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ECONOMIC COMMISSION FOR EUROPE

MEETING OF THE PARTIES TO THE CONVENTION ON THE PROTECTION AND USE OF TRANSBOUNDARY WATERCOURSES AND INTERNATIONAL LAKES

Working Group on Integrated Water Resources Management

Third meeting
Rome, 22–24 October 2008
Item 4 of the provisional agenda

WATER AND ADAPTATION TO CLIMATE CHANGE IN TRANSBOUNDARY BASINS, INCLUDING FLOOD AND DROUGHT RISK MANAGEMENT

GUIDANCE ON WATER AND CLIMATE ADAPTATION[*]

Note by the secretariat[**]

1. This document was prepared in line with the mandate given by the fourth meeting of the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), held from 20 to 22 November 2006 in Bonn, Germany. The Meeting of the Parties entrusted the Task Force on Water and Climate to prepare a Guidance on "water and climate adaptation". In addition, the first Meeting of the Parties of the Protocol on Water and Health, held on 17 and 19 2007 January in Geneva, decided that a Task Force on Extreme Weather Events should prepare a strategy paper on how to cope with the potential impact of climate change, and on adaptation and mitigation programmes for water supply and sanitation. According to the decision of the joint meeting of the Bureaux of the Water

[*] Due to resources constraints, this document has not been formally edited.

[**] This document has been submitted late for technical reasons.

Convention and of the Protocol on Water and Health (13 September 2007), the guidance should be a joint product of both Task Forces for possible adoption by both Meetings of the Parties to the Convention and to the Protocol in 2009/2010.

2. The Task Force entrusted a drafting group to develop the draft Guidance. The drafting group was composed of Mr. Edgar Pirumyan (Armenia), Mr. Mikhail Kalinin (Belarus), Ms. Tanja Dubrovin (Finland) Ms. Meike Gierk (Germany), Ms. Zsuzsanna Buzas and Ms. Zsuzsanna Engi (Hungary), Ms. Luciana Sinisi and Ms. Benedetta Dell'Anno (Italy), Mr. Henk Van Schaik, Ms. Marloes Bakker and Mr. Laurens Bouwer (the Netherlands), Ms. Inmaculada Paniagua (Spain), Mr. Christian Goldi (Switzerland), Ms. Natalya Agaltseva (Uzbekistan), Mr. José Luis Martin Bordes (UNESCO), Mr. Avinash Tyagi and Mr. Giacomo Teruggi (WMO), as well as members of the UNECE and WHO-EURO secretariat. Mr. Jos Timmerman (the Netherlands) was the lead author and Mr. Joost J. Buntsma (the Netherlands) chaired the drafting group.

3. The annexes to this document contain an intermediary version of the Guidance which has been jointly prepared by the Convention's Task Force on Water and Climate and the Protocol's Task Force on Extreme Weather Events.

4. The document includes as far as possible the comments and outcome of the workshop "Water and Adaptation to Climate Change: Joining Efforts to adapt" which was organized under the auspices of the Water Convention and of its Protocol on Water and Health, under the joint leadership of the Governments of Germany, Italy, and the Netherlands, and held on 1-2 July 2008 in Amsterdam. Comments needing further redrafting of the Guidance will be taken up by the drafting group.

5. The current draft is still incomplete. In particular, the final Guidance should include:

(a) An executive summary for policymakers;

(b) Examples in the Guidance text to make it more concrete;

(c) Climate-oriented case studies to be included in the annexes;

(d) Additional recommendations related to water supply and sanitation in extreme events (these policy recommendations should be read together with the technical and operational guidelines on water supply and sanitation in extreme weather events to be developed by the Protocol's Task Force on Extreme Weather Events);

(e) Additional specific recommendations related to the transboundary context;

(f) Financial aspects, in particular approaches to costing.

6. The Working Group on Integrated Water Resources Management is expected to comment and review the draft guidance. Participants are therefore invited to provide their comments to the existing text as well as suggestions for how its content and main message should be further developed. Comments can be submitted in written form after or prior to the meeting, latest by

1 December 2008. The document will be further developed by the two Task Forces for endorsement by the next meeting of the Working Group on Integrated Water Resources Management in June 2009 and possible adoption by the fifth Meeting of the Parties in November 2009.

Annex

DRAFT GUIDANCE ON WATER AND CLIMATE ADAPTATION

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INTRODUCTION

1. As recognized by the Fourth Assessment Report of the Intergovernmental Panel on Climate Change[*] in 2007, observational evidence from all continents and most oceans shows that many natural systems, among which the hydrological cycle and thus water availability and water quality as well as water services, are being affected by anthropogenic climate changes. 'Climate change' is defined as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

2. These changes have significant socio-economic impacts: in the period 2000–2006, worldwide the frequency of disaster from extreme climatic events increased by 187 per cent compared to the previous decade, accounting for 33,000 deaths and 400 million people affected. In the same period, global economic damages for flooding events and heavy storms were estimated in about US$ 25 billion. [†]

3. Nearly all UNECE countries are anticipated to be negatively affected by the future impacts of climate change. Impacts will vary considerably from region to region and even from basin to basin. Negative impacts include increased risk of (flash) floods, intensified erosion and extensive species losses. Mountainous areas will face glacier retreat causing changes in mountain rivers' water regime and streamflow, and reduced snow cover which will affect winter tourism, development of hydro- energy and agriculture. Coastal areas face negative impacts from sea level rise, including salt intrusion in coastal groundwaters, as well as increased river discharges. Wetlands face the danger of drying out.

