between the Nairobi Work Programme and the Hyogo Framework for Action have already been identified by ISDR, particularly in the areas of methods and tools; data and observations; climate-related risks and extreme events; socioeconomic information; adaptation planning and practices and technologies for adaptation.

The **World Meteorological Organization** (WMO) already provides a number of services relating to data and observations, including training and capacity-building, data management, data rescue, climate monitoring and monitoring atmospheric composition. Associated regional climate centres provide support for climate monitoring and prediction services, understanding local and regional impacts, and early warning for mitigating impacts of extreme events.

The **Food and Agriculture Organization of the United Nations** (FAO) has invaluable experience in dealing with natural hazards that impact food security, including increasing the resilience and capacity of countries and their populations to cope with the impacts of disasters by strengthening disaster preparedness; forecasting and providing early warning of adverse conditions in the food and agricultural sectors; and strengthening local capacities and coping mechanisms through guiding the choice of agricultural practices, technologies and support services.

The **United Nations Development Programme** (UNDP) supports mainstreaming of climate risk management into development processes for disaster reduction, and climate risk management to protect development in high-risk areas. UNDP took the lead in developing the Adaptation Policy Frameworks (APF) for Climate Change - a structured approach to formulating and implementing adaptation strategies, policies and measures to ensure human development in the face of climate variability and change. The APF links climate change adaptation to sustainable development and global environmental issues, and can be used for formulating and designing adaptation-related projects, or for exploring the potential to add adaptation considerations to other types of projects.

Realising the severe implications from climate related variability and change to development investments, poverty alleviation efforts and infrastructure projects, the **World Bank** and bilateral donor agencies are in different stages of planning and implementation of integrating climate risk management into projects through early risk identification and inclusion in project designs.

Several organisations, such as the International Federation of the Red Cross and Red Crescent Societies, Organisation for Economic Cooperation and Development, UN World Food Programme, CARE Canada, and Stockholm Environment Institute have valuable experience in vulnerability assessments and promoting adaptive capacity.

III. AGRICULTURE AND FOOD SECURITY

32. Of all economic sectors, agriculture is one of the most vulnerable to climate variability and an increased frequency of extreme events. These include direct climate-related threats such as extremes in temperatures and precipitation and changes in the growing seasons, and indirect impacts such as a decline in soil quality, pest and pathogen outbreaks and increased risk of fires.

33. Developing countries are particularly affected as nearly 70 per cent of people live in rural areas where agriculture is the largest supporter of livelihoods, but technology generation, innovation and adoption do not keep pace with the adverse effects of climate variability.[16] Poor communities are especially vulnerable as they tend to have limited adaptive capacities and are more dependent on climate-sensitive resources such as local water and food supplies.

34. However, not even industrialised countries are immune to considerable impacts from climate variability. The yield of key crops dropped by as much as 36 per cent in some countries in Europe as a result of the 2003 heat wave, and uninsured economic losses for the agriculture sector in the European Union were estimated at €13 billion.[17]

35. The future productivity of the agricultural sector is closely linked to water availability, just as future water availability is closely linked to practices in the agricultural sector. Human water use is dominated by irrigation, which accounts for almost 70 per cent of global water withdrawals. The future extent of irrigated areas is the dominant driver of future irrigation water use, together with cropping intensity and irrigation water use efficiency. Water quality is also impacted by the emission of nutrients and pesticides from agriculture both in developed and developing countries.[18]

A. Predicting climate-related risks, and early warning

36. In the long term, the IPCC predicts that crop yield potential is likely to increase at higher latitudes for global average temperature increases of 1-3°C depending on the crop, and then decrease beyond that (allowing for effects of carbon dioxide fertilisation). At lower latitudes, however, especially the seasonally dry tropics, crop yield potential is likely to decrease for even small global temperature increases. Increased frequency of droughts and floods would affect local production negatively, especially in subsistence sectors at low latitudes. Projected reductions in yield in some countries in Africa by 2020 could be as much as 50 per cent, and crop net revenues could fall by as much as 90 per cent by 2100, with small scale farms being the most affected. This would adversely affect food security in the continent.[19]

37. Seasonal weather forecasts and early warning methods help reduce the possibility of yield losses from climate variability and extremes. For instance, early detection and warning of systematic disturbances in climate, such as the El Niño-southern oscillation (ENSO), can help in decision-making to better accommodate these disturbances. An assessment found that an ENSO early warning system for Mexico could add up benefits of approximately US$10 million annually, based on a 51-year time period of ENSO frequencies and when a forecast skill of 70 per cent is assumed. This value translates into an internal rate of return for such an early warning system of approximately 30 per cent. The early warning would allow Mexican farmers to adjust by altering a variety of crop decisions, such as growing less (or more) water consumptive crops, planting drought resistant varieties, or altering planting times.[20]

B. Assessing climate-related impacts on agriculture and food security

38. The overall vulnerability of the agricultural sector in a country or community to climate variability and extremes is usually determined by a complex mix of factors that include the extent of

[16] IPCC (2007). Coastal Zones. Fourth Assessment Report. Chapter draft
[17] IPCC (2007). Fourth Assessment Report. Chapter draft
[18] IPCC (2007). Freshwater resources and their management. Fourth Assessment Report
[19] IPCC (2007). Summary for Policymakers Fourth Assessment Report. Chapter draft
[20] Adams, R.M., Houston,L.L., McCarl,B.A., Tiscareño M.L., Matus J.G. and Weiher, R.F. (2003). The benefits to Mexican agriculture of an El Niño-southern oscillation (ENSO) early warning system. *Agricultural and Forest Meteorology*. Vol 115. No.3. Elsevier. March

climate variability, extent of reliance on agriculture, agricultural practices, pre-existing condition of the agricultural land base, institutional systems, cultural and social practices and market factors - all of which need to be considered in risk and vulnerability assessments. For instance, the availability of market and institutional factors to redistribute agricultural surpluses to make up for shortfalls reduces the risk of food shortages due to climate variability and extremes.[21]

39. Food security, meanwhile, depends not only on sufficient global and national agricultural food production, but also on livelihoods that are sufficient to provide enough food for individuals and households. Assessments of food security include factors such as household income, human health, government policy, conflict, globalisation, market failures, as well as environmental issues.[22]

40. Risk assessments for the agricultural sector at the national and local levels, with active involvement of user groups, could help plan interventions to reduce adverse effects. National level assessments have already been carried out or are underway in some developed countries (for example, as part of the National Assessment of the Potential Consequences of Climate Variability and Change in the US). The involvement of user groups is particularly important – experiences so far have clearly shown that top-down solutions may fail to meet the needs of communities, and face resistance.

C. Managing climate-related risks in the agriculture sector

41. A range of options exists to manage risks in the agricultural sector. Close cooperation is essential among organisations and institutions working on agriculture, climate change, and sustainable development including, for example, interventions to alleviate poverty, improve water management, soil fertility and markets, and enhance communication. Efforts to promote such synergies are already underway by organisations such as FAO, which has the technical and operational capacity to actively contribute to streamlining disaster risk reduction into national agriculture and food development policies.

42. At the national scale, specific risk management options include a more informed choice of agricultural policies, practices and technologies to ensure optimal management, new cultivars, large-scale expansion of irrigation to areas previously dependent on rain, and fertiliser application. Effective early warning systems are also important. Farm-level interventions include choice of crop varieties, changes in planting date and local irrigation, and diversification of the crops grown instead of reliance on cash crops that are vulnerable to adverse effects of climate change.