4. In Southern Europe, Caucasus and Central Asia, climate change is projected to lead to high temperatures and drought and to reduced water availability, hydropower potential, summer tourism and, in general, crop productivity. In Central and Eastern Europe, summer precipitation is projected to decrease, causing higher water stress. In Northern Europe, climate change is initially projected to bring mixed effects, including some benefits such as reduced demand for heating, increased crop yields and increased forest growth.

5. The first Assessment of transboundary rivers, lakes and groundwaters in the UNECE region [‡] has demonstrated that in many basins, climate change impacts can already be observed.

6. Climate change impacts on freshwater resources affect sustainable development and puts at risk economic development, poverty reduction, child mortality, production and availability of

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[*] IPCC 2007.
[†] Emergency Events Database (EM_DAT) of the Centre for Research on the Epidemiology of Disasters (CRED), 2007.
[‡] UNECE, 2007. Our waters: joining hands across borders. First Assessment of Transboundary Rivers, Lakes and Groundwaters. Economic Commission for Europe, Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Geneva, Switzerland. (www.unece.org/env/water/publications/assessment/assessmentweb_full.pdf).

food, and the health of people and ecosystems, thus the capacity of achieving the Millennium Development Goals.

7. Climate change and variability and associated changes in the available water resources and their quality are responsible for increased health risks. Direct effects may include lesions and death from drowning or trauma in floods and premature deaths attributed to heat waves and cold waves. Indirect effects relevant to health risk can include post-traumatic mental disorders, infectious and non- infectious diseases and population displacement. Especially after flood events, populations are exposed to health hazards caused by contamination of water (e.g. pathogens, waste and toxic chemicals), lack of household hygiene, reduction of food safety, and increase in the number and geographical distribution of disease carrying vectors. These changes can result in an increase of infectious diseases. In addition, due to increasing temperatures, new diseases are introduced in regions where they were previously absent, and diseases that had been controlled in the past, such as malaria in Central Asia, reappear. However, despite of the importance of these health risks, they are often beyond the reach of the health sector, thus other sectors have to develop and implement mitigation measures.

8. Availability of a reliable supply of safe water and adequate sanitation is essential to safeguard human health. Disruption of these services, especially during extreme events, will result in an increase in water borne infectious diseases. It is therefore important to develop coping mechanism to deal with such disruption. The safety of the water supply and sanitation sector relies on close inter-sectoral cooperation during the prevention, management and recovery phases.

9. Adaptation to climate change is consequently indispensable and urgent since mitigation will take too long to show effects. In addition, as recognized by various scientific panels, it is more cost-effective to start preparing for adaptation now than to wait until impacts of climate change are irreversible.

10. Any adaptation policy should consider that climate change is one of the many increasing pressures on water resources such as population growth, changing consumption patterns or industrial development. Future scenarios should take into account also other causes of change such as energy shortage, food prices variation, etc. Therefore, climate change adaptation should not be done in competition with, but in addition to other water management measures. Climate proofing of existing water supply systems can for instance be done in combination with ensuring the basic human right to water to those that do not enjoy that right at present.

11. Countries with economies in transition and less developed countries are among the most vulnerable to the adverse effects of climate change; in addition, widespread poverty limits their adaptive capacity. The timely elaboration of national adaptation strategies and the integration of climate change aspects into development cooperation as well as into concerned national sectoral policies is therefore important.

12. Adaptation is a continuous process and not a one-off exercise; it requires continuous consideration and long-term thinking. Currently, short-term thinking is still too frequent.

13. Adaptation represents an important challenge for all countries and especially for countries with economies in transition, but few countries have developed adaptation strategies so far. Knowledge on adaptation in a transboundary context is especially lacking. For this reason, the Parties to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), at their fourth meeting (Bonn, Germany, 2006), decided to assist Governments in developing adaptation strategies at different government levels by elaborating a guidance on water and adaptation to climate change. Pursuant to this decision, the present Guidance was prepared by the Task Force on Water and Climate under the Water Convention, in close cooperation with the Task Force on Extreme Weather Events, under the Convention's Protocol on Water and Health.

Aims

14. This Guidance aims at supporting decision makers from the local to the transboundary and international level by offering specific advice on the challenges caused by climate change. It builds on the concept of integrated water resources management (IWRM), which many countries are in the process of implementing. Climate change adds to the complexity of its implementation. The Guidance addresses the additional challenges of climate change and does not address IWRM as a whole.

15. The Guidance puts special emphasis on the specificities and requirements of transboundary basins, with the objective of preventing, controlling and reducing transboundary impacts of national adaptation measures. The Guidance endeavours to promote sustainable water resources management and contributes to preventing and resolving challenges and possible conflicts related to the impact of climate change on water resources. It is intended to guide Parties to the Water Convention and Parties to the Protocol on Water and Health in the implementation of the provisions of the Convention and the Protocol within the context of climate change.

Target Group

16. The key target groups of the Guidance are decision makers responsible for water management in general including relevant health-related issues such as the provision of safe drinking water and adequate sanitation, in particular in the transboundary context. Therefore is may also include ministries of health, regional and local health managers etc.

17. The document is also of interest for officials, managers and stakeholders (e.g. private sector, consumers) of other sectors with a direct relevance to water and health, such as the forestry sector, the food sector (particularly aquaculture), the tourism sector, the agricultural sector managing irrigation and reuse of treated wastewater, industrial water users, inland water transport, production of electricity, fisheries, etc.

18. The Guidance is relevant for the entire UNECE region, with a focus on countries with economies in transition.

19. The Guidance was specifically prepared to assist Governments, joint bodies and other actors in the UNECE region. However, it could also be applied, as appropriate, in other regions.

Scope

20. The Guidance is a general roadmap towards adaptation of water management to climate change but needs to be tailored to specific local situations. It provides a step-wise approach on how impacts of climate change can be assessed and how policy, strategic and operational responses can be developed. However, it does not provide a detailed overview of all possible measures or elements of an adaptation strategy since these depend on the local context.

21. The Guidance provides advice on how to assess impacts of climate change on water quantity and quality, how to perform risk assessment, including health risk assessment, how to gauge vulnerability, and how to design and implement appropriate adaptation measures. The Guidance addresses not only extreme events but also water management in general under the influence of climate change and variability and uncertainties of climate change, its assessment and related response action.

22. The Guidance also addresses additional issues, such as spatial and planning aspects; prioritization; specific changes in measures required due to the climate change; the concept of risks and vulnerability (including their socio-economic dimension and the burden of disease due to climate changes), water quality, possible measures (e.g. regulatory and operational measures), capacity-building, financial instruments), awareness-raising and the involvement of the public, and transboundary aspects and the issue of solidarity between countries.

23. The general application of IWRM, on the basis of the catchment as required by the Water Convention and its Protocol on Water and Health, is an important precondition for the development of realistic vulnerability assessments and the formulation of appropriate adaptation strategies.

Key-steps of the Guidance

24. The Guidance provides a step-by-step framework for the development of an adaptation strategy (see figure 1). The key-steps in this guidance which follow the process of developing an adaptation strategy are:

(a) Establish the policy, legal and institutional framework (chapters II and III):
  (i) Assess existing policies, laws and regulatory systems in relation to their effects on climate-induced vulnerabilities, including agriculture, forestry, disaster management, water and all other relevant sectors, and revise and complement them as needed;
  (ii) Define the institutional processes through which adaptation measures are or will be implemented, including where decision-making authority lies at the national, local and intermediary levels and what the links are between these levels;

(b) Understand the vulnerability (chapters IV, V and VI):
  (i) Ascertain the information needed to assess vulnerability;

(ii) Gauge the future effects of climate change on the hydrological conditions of the catchment in terms of water demand and water availability, based on different socio-economic and environmental scenarios;

(iii) Identify the main climate-induced vulnerabilities that affect communities in different places, with particular attention paid to water resources and the health related aspects (e.g. continuous supply of safe water and access to adequate sanitation);

(iv) Determine, through participatory processes, the needs, priorities and capabilities of different stakeholder groups in relation to adaptation to climate-induced vulnerabilities;

(c) Develop and implement an adaptation strategy (chapters VII and VIII):

(i) Identify potential adaptation measures to reduce vulnerability to climate change and variability by preventing negative effects, by enhancing the resilience to climate change, and by reducing the effects of extreme events through preventive, preparatory, response and recovery measures. Measures should include both structural and non-structural measures as well as the financial means and the institutional changes necessary to implement successful adaptation processes;

(ii) Based on participatory processes, prioritize the potential reforms and investments taking into account the financial, institutional resources and other means and knowledge available to implement them;

(iii) Ensure the step-wise implementation of the adaptation strategy, in accordance with determined priorities, including coping measures from the individual to the State level;

(d) Evaluate (chapter IX)

(i) Determine if the measures are implemented and if those measures that are implemented lead to reduction of the vulnerability; if not, adjust the measures accordingly;

(ii) Assess if the scenarios as applied materialize in practice and adjust the scenarios accordingly.