43. Early warning of impending poor crop harvests through improved reliability of crop simulation modelling to predict yields can allow policy makers time to take appropriate action to ameliorate the effects of regional food shortages on vulnerable rural and urban populations. A number of global early warning information systems for food security risks already exist, of which the FAO Global Information and Early Warning System on Food and Agriculture (GIEWS) is the most globally comprehensive. Other systems include the Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS), the WFP Vulnerability Analysis and Mapping (VAM) system and the USAID-sponsored Famine Early Warning Systems Network (FEWS NET).[23] However, much more work is needed on improving agriculture-related early warning systems at the regional, national and local level.

44. Strategies to improve water management and increase the efficient use of water include crop diversification and better irrigation. Some studies suggest that relatively simple and low-cost adaptive measures, such as a change in planting date and increased irrigation, could reduce yield losses by at least 30–60 per cent compared with no adaptation.[24]

45. Given the dominant role of irrigated agriculture in global water use, management practices that increase the productivity of irrigation water use can greatly increase the availability of water for other

[21] Watson, R.T., Zinyowera, M.C., Moss, R.H. (1997). The Regional Impacts of Climate Change: An Assessment of Vulnerability. Intergovernmental Panel on Climate Change. http://www.ipcc.ch/pub/sr97.htm
[22] IPCC (2007). Africa. Fourth Assessment Report. Chapter draft
[23] UN 2006. *A global survey of early warning systems*. http://www.unisdr.org/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf
[24] IPCC (2007). Fourth Assessment Report. Chapter draft

human and environmental purposes. Traditional water management, harvesting and saving methods could play a key role.

46. National level strategies include exploring the possibilities for economic diversification for countries that rely on a narrow range of climate-sensitive economic activities such as agriculture. Globally, agricultural trade policies that contribute to increasing vulnerability of farmers need to be addressed.[25]

47. Future vulnerability and resilience are further eroded in the absence of ex ante schemes in the aftermath of a disaster, as farmers are forced to sell assets and resort to debt. Risk sharing policy instruments, such as insurance, are therefore important. A number of problems exist, however, including the lack of insurance schemes that cover agricultural risks, and high premiums, which are unaffordable for poor farmers.

48. Index-based weather risk insurance contracts in agriculture have emerged as an alternative to traditional crop insurance in many parts of the world. These are linked to the underlying weather risk (such as rainfall and temperature) defined as an index based on historical data rather than on the extent of loss (for example, crop yield loss). As the index is objectively measured and is the same for all farmers, the need to draw up and monitor individual contracts is avoided, and administration costs are reduced. Weather-indexed insurance can help farmers protect their overall income rather than the yield of a specific crop, improve their risk profile enhancing access to bank credit, and hence reduce overall vulnerability to climate variability and change. However the disadvantage is that because of the way the index is defined, there can be a mismatch between payoffs and actual farmer losses.[26]

49. In Malawi, a country with predominantly smallholder agriculture, the World Bank and Opportunity International developed a scheme whereby a packaged loan and index-based microinsurance product was offered to groups of groundnut farmers. The farmers entered into a loan agreement with a higher interest rate that includes a weather insurance premium, which the bank paid to the insurer, the Insurance Association of Malawi. In the event of a severe drought (as measured by the rainfall index), the borrower pays a fraction of the loan due, while the rest is paid by the insurer directly to the bank. Thus, the farmers are less likely to default, and are able to obtain the credit they need for investing in seeds and other inputs necessary for higher-yield crops.[27]

50. Challenges include assuring the financial sustainability of microinsurance providers, while at the same time providing affordable premiums to poor and high-risk communities; and creating partnerships and institutional frameworks that contribute to credible and trusted microinsurance systems.[28]

51. Traditional knowledge and technologies to deal with climate variability and extreme events in the agricultural sector are important in many developing countries which have limited access to new technological advances to reduce vulnerability. Examples include the Zaï technique used in Burkina Faso to cope with arid conditions, by water harvesting and conserving soil nutrients. Termite activity is used to incorporate sand, loam and other organic material from the surface into the soil, while creating tunnels within which pockets of water can be retained without being subject to evaporation.[29]

52. Traditional practices used in semi-arid regions to cope with climate risk include intercropping, relay cropping and crop mixtures. Experts from WMO's Commission for Agricultural Meteorology are assessing these practices to better understand their scientific basis, and make further improvements in these systems.

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[25] Wehbe M.B, Seiler R.A, Vinocur M.R, Eakin H, Santos C and Civitaresi H.M (2005). Social Methods for Assessing Agricultural Producers' Vulnerability to Climate Variability and Change based on the Notion of Sustainability. AIACC Working Paper No.19

[26] Kelkar, U. (2006?). Adaptive policy case study: weather-indexed insurance for agriculture in India. IISD-TERI-IDRC Adaptive Policies Project. http://www.iisd.org/pdf/2006/climate_designing_policies_chap4.pdf

[27] Mechler, R.,Linnerooth-Bayer, J., and Peppiatt, D. (2006). Disaster Insurance for the Poor? A review of microinsurance for natural disaster risks in developing countries. ProVention and IIASA. July

[28] Mechler, R.,Linnerooth-Bayer, J., and Peppiatt, D. (2006). Disaster Insurance for the Poor? A review of microinsurance for natural disaster risks in developing countries. ProVention and IIASA. July

[29] UNFCCC (2007). Report on the African regional workshop on adaptation. http://unfccc.int/resource/docs/2007/sbi/eng/02.pdf

53. Traditional water management practices in many parts of the world that could reduce vulnerability to drought have been eroded through increased reliance on centralised irrigation systems. The revival or introduction of proven and effective water harvesting practices could help in dealing with water shortages.

54. At the same time traditional knowledge and practices are the result of centuries of adaptation to existing climatic conditions, and may not evolve as rapidly as changes in climate. Careful monitoring and a judicious mix of new developments in technology will therefore be required. WMO facilitates the assimilation of traditional knowledge into modern climate related risk management strategies, for instance through Regional Climate Outlook Forums that liaise closely with end-users in communities.

55. Flexible assessment methods, where deemed useful, might be helpful in taking on board traditional practices. For instance, the FAO crop-specific soil-water balance model allows the inclusion of information on local agricultural practices such as irrigation practices and choice of crop varieties.

IV. COASTAL ZONES

56. Coastal zones are already experiencing some of the changes that are expected to accelerate with global warming, such as the increased frequency of extreme events. Coastal erosion and ecosystem loss are already taking place, although it is unclear to what extent these are due to global warming. Coral and coastal wetland ecosystems, and the goods and services they provide, are threatened, with additional serious implications for human well-being. The IPCC AR4 lists a range of impacts and activities that affect coastal zones.[30]

57. The direct impact of human activities on coastal zones over the past century has been greater than impacts that can be directly attributed to observed climate change. Human population and pressures are dramatically on the rise, increasing the levels of risk. Population densities in coastal regions are about three times higher than the global average, with 23 per cent of the world's population living both within 100 km distance of the coast and less than 100 m above sea level. Sixty percent of the world's cities with a population of over 5 million are located within 100 km of the coast, including 12 of the world's 16 cities with populations greater than 10 million.

58. Human activities that directly impact coastal zones include drainage of coastal wetlands, deforestation and reclamation; discharge of sewage, fertilisers, and contaminants into coastal waters; extractive activities including sand mining and hydrocarbon production; harvest of fisheries, and other living resources; introduction of invasive species; construction of seawalls and other structures; engineering activities such as damming, channelisation, and diversions of coastal waterways; and disruption of ecosystem services by large-scale ecosystem conversion for agriculture, industrial and urban development or aquaculture.

59. Populated deltas, low lying coastal urban areas, and atolls are societal hotspots of coastal vulnerability, occurring where the stresses on natural systems coincide with low human adaptive capacity and high exposure.