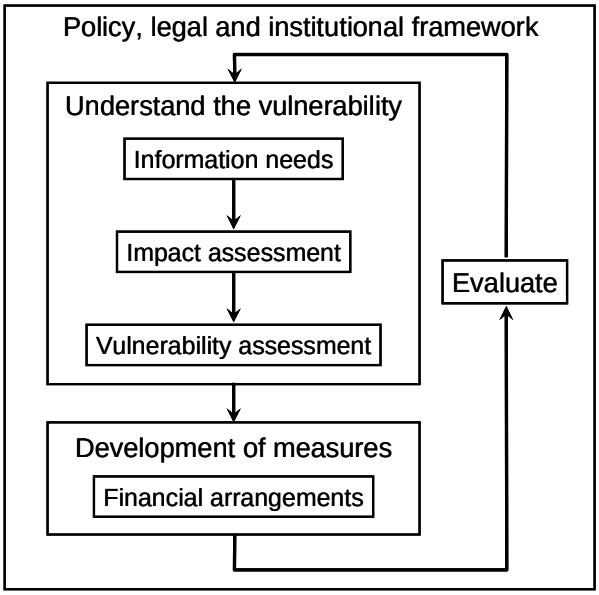

Figure 1: Suggested process for developing an adaptation strategy

I. GENERAL CONCEPTS, PRINCIPLES AND APPROACHES

25. In their actions to design and implement adaptation measures and policies, Parties should be guided by the following principles and approaches:

26. Climate change is characterized by a number of uncertainties and risks relative in particular to the magnitude, timing and nature of the changes. However, decision makers are not used to such uncertainty when dealing with other problems. Various methods should be used to reduce or manage the uncertainty. These include sensitivity analysis, risk analysis, simulation and scenario development.

27. As climate change raises threats of harm to human health and the environment, the precautionary principle should be applied and preventive actions should be taken even if some cause and effect relationships are not yet fully scientifically proven. In the face of great uncertainty, a precautionary approach might even result in a more stringent emission-reductions target and/or adaptation response.

28. Climate-proofing of countries or vulnerable regions should become a political priority. Such programmes should aim to: insulate human activities from the influence of weather and climate conditions, most likely extremes in precipitation (rain or snow), in drought and in temperature (both heat and cold waves); and reduce the exposure of weather- and climate-sensitive activities to climate-related hazards.

29. All new measures should take into account possible impacts of climate change and best available technology should be used as much as possible. Innovative sustainable approaches and technologies should also be taken into account.

30. The impacts of climate change are locally specific and change over time. Measures to cope with the effects of climate change therefore have to be considered at different scales, both in space and in time. However, the level of specificity of knowledge at the local level is limited and global trends need to be downscaled to the local level. Any policy or measure should be developed for and applied at the appropriate level (international, national, sub-national and local) taking into consideration the river basin/ catchment approach. Regarding the time component, distinctions should be made between the strategic, tactical and operational levels. In addition when developing an adaptation strategy the local physical and socio-economic conditions and capacities (both financial and human) should be taken into account.

31. The possible health risk of climate change adaptation options should be assessed before adopting any strategy (e.g. the increased use of individual open-water reservoirs may create breeding grounds for vector-borne diseases).

32. Mitigation and adaptation strategies should be developed and implemented in an integrated manner aiming to minimize harm to humans and the environment and should take into consideration the adaptive capacity of a system. It should be avoided that any measure taken exacerbate the climate change problem or have other undesirable side-effects.

33. The following overarching principles should apply to any adaptation policy framework:

(a) Adopt a long-term approach in which adaptation to short-term climate variability and extreme events is a basis for reducing vulnerability to longer-term climate change;

(b) Adaptation is not a “one go” exercise but rather a continuous, long term progress to be integrated in all levels of planning;

(c) Adaptation policy and measures are assessed in a socio-economic development context;

(d) Following the principles of sustainable development adaptation policy and measures take social, economic and environmental concerns into consideration and ensure that the needs of the present generation are met without compromising the needs of future generations;

(e) Adaptation policies/ strategies are elaborated at different levels in society, including the local level;

(f) Effective transboundary cooperation is ensured at all relevant stages of decision-making, planning and implementation;

(g) In accordance with article 2 of the Water Convention, riparian Parties shall cooperate on the basis of equality and reciprocity, in particular through bilateral and multilateral agreements, to develop harmonized policies, programmes and strategies to adapt to climate change in order to prevent, control and reduce transboundary impacts;

(h) The principle of solidarity is applied, which means that risks, costs and responsibilities are shared between riparian States, also taking into account their capacities and the effectiveness of the different options;

(i) Planning should in first instance be based on existing systems and structures.

34. Strong interdepartmental (inter-ministerial) and intersectoral cooperation with the involvement of all relevant stakeholders should be a precondition for decision-making, planning and implementation. This entails effective communication with and between the stakeholders.

35. Effective cooperation should successfully integrate both top-down and bottom-up approaches [§].

36. IWRM should be applied as a first step to ensure the multi-layered integration of management in which existing approaches are distinct from one another and take into account the environmental, economic, political and socio-cultural conditions of the respective region. Some principal components of IWRM are:

(a) Managing water resources at the basin or watershed scale. This includes integrating land, rivers, lakes, groundwaters and coastal water resources as well as their interaction with other ecosystems, in particular upstream and downstream dimensions. It is therefore, critical that any policy or measure is developed and implemented in accordance with the river basin approach;

(b) Establishing improved and integrated policy, regulatory, and institutional frameworks. Examples are implementation of the polluter-pays principle, water quality norms and standards, and market-based regulatory mechanisms;

(c) Taking an intersectoral approach to decision-making, where authority for managing water resources is employed responsibly and stakeholders have an impact on the process;

(d) Optimizing the use of limited and valuable water resources to meet changing water supply and demands. This involves conducting assessments of surface and groundwater supplies, analysing water balances, adopting safe wastewater reuse and the use of rainwater, and evaluating the environmental impacts of distribution and use options;

(e) Carrying out health risk assessment within IWRM;

(f) Managing demand. This includes adopting cost recovery policies, utilizing water-efficient technologies and establishing decentralized water management authorities;

(g) Planning and implementation of water management and of water services in coordinated way;

(h) Providing equitable access to water resources through participatory and transparent governance and management. This may include support for effective water users' associations, involvement of marginalized groups and consideration of gender issues;

(i) Sustainable groundwater use. This can be achieved through:

(i) developing and promoting a more accurate understanding of the socio-ecological value of groundwater as well as the nature and scale of the consequences of its unsustainable use;

(ii) developing and disseminating research knowledge on promising technologies and management approaches; and

[§] See also the United Nations Development Programme's Adaptation Policy Frameworks (APFs) for Climate Change. APFs focus on adaptation measures that are in line with a country's broader development goals, and highlight the "bottom-up" approach increasingly used by policymakers and scientists.

(iii) exploring sustainable solutions and sharing them with the main strategic actors involved in national and regional groundwater systems. Surface and groundwater in one basin should be used in an integrated way.

37. No-regret and low-regret options should be considered as a priority. No-regret options are measures or activities that will prove worthwhile even if no (further) climate change occurs. For example, early-warning systems for floods and other extreme weather events will be beneficial even if the frequency of the events does not increase as expected. Low-regret options are low-cost options that can potentially bring large benefits under climate change and will have only low costs if climate change does not happen. One example is accounting for climate change at the design stage for new drainage systems, through making pipes wider.

38. The setting of time horizons should be considered when defining a strategy, policy, or measure, and also for monitoring the implementation of an adaptation strategy. Generally, strategies would be long-term in nature, and policies targeted at the medium to long term. Measures may have an implementation time of any length, but are expected to have sustained results. Prioritization – mostly of measures, but in some cases also of (alternative) policies – should take the whole period into account.

39. Estimating costs of a measure is a prerequisite for ranking a measure and including it in the budget or in a wider adaptation programme. The four major methods used for prioritizing and selecting adaptation options are cost-benefit analysis, multicriteria analysis, cost-effectiveness analysis and expert judgement. The costs of non-action that could lead to a number of environmental and socio-economic effects (e.g. lost jobs, population displacement, and pollution) should also be considered.

II. INTERNATIONAL COMMITMENTS

40. A number of international agreements include recommendations or even obligations for countries to develop strategies and measures for adaptation to climate change, in the water sector as well as in other areas. This Guidance builds upon these agreements. When developing their adaptation strategies, countries should take into account their obligations under such international agreements.

A. United Nations Framework Convention on Climate Change

41. The main obligations related to adaptation in the United Nations Framework Convention on Climate Change (UNFCCC) are contained its article 4, which requires Parties to develop, implement and regularly update national and when necessary also regional programmes of measures to facilitate adequate adaptation to climate change. Parties should cooperate in preparing for adaptation. They are requested to elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, as well as for the protection and rehabilitation of areas affected by floods or drought and desertification. Parties shall also take climate change considerations into account in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, to minimize adverse effects on the economy, public health and the quality of the environment due

to projects or measures undertaken by them to mitigate or adapt to climate change. Thus, adaptation and mitigation obligations are linked and should reinforce each other. In addition, Parties are requested to assist developing countries in particular in their efforts to adapt to climate change impacts.

42. The UNFCCC Nairobi work programme on impacts, vulnerability and adaptation to climate change, launched in 2005, aims to help all countries improve their understanding of the impacts of climate change and to make informed decisions on practical adaptation actions and measures. It covers nine areas of work: (a) methods and tools; (b) data and observations; (c) climate modelling, scenarios and downscaling; (d) climate-related risks and extreme events; (e) socio-economic information; (f) adaptation planning and practices; (g) research; (h) technologies for adaptation; and (i) economic diversification. Action pledges provide an interactive way for Nairobi work programme partners, including Parties, Intergovernmental Organizations (IGOs), NGOs and research institutes, to identify and commit publicly to undertaking activities towards the objectives and expected outcomes of the Nairobi work programme.

B. World Health Organization International Health Regulations

43. The International Health Regulations (IHR)[**] entered into force on 15 June 2007 as a new legal framework to better manage our collective defences to detect disease events and to respond to public health risks and emergencies. The IHR require State Parties to notify a potentially wide range of events to WHO on the basis of defined criteria indicating that the event may constitute a public health emergency of international concern. Parties are further required to ensure that their national health surveillance and response capacities meet certain functional criteria and have a set time frame in which to meet these standards. The IHR therefore constitute an important additional defence framework for coping with the health impacts of climate change in general, and with changes in incidence and outbreaks of water-related diseases in particular.