60. While the vulnerability of developing countries to climate changes is much greater due mainly to a low adaptive capacity and lack of necessary financial and other resources, Hurricane Katrina showed that developed countries are not insulated from the adverse consequences of extreme events. Over 1300 lives were lost as a result of the hurricane, and economic damages totalled over US$100 million.

A. Predicting climate-related risks to coastal zones

61. Predicted climate-related impacts on the ocean include increases in sea level and sea-surface temperature; decreases in sea-ice cover; and changes in salinity, alkalinity, wave climate, and ocean circulation. These changes are expected to impact fresh water resources due to seawater intrusion into

30 IPCC (2007). Coastal Zones. Fourth Assessment Report. Chapter draft

surface water and coastal aquifers; and result in encroachment of saltwater into estuaries and coastal river systems, coastal inundation and higher levels of sea flooding. In addition, key coastal sectors such as fisheries and aquaculture, agriculture and forestry, tourism, settlements and infrastructure, biodiversity and health will be affected.

62. The IPCC AR4 recognises the need to improve predictive capacity for future global coastal change due to climate and other drivers through field observations, experiments and model development. Coastal systems often show complex, non-linear morphological responses to change. For instance, climate change and sea level rise affect sediment transport in complex ways, which could result in abrupt, non-linear changes as thresholds are crossed.[31] A possible breakdown of the West Antarctica and/or Greenland ice sheets triggered by rising temperature could increase sea level by up to 3m and render many coastal settlements unviable. In order to understand these changes, the processes and agents that drive coastal change need to be isolated and quantified, and the role and importance of feedbacks and thresholds of change better understood.[32]

63. Improved monitoring and understanding of the impacts of climate-ocean regimes can help predict changes that have been associated with these regimes. For instance, changes in the spatial distribution of fish stocks have been linked to climate-ocean system variations such as ENSO and decadal-scale oscillations. An understanding of the role played by the variations in the management of fish stocks is leading to new adaptive strategies that are based on the determination of stock resilience and acceptable removable percentages of fish.[33]

B. Assessing climate-related risks to coastal zones

64. The level of knowledge on coastal zone issues is not consistent with the potential severity of the problem, according to the IPCC. The largest uncertainties involve the interaction between the natural and human sub-system within coastal zones.

65. Increasing recognition of the intricate linkages between physical coastal processes, diverse coastal systems, the resources and ecosystem services they provide and the variety of human amenities and activities that depend on them has resulted in a more integrated assessment approach that takes into account social, economic and environmental criteria. However, the crossing of disciplinary boundaries remains insufficient.[34]

66. Methods available to assess impacts and management strategies include the IPCC Common Methodology, the UNEP Handbook Methodology, the Coastal Zone Simulation Model (COSMO), the South Pacific Island Methodology (SPIM), RamCo and ISLAND MODEL, the Dynamic Interactive Vulnerability Assessment (DIVA), and Shoreline Management Planning (SMP) (see the UNFCCC Compendium).[35]

67. Tools identified by the IPCC to support coastal adaptation assessments and interventions include indices of vulnerability to sea-level rise; integrated models and frameworks for knowledge management and adaptation assessment; geographic information systems for decision support; scenarios to facilitate thinking and deciding about the future; community vulnerability assessment tool; flood simulators for flood and coastal defences and other responses; estimating socioeconomic and environmental effects of disasters; monetary economic valuation of the environment, evaluating and mapping return periods of extreme events and methods and tools to evaluate vulnerability and adaptation.[36]

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[31] IPCC (2007). Coastal Zones. Fourth Assessment Report. Chapter draft
[32] Williams. J. and Thieler, R. (2005). The Need for Better Understanding of Sea-Level Change. US Geological Survey.
[33] IPCC (2001). Third Assessment Report
[34] IPCC (2007). Coastal Zones. Fourth Assessment Report. Chapter draft
[35] UNFCCC (2005). Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change. http://unfccc.int/files/adaptation/methodologies_for/vulnerability_and_adaptation/application/pdf/consolidated_version_updated_021204.pdf
[36] IPCC (2007). Coastal Zones. Fourth Assessment Report. Chapter draft

C. Managing climate-related risks to coastal zones

68. Non-climate stresses play an important role in increasing coastal vulnerability to climate variability and extreme events. An integrated coastal zone management approach requires policies that enhance social and economic equity, reduce poverty, increase consumption efficiencies, decrease the discharge of wastes, improve environmental management, and increase the quality of life of vulnerable and other marginal coastal groups. Such policies can collectively advance sustainable development, and hence strengthen adaptive capacity and coping mechanisms.[37]

69. Management options will need to span policies and activities under a variety of government departments, institutions and stakeholders, including, for instance, those dealing with coastal zone management, climate change and variability, disaster mitigation, land-use, watershed plans and sustainable development. Closer links and integration of efforts are essential between local governing bodies of coastal villages, towns and cities. Stronger links and channels of communication are essential between researchers, stakeholders and decision-makers at the local, regional and global level.

70. Underlying causes, such as those that lead to the increase of migration to coastal areas, will also have to be addressed as part of this integrated approach. Diversification of income options, as proposed by the Hyogo Framework, will be needed where livelihoods are at stake. Currently, however, planning failures increase the stresses on coastal zones, and progress in implementing integrated management strategies to deal with coastal issues has been slow.

71. The need for integration in several areas was pointed out by the IPCC TAR, including subject/topic area integration (for instance, climate-change related stresses plus non-climate stresses; biophysical and socioeconomic susceptibility, resilience, vulnerability, impacts); geographical/spatial integration (for instance, linkages between terrestrial, coastal, and oceanic systems and feedbacks; global, regional, local scales); methodological integration (such as integrating physical, social, and economic models); integrated implications (for instance, for sustainable development, intergenerational equity and ethics); and integration of science, impacts, and policy.[38]

72. Traditional practices and knowledge along the coastline can contribute to adaptive capacity and resilience. For instance, the implementation of traditional marine social institutions, as exemplified in the Ra'ui in Rarotonga, Cook Islands, is an effective conservation management tool for improving coral reef health.[39] In Fiji, traditional practices guide the sustainable use of the rainforest, mangrove forest, coral reefs, and village gardens.[40]

73. The need for early warning systems to warn against coastal hazards was acutely recognized following the 2004 Indian Ocean tsunami. The 2006 global survey of early warning systems carried out by the UN found, however, that while numerous national and international organizations have made efforts to monitor and protect human life and environment in coastal areas from hazards, it is rarely done in a coordinated and efficient manner. The survey pointed to the crucial need for a coordinated and integrated mechanism for coastal observations (in-situ and remotely sensed), as well as early warning systems for coastal hazards, including appropriate risk assessment systems to each region's needs.[41]

74. Reducing vulnerability through risk-sharing instruments and mechanisms such as insurance is increasingly being discussed in the context of coastal hazards. In addition to accelerating economic and social recovery following a disaster, insurance can act as a deterrent for new developments in hazard-prone areas.[42] Sustainable development can contribute to managing and maintaining the insurability of

[37] IPCC (2007). Coastal Zones. Fourth Assessment Report. Chapter draft
[38] IPCC (2001). Coastal Zones and Marine Ecosystems. *Climate Change 2001: Impacts, Adaptation and Vulnerability*. IPCC.
[39] IPCC (2007). Small Islands. Fourth Assessment Report. Chapter draft
[40] IPCC (2007). Small Islands. Fourth Assessment Report. Chapter draft
[41] UN 2006. *A global survey of early warning systems*. http://www.unisdr.org/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf
[42] Clark, M.J (1998). Flood insurance as a management strategy for UK coastal resilience. *The Geographical Journal*. Vol 164. The Royal Geographical Society. November 1998

climate-related risk, though development projects can be stranded where financing is contingent on insurance, particularly along coastlines and shorelines vulnerable to sea-level rise.