C. Relevant United Nations Economic Commission for Europe Conventions and Protocols

1. United Nations Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention)

44. Although the UNECE Water Convention does not explicitly mention climate, it represents one of the most essential legal frameworks in the UNECE region for cooperation on transboundary aspects of climate change and on development of adaptation strategies.. The Convention obliges Parties to prevent, control and reduce transboundary impacts including those related to adaptation to or mitigation of climate change. It also stipulates that water quality objectives shall be set and best available technology be used. Parties are required to follow the precautionary principle which implies in the case of climate change taking action even before adverse impacts are fully proven scientifically. The Convention also includes provisions for the exchange of information, common research and development and joint monitoring and

[**] The complete text of the IHR (2005) can be downloaded from: http://www.who.int/csr/ihr/WHA58-en.pdf (accessed 9 May 2008).

assessment; encouraging riparian countries to cooperate in the development of adaptation strategies. In addition, Parties are obliged to establish early-warning systems and mutually assist each other.

2. Protocol on Water and Health

45. The Protocol on Water and Health to the Water Convention aims to protect human health and well-being through improving water management and through preventing, controlling and reducing water-related disease. The Protocol is the first legally binding instrument to ensure the sustainable management of water-resources and reduction of water-related disease. A number of its provisions are highly relevant to the adaptation to climate change, in particular:

(a) International cooperation to establish joint or coordinated systems for surveillance and early-warning systems, contingency plans and response capacities, as well as mutual assistance to respond to outbreaks and incidents of water-related disease, especially due to extreme weather events;

(b) International support for national action, provided by the Ad Hoc Project Facilitation Mechanism, which aims to help provide access to funding for activities to implement the Protocol.

46. In addition, the Protocol aims at providing access to safe drinking water and sanitation for everyone – a goal which could be complicated by climate change.

3. United Nations Economic Commission for Europe Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)

47. The Espoo Convention supports environmentally sound and sustainable development by providing information on the interrelationship between certain economic activities and their environmental consequences, in particular in a transboundary context.

48. The Convention is the one of the first multilateral treaties to specify the procedural rights and duties of Parties with regard to transboundary impacts of proposed activities and to provide procedures in a transboundary context for the consideration of environmental impacts in decision-making. The Convention stipulates that an environmental impact assessment (EIA) procedure be undertaken for a proposed activity planned by one Party that is likely to have a significant transboundary impact in the territory of another Party.

49. The Convention describes an “impact” as any effect caused by a proposed activity on the environment including human health and safety, flora, fauna, soil, air, water, climate, landscape and historical monuments or other physical structures, or the interaction among these factors. It also includes effects on cultural heritage or socio-economic conditions resulting from alterations to those factors.

50. The Espoo Convention is an important framework for ensuring that the adaptation strategies developed in a country do not cause transboundary impacts in neighbouring countries.

4. The United Nations Economic Commission for Europe Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention)

51. By linking environmental rights and human rights, the Aarhus Convention provides the fundamental basis for developing and implementing national and transboundary environmental instruments, including those related to mitigation and adaptation to climate change. The Convention imposes on Parties and public authorities obligations and grants the public rights regarding access to information, public participation and access to justice. It establishes that sustainable development can be achieved only through the involvement of all stakeholders. It links government accountability and environmental protection and focuses on interactions between the public and public authorities in a democratic context.

52. The principles underlying the Aarhus Convention, which were also recognized by the UNFCCC at its thirteenth session, inter alia, encourage Parties to undertake activities to facilitate public access to data and information and to promote public participation in addressing climate change and its effects and in developing adequate responses.[††]

D. European Union legislation

53. The European Union (EU), having focused until 2005 mainly on climate change mitigation, has been progressively recognizing the need for adaptation. In June 2007, the Community published the Green Paper, "Adapting to climate change in Europe – options for EU action". This Green Paper examines the impacts of climate change effects in several European regions and attempts to define the possible adaptation actions which have a pan-European dimension, while recognizing that cooperation with and between Member States and regions will be essential. Stakeholders and the public have been consulted and the Commission plans to publish a White Paper with concrete actions for adaptation at the end of 2008.

54. Although there is currently no explicit obligation for adaptation to climate change in EU water-related legislation, the EU Water Framework Directive[‡‡] in principle includes the requirements needed for addressing climate change impacts since it obliges Member States to assess environmental pressures on river basins, to set targets for improving the status of water bodies and to devise and implement management plans with concrete measures to achieve these targets. The need for greater integration of the qualitative and quantitative aspects of both surface and ground water, considering natural flow conditions within the hydrological cycle, is clearly laid down in this directive. Within transboundary river basins, requirements for environmental objectives as well as programmes of measures should be coordinated for the basin as a whole. Member States are also obliged to review management plans regularly to take into account recent data and information, such as those related to climate change.

[††] Decision 9/CP.13, paragraphs 14 and 15 (FCCC/CP/2007/6/Add.1), amended the New Delhi Work Programme on article 6 of the UNFCCC. The thirteenth session was held from 3 to 15 December 2007 in Bali, Indonesia.

[‡‡] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy.