V. HEALTH

75. Climate variability and extreme events have direct impacts on human health through exposure to temperature extremes and extreme events, and indirect impacts through changes in air, water and food quality and availability, ecosystems and economies. The main effects recorded so far include altered distributions of some vectors and infectious diseases; altered distribution of allergenic pollen species; and an increase in mortality due to heat waves.[43]

76. Health impacts related to climate variability and extreme events - including the number of people affected and killed - are greater in developing countries, particularly among the urban poor, the elderly and children, traditional societies, subsistence farmers, and coastal populations. Economic growth has the potential to reduce some of these impacts only if it comes with accompanying benefits such as education and awareness, health care, and improved public health infrastructure.[44]

A. Predicting climate-related health risks

77. Changes expected in the future include an increase in under-nutrition and consequent disorders, including child growth and development, due to food and water shortages; increase in the number of people suffering from disease and injury due to heat waves, floods, storms, fires, and droughts; mixed impacts on malaria, with a contraction of the geographic range in some areas, and expansion in others, and extension of the transmission season; increase in the burden of diarrhoeal diseases and other transmissible diseases such as dengue; and an increase in the frequency of cardio-respiratory diseases due to higher concentrations of ground level ozone.[45]

78. Reliable seasonal forecasts can help in predicting impending climate-related health crises, and allow more time for interventions to limit impacts. For instance, a timely warning by the Pacific ENSO Application Center of a strong El Niño in 1997 to 1998, which could result in severe droughts and tropical cyclones, gave governments in the Pacific region sufficient time to intervene. Interventions such as public education and awareness campaigns were effective in reducing the risk of diarrhoeal and vector-borne diseases.[46]

79. Studies have been carried out to isolate meteorological and climatalogical conditions that favour the development of infectious diseases and epidemics, particularly vector-borne diseases such as malaria. For instance, a detailed retrospective study in Columbia revealed that a significant increase in numbers of Plasmodium vivax malaria cases was associated with a pattern of hydrological and climatic ENSO-related anomalies, namely: an increase in mean temperatures; a decrease in rainfall; an increase in dew point and a decrease in river charges.[47] A connection has also been shown between ENSO and the intensification of seasonal malaria transmission in India and Latin America.

80. Another collaborative study between the International Research Institute for Climate and Society (IRI), the Ministry of Health Botswana and the EU-DEMETER project showed that December-January-February national rainfall totals, available at the beginning of March, are highly predictive of the annual adjusted malaria incidence in Botswana. The study confirmed that warnings of changes in malaria risk could be anticipated three to five months in advance using seasonal rainfall forecasts, available in early November, with only a slight loss of accuracy.[48]

81. WMO and WHO work together to develop the capacity of national meteorological services to monitor and detect meteorological and climatological conditions that could pose a health risk.

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43 IPCC (2007). Human Health. Fourth Assessment Report. Chapter draft
44 IPCC (2007). Human Health. Fourth Assessment Report. Chapter draft
45 IPCC (2007). Human Health. Fourth Assessment Report. Chapter draft
46 IPCC (2007). Human Health. Fourth Assessment Report. Chapter draft
47 Madeleine C. Thomson and Stephen J. Connor. The development of Malaria Early Warning Systems for Africa
48 IRI (2005). *Climate risk and health*. The International Research Institute for Climate and Society. http://iri.columbia.edu/outreach/meeting/FINLAND2006/docs/IRI_Climate_Risk_and_Health.pdf

B. Assessing climate-related health risks

82. Assessing the potential health impacts of climate variability and change requires understanding of both the vulnerability of a population and its capacity to respond to new conditions.[49] Assessments need data and information on a number of non-climatic factors such as environmental and social conditions, access to health care, demographics and behaviour. A key uncertainty in assessing future impacts involves how public health and other infrastructure will develop - a factor which is not determined by GDP per capita alone.[50]

83. While there have been advances in research on health issues faced by high income countries since 2001, the IPCC AR4 finds important gaps in information for low and middle income countries, which have limited capacity for research. Although several countries have carried out health impact assessments which provide more detailed information on population vulnerability to climate, and some adaptation measures specific to climate variability have been developed and implemented within and beyond the health sector, further advances are essential in the development of climate health impact models that project future health effects.

84. Cross-border and regional initiatives are essential to deal with direct and indirect climate-related threats to health, such as floods, droughts and epidemics.

85. Examples of region-wide assessments to identify areas of vulnerability; review current measures, technologies, policies and barriers to improving adaptive capacity; identify adaptive measures and provide estimates of the health benefits of strategies include the Climate Change and Adaptation Strategies for Human Health in Europe (cCASHh) study, coordinated by the WHO and completed in 2004.

86. The study found that relatively little has been done so far in public health to incorporate projections of climate variability and change in policy planning. Barriers include a limited sense that climate change matters in public health, few exposure-response relationships for climate-sensitive diseases that are used to measure impacts, and the political will to tackle the problem. In addition to new programmes and polices to address new threats, the study proposed that existing programmes will have to be modified or strengthened to take climate variability into account.[51]

C. Managing climate-related health risks

87. For effective management of climate related health risks closer interaction is needed between the health sector, healthcare and public health industry and the climate, disaster reduction and development community. A range of other sectors and disciplines need to be involved – including, for instance, urban planners and architects, to plan better to deal with extreme temperatures, extreme events, and increase in vectors; and the agricultural sector, since certain agricultural practices that provide breeding grounds for vectors will need to be altered. Synergies with global and national programmes to control the spread of specific diseases (such as the Roll Back Malaria (RBM) Partnership) are also essential.

88. The Hyogo Framework for Action 2005-2015 already calls for integration of disaster risk reduction planning into the health sector. In response, WHO works with national health ministries and other partners to ensure that health sector vulnerability reduction priorities are formulated and instituted, and relevant capacities such as disease surveillance and control are considered.[52]

89. Surveillance and early warning systems have a key role to play in limiting the health impacts of climate-related risks. Heat-health warning systems (HHWS) have been implemented in some countries, mainly in Europe and the US. The warning is normally issued by the health sector, based on the model run by the meteorological agency. The systems often include outreach and education, and interventions

[49] Ebi, K.L.. Assessing Human Health Vulnerability and Public Health Adaptation to Climate Variability and Change
[50] IPCC (2007). Human Health. Fourth Assessment Report. Chapter draft
[51] Menne, B. and Ebi, K.L. (eds) (2006). Climate Change and Adaptation Strategies for Human Health. Steinkopff Darmstadt, Germany
[52] WHO (2005). WHO Hyogo Priorities for Action. http://www.unisdr.org/eng/hfa/intern-org/WHO-hf-priorities.doc

by the health and social sectors to follow up with the most vulnerable groups to achieve appropriate responses to the warnings. WMO is at an advanced stage of developing guidelines to help the meteorological and health communities develop such services.[53]

90. Global health-related surveillance and early warning systems are at various stages of development and effectiveness. WHO's integrated disease surveillance strategy aims at developing national capacities for participatory and people-targeted surveillance systems, and is being adapted in the Africa region and applied to monitoring and alert activities in the Eastern Mediterranean region, Europe and South East Asia. WHO also coordinates the Global Outbreak Alert and Response Network (GOARN), a technical collaboration of existing institutions and networks, to undertake rapid identification and confirmation of epidemics. This network is supported by databases, including the Global Public Health Intelligence Network that scans global sources for outbreak-related information.[54]

91. A few countries have started to develop Malaria Early Warning Systems (MEWS) that use simple transmission risk indicators such as excess rainfall. In Africa, a framework for designing malaria early warning systems has been developed and disseminated as part of the global RBM Partnership. Other initiatives in Africa include the joint WHO-UNICEF HealthMap initiative, which is being assessed for use in malaria surveillance, and the continent-wide Mapping Malaria Risk in Africa (MARA) project for malaria early warning using Geographical Information System (GIS).[55] However, the routine use of such information within African malaria control programmes is limited mainly because of poor collaboration between health and other sectors (including meteorology and agriculture) and the lack of systematic evidence concerning the cost-effectiveness of MEWS. Efforts are now focused on developing a predictive capacity and recognising that a multi-sectoral approach is required.[56]

VI. WATER - A CROSSCUTTING CONCERN

92. The impacts of climate-related factors on water quality and quantity have already been experienced in most parts of the world and by most sectors, and are likely to be exacerbated in the future. Water use has increased over recent decades in most countries due to demographic and economic growth, changes in lifestyle and expanded water supply systems. Although water use is impacted by climate change, more important drivers include changes in population, life style, economy and technology, in particular by food demand that drives irrigated agriculture.[57]

93. Globally, the quality and availability of water resources are likely to be further affected by observed and projected increases in temperature, evaporation, sea level and precipitation variability. Some of the predicted impacts of climate-related factors are: a decrease of water volumes stored in glaciers and snowpacks, affecting more than one sixth of the world population living in glacier- or snowmelt-fed river basins; increased precipitation intensity and variability, resulting in an increase in the risk of floods and droughts in many areas; and salinisation of groundwater and estuaries in coastal areas due to sea level rise, exacerbated in the case of aquifers by excessive water withdrawals and a reduction in recharge.

94. Higher water temperatures, increased precipitation intensity and longer periods of low flows are likely to exacerbate many forms of water pollution, with impacts on ecosystems, human health and water system reliability and operating costs. This is particularly the case in developing countries, where the biological quality of water is poor due to the lack of sanitation and water purification technologies.

[53] UN 2006. *A global survey of early warning systems*. http://www.unisdr.org/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf
[54] UN 2006. *A global survey of early warning systems*. http://www.unisdr.org/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf
[55] UN 2006. *A global survey of early warning systems*. http://www.unisdr.org/ppew/info-resources/ewc3/Global-Survey-of-Early-Warning-Systems.pdf
[56] Madeleine C. Thomson and Stephen J. Connor. The development of Malaria Early Warning Systems for Africa
[57] IPCC (2007). Freshwater resources and their management. Fourth Assessment Report

95. Both supply and demand issues will need to be addressed by water management strategies. Limiting factors listed by the AR4 include physical limitations (for instance, it may not be possible to prevent adverse effects through technical or institutional procedures); economic constraints; political or social limits; and the limitations imposed by the capacity of water management agencies and the water management system as a whole. Constraints include the low priority given to water management, lack of coordination between agencies, tensions between national, regional, and local scales, ineffective water governance and uncertainty over future climate change impacts.[58]

VII. IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT

96. Climate variability and change can have a profound impact on the livelihoods and well-being of millions of people and should be factored into national social and economic development efforts both at the policy and practical levels. Building adaptive capacity and resilience to climate-related risks is essential to meet development goals, including the Millennium Development Goals (MDGs) which address issues such as poverty alleviation, hunger, access to water and human health, and achieve the objectives set out in poverty reduction strategies.

97. The IPCC AR4 has pointed out the many synergies between efforts towards sustainable development and those that deal with climate change. They include access to resources (including information and technology), equity in the distribution of resources, stocks of human and social capital, access to risk sharing mechanisms, abilities of decision-support mechanisms to cope with uncertainty. However, most of the scholars and practitioners of development who recognise that climate change is a significant issue at local, national, regional and/or global levels focus their attention almost exclusively on mitigation.[59]

98. Researchers have pointed out that they key to successful adaptation processes lies in enabling communities and individuals that are the targets of adaptation efforts, providing them with the assets and capabilities they need to take conscious adaptive actions. External agencies can and should support their action through, for example, changes in laws and policies that govern access and rights to resources, different aspects of natural resource management, access to information and technologies, and governance conditions that affect the poor. Such actions should include efforts to build up the asset base of the poor, sustain existing and open up new livelihood opportunities, and forge stronger and more cohesive community-level institutions.[60]

VIII. POSSIBLE ISSUES FOR CONSIDERATION AT THE WORKSHOP

99. The workshop needs to be forward looking. The impact of current climate variability and climate change is well documented. The emphasis must be on how to promote understanding of the risks, particularly among vulnerable countries and regions; and how best to tackle assessing future risks and how to plan and implement response measures within the context of sustainable development.

100. Given the broad nature of the issue of climate-related risks, it may be reasonable to focus the workshop discussions on a limited number of risks and specific questions in order to ensure meaningful and practical outcomes. One way of achieving this could be for each sectoral group to identify a limited number of risks to be considered at the workshop. Possible climate-related risks and extreme events to be considered could include:

(a) Agriculture and food security: droughts, floods, storms, plant diseases and pest/insect infestations

(b) Coastal zones: tropical cyclones, sea level rise and salinization of fresh water

[58] IPCC (2007). Freshwater resources and their management. Fourth Assessment Report

[59] IPCC (2007). Fourth Assessment Report. Chapter draft

[60] Soussan,J., and Burton, I.. Adapt and Thrive: Combining adaptation to climate change, disaster mitigation and Natural Resources Management in a New Approach to the Reduction of Vulnerability and Poverty.

(c) Health: vector and water-borne diseases, heat waves and respiratory diseases

101. Potential issues related to each of these risks, including ability, gaps, needs, opportunities, barriers and constraints, could then be addressed by each group through a limited number of questions, such as those listed below.

102. **Experience with assessment and prediction of climate-related risks and impacts, including extreme events:**

(a) What is the level of stakeholder involvement in risk assessment? How can risk assessments be improved?

(b) What should be the criteria for evaluating the applicability of instruments, tools, methods for the assessment and prediction of climate-related risks and impacts?

(c) How and by whom are climate-related risks predicted? How can predictions be improved?

(d) To what extent are long-term trends and future climate-related risks taken into account in risk assessment?

(e) What are the recommendations for specific actions by relevant organizations engaged in the Nairobi work programme?

103. **Experience with management of climate-related risks and impacts, including extreme events:**

(a) How and by whom are climate-related risks communicated? How can the communication process be improved?

(b) What are the policy instruments and relevant tools for the management of climate-related risks and impacts, including risk-sharing mechanisms? How can they be improved?

(c) What should be the criteria for evaluating the applicability of policy instruments and relevant tools for future climate-related risks?

(d) What are the recommendations for specific actions by relevant organizations engaged in the Nairobi work programme?

104. **Contribution of traditional knowledge to understanding and managing climate-related risks:**

(a) What are the criteria that determine the applicability of traditional knowledge in assessing and managing future climate-related risks?

(b) How can traditional knowledge be best integrated in the assessment, prediction and management of climate-related risks?

(c) What are the recommendations for specific actions by relevant organizations engaged in the Nairobi work programme?

105. **Implications for sustainable development:**

(a) What actions can be taken to apply the lessons learned at the workshop to assist decision makers in their efforts towards sustainable development?

(b) What actions can be taken to enhance coordination between entities involved in the assessment, prediction and management of climate-related risks?