55. The EU Flood Directive [§§] states that measures to reduce flood risks should, as far as possible, be coordinated for the river basin as a whole, in particular for transboundary basins. Hence, even the identification of areas at significant potential flood risk belonging to an international river basin shall be coordinated between the Member States concerned from the beginning. Therefore, Member States shall ensure that exchange of relevant information and data take place between the competent authorities concerned. Accordingly, national legislation should be adjusted to the Flood Directive in an appropriate time period, be implemented, and be able to fulfil in particular the requirements at the national level as a basis for doing so at the transboundary level. Specific legislation is likely to be needed. Furthermore, in some Member States reform of the existing institutional framework will probably be unavoidable.

56. The European Commission is working on a Communication on water scarcity and droughts, which is closely linked to climate change and adaptation. In addition, other EC Directives are related to climate such as, for instance, the Bathing Waters Directive[***].

57. The *acquis communautaire* of the European Community has developed a strong body of legal instruments dealing with the surveillance and management of water-related disease. Some of the most important ones deal with:

(a) Early-warning and response systems for the prevention and control of communicable diseases[†††];

(b) Communicable diseases to be progressively covered by the Community network[‡‡‡];

(c) Laying down case definitions for reporting communicable diseases to the Community network[§§§];

(d) Setting up a network for the epidemiological surveillance and control of communicable diseases in the Community[****].

58. The activities of the European Centre for Disease Prevention and Control (ECDC) are based on Article 3 of the ECDC Founding Regulation (EC 851/2004). The Centre aims to enhance the capacity of the Community and the Member States to protect human health through the prevention and control of human diseases. Activities are designed to identify, assess and communicate current and emerging threats to human health from communicable diseases, including water-related and vector-borne diseases that are climate-sensitive.[††††] ECDC also pursues core activities such as surveillance network, scientific advice, identification of emerging

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[§§] Directive 2007/60/EC on the assessment and management of flood risks.

[***] Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC.

[†††] Commission Decision 2000/57/EC of 22 December 1999; *Official Journal of the European Communities* L 21/30 dd 26.1.2000.

[‡‡‡] Commission Decision 2000/96/EC of 22 December 1999; *Official Journal of the European Communities* L28/50 dd. 3.2.2000.

[§§§] Commission Decision 2002/253/EC of 19 March 2002; *Official Journal of the European Communities* L86/44 dd 3.4.2002.

[****] Decision 2119/98/EC of the European Parliament and of the Council of 24 September 1998; *Official Journal of the European Communities* L268/1 dd 3.10.1998.

[††††] http://ecdc.europa.eu/index.html.

health threats ("epidemic intelligence"), training, health communications and technical assistance ("country support").

III. POLICY, LEGISLATION AND INSTITUTIONAL FRAMEWORKS

59. This chapter aims to help decision makers to introduce and adopt policy, legislation and institutional frameworks that support adaptation to climate change at the national level as well as in a transboundary context. There are certain policies that will be directly or indirectly affected by the impacts of climate change and for which an appropriate response needs to be developed. The need for adaptation is not only a threat but also an opportunity for innovation and new technologies. This should be explored in close cooperation with the public and private sectors.

A. Policy and governance

60. Many policy tools such as land planning, environmental protection and monitoring, and health management are based on stable "old" climate and environmental conditions which do not take into account variability and change. Sound and sustainable policies at the local, national and transboundary levels should therefore include adaptation to new conditions, according to current and long-term scenarios.

61. International rivers pose particular management challenges because of potentially competing national interests. Adaptation therefore requires a cross-boundary approach, based on river basins and bio-geographic regions. Effective and sustainable achievement of most of the adaptation measures requires inter-State coordination and cooperation at the level of transboundary river basins. While measures will have to be taken or implemented at the national or local level, where operational capacities exist, it is essential that efforts be coordinated in an equitable, acceptable and cost-effective manner at the level of the transboundary basin.

62. Policy, legislation and institutional frameworks, both at the national and transboundary levels, should together support adaptation to climate change. This is needed at all national governmental levels as well as at the transboundary level, with effective frameworks, clear responsibilities and roles for all players. The three frameworks are interwoven as policies and legislation together shape the institutions, institutions and legislation provide structures to enable policy development, and policies and institutions are the basis upon which the legislation builds.

63. Existing policy, legislation and institutional frameworks should be assessed vis-à-vis their capacity to support adaptation to climate change, and if needed should be reformed.

64. To enable cooperation between the different levels and across borders and to ensure broad-based decision-making on adaptation, the relationship between policy, legislation and institutional frameworks should be based on the principles of good governance:

(a) Making decisions at the appropriate level;
(b) Providing access to information;
(c) Enable participation by all stakeholders;
(d) Providing access to justice in environmental matters;

(e) Integrating environmental and health concerns into all decisions.

65. Spatial planning provides an integrated framework, linking vulnerability and risk assessment with adaptive capacities and adaptation responses. It is therefore the pre-eminent policy sector to facilitate the identification of policy options and cost-efficient strategies.

66. Multilevel governance is emerging on climate change adaptation involving all actors from individual citizens to local authorities to policymakers at the international level. The different levels interact and should support each other. This includes stimulation and development of interdepartmental and multi-stakeholder as well as transboundary cooperation, through, inter alia, the establishment of consultative mechanisms at both the national and transboundary levels. Although one department or ministry within the government may take the initiative and the lead in developing adaptation strategies, it should be clear that it is a responsibility of the whole government. Representation is particularly important to supporting good governance; key decisions should be made by representative authorities who are accountable to a broad public.