Annex 1: Summary of examples of gaps, needs and priorities identified by Parties in their submissions

At its twenty-fifth session, the Subsidiary Body for Scientific and Technological Advice (SBSTA), invited Parties to submit to the UNFCCC secretariat information on their relevant programmes, activities and views on a number of issues relating to climate related risks and extreme events.

The following is a summary of some of the gaps, needs and priorities related to the assessment, prediction and management of current and future climate variability and change and extreme events which were included in the 12 submissions received by the secretariat.[61]

Data

- The lack of quality, comprehensive, and comparable data over preceding decades limits the capacity to analyse climate variability and extreme events. Improved mechanisms for gathering, collection, storage and sharing of data covering physical, environmental, financial, social and economic aspects are needed. Easily accessible, comprehensive databases on historical climate variability, extreme events, and the impacts of extreme events within countries and regions would greatly facilitate risk management planning in anticipation of future climate- and climate change-related events.
- Enhanced human and technical capacity is needed to ensure effective management of these databases.
- Additional resources may be needed to assist in data recovery (where old data is maintained in incompatible formats), to ensure the robustness and compatibility of historical data, and to gather new data.

General gaps and needs with regard to prediction and assessment tools

- Further improvements to address uncertainties, especially at the local scale.
- Higher spatial resolution of regional climate models.
- Improved methods for modelling and for downscaling climate information to the scales required for extreme event analysis.
- Understanding of the processes by which climate variability and change modulate extreme event behaviour is incomplete.
- Improved diagnostic capabilities to better interpret the causes of high-impact climate events, such as droughts or unusually cold or warm seasons.
- Assessments of potential predictability and forecasts of probabilities of extreme events associated with natural climate variations.
- Focused research on variations and changes that generate conditions favourable for extreme events, assess the predictability of these events, and develop products useful for applications (e.g., extreme event outlooks) on seasonal and longer time scales.
- Policy-relevant information on past variability and trends in extreme events, and probabilistic estimates of possible future changes in frequencies, intensities, and geographical distributions of extreme events in support of national and international assessments.
- Improved anticipation of and response to extreme climate events (e.g., to reduce regional impacts of ENSO or more rapidly respond to emerging droughts).
- Better modelling of natural variability (e.g. El Nino) and their interactions with local weather events as the climate changes.
- Increased understanding of and capabilities to project the regional manifestations of extreme climate events, to provide a sounder scientific basis for policymakers to develop strategies to minimise potential vulnerabilities.
- High resolution projections of extremes that better include the associated uncertainties.
- More robust projections of climate variability and extremes for the period T+4-10 years which

[61] http://unfccc.int/documentation/documents/items/3595.php See documents FCCC/SBSTA/2007/MISC.4 and Add.1 and MISC.5

are more often the decision-making timeframes of interest to decision makers.

- More research to better understand abrupt climate-related changes in, for instance, thermohaline circulation (including high resolution modelling of ocean processes and better representation of ocean-atmosphere interactions, and more data/analysis to clarify whether this indicated a temporary halt in the circulation, or geographical re-arrangement of the system); natural methane emissions (better understanding of location and scale of deposits and modelling of the processes involved in releasing them); collapse of ice sheets (greater understanding of ice sheet processes and ocean-atmosphere interactions; and carbon-cycle feedbacks (high resolution hydrology models and better knowledge and modelling of biosphere interactions).
- Special prediction models for urban areas and catastrophe plans.
- Improvements in flash flood forecasting.
- Increased understanding of the formation of tornadoes.
- Technologies around climate modelling and the mapping of vulnerable areas and communities.

Research priorities related to extreme events

- What is the range of natural variability in extreme events, by phenomena and region?
- How do frequencies and intensities of extreme events vary across time scales?
- What are observed and modelled trends in extreme events and how do they compare?
- How are the characteristics of extreme events changed by natural climate variations, for example, by ENSO, PDO, and NAO?
- To what extent are changes in the statistics of extreme events predictable?
- How will the behaviour of extreme events change over this century, and what are the mechanisms that would be expected to produce these changes?
- How can the emerging findings on climate-extreme event links be best developed and communicated to evaluate societal and environmental vulnerability and opportunities?

Research priorities related to drought forecasting

Research priorities supporting drought risk assessment and drought risk management seek to enhance understanding leading to:

- Skilful predictions of drought onset, termination, duration, and severity.
- Predictions of multiyear to decadal drought as a function of SST variability, deep soil moisture/ground water variability, and global change trends.
- Assessments of societal, economic, and environmental vulnerability, impacts and response capacity to drought to inform risk reduction efforts.
- Development of objective quantification of drought and associated economic impacts to accurately quantify the monetary benefits of improved drought prediction and mitigation.
- Methods to incorporate uncertain drought predictions to improve public and private sector planning and operational decision making for water supply, transportation, hydropower, and irrigation.
- Future impact of droughts on water resources is poorly known.

Specific gaps and needs to achieve this include the following:

- Better depiction of current drought areas through improved monitoring capabilities.
- More accurate forecasts of temperature and precipitation, especially for seasonal periods.
- Better ways to incorporate forecasts of temperature and rainfall into forecasts of drought indices (Palmer, soil moisture, stream-flows).
- Greater understanding of surface-air feedback processes through statistical and dynamic modelling improvements.
- Better ways to depict the probabilities of drought worsening or improving.
- Establish long (multi-decade) climate records adequate for retrospective studies, and as required for initialisation, calibration and validation.
- Improve (real-time) observation/assimilation of key surface variables needed for monitoring, model initialisation and/or validation (with uncertainty estimates).
- Improve coupled (atmosphere-ocean-land) model prediction system.

- Improve understanding of roles of local and remote processes on drought variability and predictability, as a function of timescale.
- Foster research into the mechanisms that control the land surface branch of the hydrological cycle at multi-year (decadal) timescales.
- A research effort focusing on the causes of historical droughts (attribution studies).
- Improve simulations of hydrological variability on decadal time scales.
- Foster research focusing on the predictability of multiyear-to-decadal drought.

Specific issues related to precipitation forecasting

- More robust projections of extreme precipitation at appropriate temporal and spatial scales to support decision-making, and including realistic measures of uncertainty.
- Improvements of quantitative precipitation forecasts needed (including probabilistic uncertainty estimations). Significant improvement of regional climate models needed (precipitation has a very high spatial and temporal variability).
- Ability to model changes in extreme rainfall is limited by the resolution of climate models and representation of small-scale processes (e.g. cloud physics).
- Little understanding about the flood risk in relation to urban drainage and waste water infrastructure.
- Climate modelling work needs to be extended to model high intensity rainfall events out to 2080, to get a better assessment of the economic impacts of projected extreme events in sectors e.g. agriculture.

Early warning

- Improved early warning and monitoring systems for extreme weather events.
- Cross-border exchange of warnings between National Meteorological Services.

Socioeconomic factors

- A limitation with many integrated assessment models is that they tend to assess impacts on a sectoral basis, ignoring complex ecosystems and economic sectors. As a result, there are significant information gaps that lead to an incomplete portrayal of climate change impacts. This in turn creates challenges for identifying and disseminating risk management options for adaptation.
- Economic impact studies are needed across a range of sectors and these studies need to be integrated with the physical impact studies.
- Studies are needed of the social impacts and costs of climate change to communities, including sensitivity studies of most vulnerable groups and communities e.g. health risks and the financial impacts of extreme events.
- Urgent need to connect modelling and impact community with adaptation stakeholders.
- Better cooperation between involved institutions.
- Appropriate mechanisms for the management of climate change-related financial risks and impacts on exposed sectors, including insurance-related mechanisms.
- Technological improvements in the resilience of physical infrastructure.
- Improved public awareness and preparedness are essential ingredients for ensuring effective adaptation planning and implementation.

Water

- Ability to model accurately the interaction of rainfall with land surface processes and implications for groundwater. It is difficult to generalise the potential impacts of climate change on water resources, as site-specific factors (such as existing regulatory requirements, infrastructure, and catchment characteristics) are as important as changes in 'drivers' (such as precipitation). Even within the same region, results can vary from negative to positive depending on local factors. Prediction of impacts requires more effort including the involvement of social scientists.
- Need for coupling of hydrometric and climate models, and for better hydrometric modelling.

- Need for better understanding (and modelling) of behaviour of groundwater in response to climate change.

Agriculture and food security

- Assessment of climate change and climatic variability impacts on agricultural crops and the main water balance elements, including the effects of agriculturally significant climatic extremes by using modelling approaches.
- Improved early warning for timely warnings of the need to irrigate crops.
- Plant crop species that need less water.

Coastal zones

- Baseline and monitoring data to help identify zones at risk from coastal erosion and flooding needed.

Health

- More research on the impacts of the pollen of neophytes such as ragweed to better understand the relationship between weather and climate and pollen transmission.
- Observations within the urban environment need to be improved, including through more effective use of remote and non-traditional observing strategies. Understanding vulnerabilities with the urban environment, including how the urban heat island enhancement will evolve (includes integrating development and socioeconomic scenarios).
- Increased attention to vaccination.
- Prediction of tick activity for early warning systems.
- Better cooperation between the meteorological services and relevant health authorities to increase the effectiveness of early warnings.

Annex 2: Examples of multi-sectoral tools available for assessment and management of climate-related risks in different communities[62]

Tool	Description
Providing Regional Climates for Impacts Studies (PRECIS)	This tool provides climate impact assessments in developing country contexts which are freely available to numerous users. The tool uses GCM to provide grid-scale averages of spatio-temporal hydro-climatic state variables as well as soil hydrology and thermodynamics, and some vegetation dynamic variables. The tool is applicable to multiple scales, sectors and levels of screening but is limited fine/point scale information.
Vulnerability mapping and impact assessment	Involves downscaling of outputs from several coupled Atmosphere-Ocean General Circulation Models (GCMs) for four different scenarios of the future, and estimating possible changes in lengths of the growing period for several different combinations of GCM and the SRES scenarios of the IPCC. Results are presented on the basis of agricultural system types by country, using a systems classification as a proxy for the livelihood options available to natural resource users. From this, areas that appear to be particularly prone to climate change impacts are identified. Aimed to provide donors (and in the future governments and NGOs) with information on key characteristics in the agriculture sector at the national level, and identify vulnerable populations ("hotspots"), and, in the second phase, assesses climate change impacts and costs and benefits of potential adaptation options. At present the tool is limited to Sub-Saharan Africa and omits other key non-agricultural impacts.
Statistical DownScaling Model (SDSM)	This computer-based information tool is open-source and is aimed at donors, governments and impact assessors. The tool provides daily, transient, climate risk information for impact assessment over the 1961-2100 time horizon and has been primarily used for water resource management, though is applicable to multiple sectors. After calibration of data, the tool provides rapid assessments to assist impacts and adaptation analysis.
Climate Analysis Indicators Tool	A vulnerability and impacts component of CAIT forms part of this a much wider tool-kit of country-level data on climate change, particularly on greenhouse gas emissions. The database includes information on historical impacts, particularly from disaster events, as well as a range of human development indices. CAIT permits manipulation of this data on a country by country basis, including cross-referencing to mitigation-related data.
NAPA Platform	The NAPA platform is aimed at providing informational support to

[62] Sources used:
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	NAPA country teams, implementing agencies (UNDP, UNEP and World Bank), vulnerability and adaptation experts, and other partners providing NAPA technical assistance. It aims to facilitate the delivery of technical assistance to NAPA teams formulating their NAPA documents, particularly with regards to the synthesis of existing vulnerability and adaptation information, and the formulation of relevant adaptation projects profiles. It provides multi-sectoral information aimed at the programme and project level for Least Developed Countries within the NAPA process.
Adaptation Wizard	The Adaptation Wizard is a web-based tool that is designed to take help users gain a basic understanding of climate change as well as integrate climate risks into their decision-making. It is a high-level, generic tool that is valuable to newcomers to the climate change issue, as well as those who are preparing to adapt. The tool is specifically aimed at the UK context. It is more a decision-support than decision-making tool, and plays a valuable awareness-raising and educational role.
Country Database – UNDP-GEF	The country database aims to help UNDP offices to develop adaptation proposals and improve staff awareness on climate risks for other project design. It compiles a common set of information for each UNDP partner country, drawn from National Communications, NAPAs and other scientific studies, together with UNDP country programme information, on an easy to operate webpage format.
Preparedness for Climate Change	This paper/process based tool is aimed at primarily at local Red Cross/Crescent societies in order to assess key climate change related risks facing vulnerable people in the country and programmes of the national society. The tools draws on RC project details, national staff and the use of RC vulnerability data in order to set priorities for follow-up, including modifications to existing programmes, and to strengthen local capacity in addressing climate-related risks. The tool is primarily aimed at disaster management, health and the water and sanitation sectors.
Climate Change Adaptation Guidance Manual	The Guidance Manual is aimed at USAID country missions to assist in the mainstreaming of climate change adaptation in all projects. At present the manual is being tested in Honduras, South Africa, Mali and Thailand in sectors such as agriculture, coastal development and flooding, water infrastructure, and fisheries and livelihoods. Future projects may cover protected lands management, integrated river basin management, and health. The manual leads project designers through a series of steps to help them understand whether their project may be vulnerable to climate variability or change.
Opportunities and Risks of Climate Change and Disasters (ORCHID)	This process-based tool is designed to be a light touch screening process for donor programmes. The process utilises quantitative inputs climate science which are applied to the risk assessment of programmes usually at wide scales, and using directional trends rather than discrete figures. The tool utilises project documents and interviews with project staff as well as past trend in vulnerability and disaster risk. ORCHID aims to raise awareness of climate risk management and future climate change among staff, to stimulate dialogue with donor partners, to integrate disaster risk reduction and climate change adaptation policies and activities. The process makes recommendations for how programmes might enhance risk management through adaptive practices and cost benefit analysis and sector economic assessment are undertaken for areas where clear

	adaptation options can be discerned and where sufficient data is available.
Assessment and Design for Adaptation to Climate Change – A Prototype Tool (ADAPT)	A computer-based prototype screening and design tool, designed by the World Bank to assess whether a project might be sensitive to the effects of climate change. It then provides guidance to the best sources of information to help take these potential effects into account in the project design. The guidance is based largely on expert assessment of the risks and opportunities that arise from climate change. The tool is meant for use by development practitioners, including bank staff, bilateral agencies, the NGO community and client governments.
Vulnerability Indices	Formal vulnerability indices help identify and target vulnerable regions, sectors or populations, raise awareness, and can be part of a monitoring strategy. Methods of aggregating across sectors and scales have been developed in other contexts (for instance, the Human Development Index) and are beginning to be applied to climate change. However, substantial methodological challenges remain — in particular estimating the risk of adverse climate change impacts and interpreting relative vulnerability across diverse situations.
Vulnerability assessments and sustainable livelihood (VASL) approaches	VASL approaches begin with present risks, and overlay climate change through a guided process of risk assessment. In this approach, climate risks – both present and future – are placed in context of present vulnerability. Further elaboration provides indications of relative risks and strategies to support sustainable livelihoods. The key analytical tools are vulnerability mapping and dynamic simulation of sustainable livelihoods. However, the broader techniques of stakeholder participation and risk assessment are essential.
Social Impact Analysis (SIA)	SIA can be used by project planners and managers in multilateral and bilateral development agencies, national and local government departments and non-governmental and private sector organisations for assessing disaster risks when planning development projects. It is the process of analysing, monitoring and managing the social consequences of policies, programmes and projects. These consequences may be positive or negative, intended or unintended, direct or indirect; they may be short-term impacts or long-term changes. As well as helping to explain how a proposed action will change the lives of people in communities, SIA indicates how alternative actions might mitigate harmful changes or implement beneficial ones.
Health Impact Assessment (HIA)	HIA is a multidisciplinary process, viewing a range of evidence within a structured framework through a variety of procedures and methods. It can be applied to both occupational health risk (within the project) and community health impact (in the project area or other areas that might be affected by it). Health is understood in broad terms, encompassing social, economic, cultural and psychological well-being and the ability to adapt to the stresses of daily life. HIA therefore considers the underlying determinants of health (e.g., employment and working conditions, physical environments, health services, education and coping skills), using checklists of these as indicators of changes in health risks. Health inequality is a central issue and identification of the most vulnerable groups is very important. Compared to some other project appraisal methodologies, HIA is relatively recent and its potential as a tool for assessing

	disaster risk or vulnerability has not been fully explored.
Sustainable livelihoods approaches	A sustainable livelihoods approach is essentially a way of organising data and analysis, or a 'lens' through which to view development interventions. Taking a holistic view of a project (need, focus and objectives), it provides a coherent framework and structure for analysis, identifies gaps and ensures that links are made between different issues and activities. The aim is to help stakeholders engage in debate about the many factors that affect livelihoods, their relative importance, the ways in which they interact and the most effective means of promoting more sustainable livelihoods. There is no single SL approach, and flexibility in method is a distinctive feature of SL.
Country Programming	All international development organisations apply some form of programming framework through which problems, needs and interests are analysed, sectoral and thematic areas of focus identified and the broad level and composition of assistance outlined. Institutions apply many different names to the resulting plans, including Country Strategy Papers (CSPs), Country Assistance Programmes (CAPs), Country Assistance Strategies (CASs) and, in the case of the UN, Common Country Assessments (CCAs) from which UN Development Assistance Frameworks (UNDAFs) are developed. Time frames for country plans are typically three to five years, giving them strategic significance. The process of country programming provides an important opportunity to address disaster risk in a strategic and coordinated fashion, exploring the complex, cross-cutting and multi-faceted nature of vulnerability from human, social, environmental and economic perspectives and identifying appropriate, proactive risk management solutions.
Project Cycle management	A 'project cycle management' approach involves a sequence of actions to develop, implement and evaluate development projects. The aim of project cycle management is to improve the management of projects (and programmes) by ensuring that all relevant issues and conditions are taken into account during design and implementation. In application, project cycle management consists of a set of design and management concepts, techniques and tasks that is used to support informed decision-making. Disaster risk management should be factored into all stages of the project cycle. The initial planning stages of the cycle (programming – identification – appraisal) are the key entry points at which disaster risk issues can be factored into projects. But disaster risk should not be forgotten during the other stages of financing, implementation and evaluation, and the various activities that take place within them.
Logical and Results based Frameworks	Logical framework, or logframe, analysis provides a structured logical approach to the determination of project priorities, design and budget and to the identification of related results and performance targets. It also provides an iterative management tool for project implementation, monitoring and evaluation. Logframe analysis begins with problem analysis followed by the determination of objectives, before moving on to identify project activities, related performance indicators and key assumptions and risks that could influence the project's success. Results-based management is a related tool that is more heavily focused on the performance, achievement and sustainability of outputs, outcomes and impacts, rather than the management of project activities. It begins with the strategic objective of a project and works down to determine what intermediary results

	and thus what activities, processes and resources are needed to achieve that objective. Both logframe analysis and results-based management provide natural tools for use in considering potential disaster risks faced by proposed development projects because analysis of risks and assumptions forms an integral part of each tool.
Environmental Assessment	The basic purpose of environmental assessments is to examine the potential environmental consequences, both beneficial and adverse, of proposed projects and to ensure that they are adequately taken into account in the project's design. It is essential that these environmental assessments cover natural hazards and related risk. The state of the environment is a major factor determining vulnerability to natural hazards. Environmental degradation is widely recognised as one of the key factors contributing to increasing human, physical and financial hazard-related losses.
Country Environmental Analysis (CEA)	CEA is a relatively new analytical tool that a number of multilateral and bilateral development organisations are beginning to apply, in particular to inform overall country programming. CEA provides systematic analysis of key environmental issues most critical to the sustained development of a country and the achievement of the Millennium Development Goals and opportunities for overcoming constraints; of the environmental implications of key development policies; and of a country's environmental management capacity and performance. The tool was developed in response to increasing focus on mainstreaming environmental issues into development policies and planning. CEA provides an important opportunity to highlight disaster risks, where significant, and helps ensure that they are adequately addressed.
Strategic Environmental Assessment (SEA)	SEA is a tool for the integration of environmental considerations into policies, plans and programmes at the earliest stages of decision-making. SEA seeks to ensure that broad environmental considerations are integrated into these higher, strategic levels of decision-making taken prior to the identification and design of individual projects, ideally based in part on a participatory process. SEA is applied in some form by many multilateral and bilateral organisations and also by a number of governments. At the country programming level, it is sometimes referred to as CEA (see above). Like CEA, SEA can provide an important opportunity to highlight natural hazard-related issues, where relevant, and ensure that they are adequately addressed. SEA is also a potentially important tool in ensuring that adequate attention is paid to disaster risk in the design of policies, in particular since SEA should include the prioritisation of environmental issues in terms of their effect on economic development and poverty reduction.
Economic Analyses	Project-based economic analyses help design and select projects that contribute to the welfare of a country and its people. Cost–benefit and related economic appraisal approaches are applied to determine the highest return to investment in a project, facilitate a rational comparison of available options and ensure that investment decisions are accountable. Economic analysis is also potentially useful in identifying and clarifying the issues involved in making particular decisions. Consideration of disaster risk concerns as part of the economic appraisal process is an essential step in ensuring that development gains in hazard-prone countries are sustainable and in highlighting related issues of responsibility and accountability.
Vulnerability and Capacity	VCA is a key component of disaster risk analysis. Its purpose is to:

Analyses (VCA)	▪ identify vulnerable groups; ▪ identify the factors that make them vulnerable and how they are affected; ▪ assess their needs and capacities (and empower them to assess these); and ▪ ensure that projects, programmes and policies address these needs, through targeted interventions or prevention and mitigation of potentially adverse impacts.
Construction Design, Building Standards and Site Selection	The majority of human and direct economic losses from a natural hazard event occur as a direct result of damage to the built environment and/or ineffective early warning and evacuation systems. The negative impact of natural hazards on communities can be limited by taking such hazards into consideration when selecting sites, designing new infrastructure and strengthening existing infrastructure.
Evaluating Disaster Risk Reduction Initiatives	The range of monitoring and evaluation (M&E) approaches and methods in development and relief has grown considerably in recent years. Far less thought has been given to M&E methods specifically for disaster risk reduction (DRR). A number of recent and ongoing evaluation and indicator initiatives, however, focus on different dimensions of DRR – for instance, ISDR and the Office for Coordination of Humanitarian Affairs (OCHA) are developing indicator sets for measuring progress towards the Hyogo Framework of Action 2005–2015.