67. All sectors should be involved, be aware of the climate change challenge, and share a common understanding of the fact that adaptation to climate change is only possible through an integrated approach. Sectors also need to reach out to each others: e.g. the health sector needs to sensitize water sector on health risks.

68. The Trialogue Model describes the basic elements for good governance, namely government (involving all sectors having responsibility for the management of the water cycle and the preservation and promotion of human health), science and society, and is the basis upon which successful adaptation measures are taken. A participatory approach is recommended, also to develop scenarios, impact assessments and measures.

69. Climate change adaptation should be integrated in development planning, programmes and budgeting, a process known as mainstreaming. Such a coordinated, integrated approach to adaptation is imperative to handle the scale and urgency of addressing climate change impacts. Governments should ensure that any national adaptation strategy is consistent with existing policy criteria, development objectives and management structures.

70. Conditions for successful adaptation strategies include willingness to cooperate, a strong political commitment at the national level and transboundary level, agreed targets and a sound science.

B. Legal aspects

71. As a first step, existing legislation, from the local to the transboundary levels, should be assessed vis-à-vis its capacity to support adaptation to climate change and, if needed, reformed. It must be recognized that some current legislation, for instance treaties drafted without taking climate change into consideration, may present barriers to future adaptation.

72. Moreover, new and newly adjusted laws and policies as well as transboundary agreements and strategies should take into consideration the results of new environmental and socio-economic scenarios that have arisen due to climate change.

73. Since the effects of climate change remain uncertain any transboundary agreements, especially those including water allocations, should be flexible enough to respond to any predicted or unforeseen change. Transboundary agreements should include mechanisms and institutions responsible for the relevant revision.

74. Economic instruments need to be consistently applied in particular in the context of legal instruments, also and especially in the transboundary context.

C. Institutional aspects

75. Regarding the development of adaptation strategies, all relevant authorities, including local authorities responsible for water management, should be involved. This is particularly important for federal States. Water management agencies and other related authorities should be willing to provide appropriate assistance to communities in support of adaptation implementation.

76. The institutional capacity of a community, region or country is crucial in implementing effective adaptation. A very clear definition of the roles and responsibilities of each agency involved is essential for enhancing adaptive capacity.

77. Such clear definition of responsibilities is particularly crucial in case of emergencies. To ensure that during the emergency such distribution is respected, contingency planning should be very clear in this respect and training and simulations exercises should be carried out on a regular basis

78. As there is a need to understand the implications of climate change for water resources, their sustainable management and societal goals, a dedicated research team, involving various disciplines, should be established at the national level for carrying out scientific activities on this topic. This team should aim to accomplish the scientific, practical and operational activities of saving, protection and increase of water resources. Similar arrangements should also be established at the transboundary level with the support of relevant institutions in the riparian countries.

79. Joint bodies, such as river basin commissions, should be responsible for the development of joint or coordinated adaptation strategies for transboundary basins and for following up their implementation and evaluating their effectiveness. The bodies should therefore have the capacity and means to ensure these tasks. In case of any disagreements in transboundary cooperation negotiation and consultation should be preferred to litigation.

D. Education, capacity-building and communication

80. Education and communication should be seen as prerequisites for achieving sustainable development and as essential tools for good governance, informed decision-making and the promotion of democracy. They strengthen the capacity of individuals, groups, communities, organizations and countries to make judgements and choices in favour of sustainable development[‡‡‡‡].

81. Education, communication and capacity-building are important to tackle the challenge of climate change. They should aim at increasing awareness and improving understanding of the mechanisms that drive climate change as well as the potential environmental and socio-economic impacts.

82. The lack of institutional capacity should not be a reason for not taking action. All countries need to take the initiative vis-à-vis building their own capacities to handle the challenges of climate change.

83. Reinforcing or creating capacity will provide a better understanding of vulnerability and needs, and will help identify adaptation measures and initiatives to reduce vulnerability and define sustainable development policies.

84. At the same time, the strengthening and/or creating of capacity at the national and regional levels will assist participating countries in international processes, make it easier to coordinate actions taken in response to climate change issues as well as integrating these issues into national and regional policies. Such a capacity-strengthening process will contribute to the negotiation of bilateral or multilateral support in the fields of disaster management, early-warning systems and climate change.

85. The issue of climate change should be addressed in formal and non-formal education as well as through communication, including awareness-raising. Governments should play a proactive role in promoting and facilitating education and communication, in partnership with stakeholders.

86. Capacity-building should be targeted at all the stakeholders that participate in the governance process, including members of joint bodies, to ensure that everyone has the same level of understanding.

87. Education, capacity-building and communication should be an integral part of any adaptation strategy and should take place at all phases of the adaptation chain. Existing institutional gaps should be identified through in-depth gap analysis that includes all steps of adaptation. A consistent programme to address such gaps should be developed as part of the national development strategy.

[‡‡‡‡] See also the UNECE Strategy for Education for Sustainable Development (CEP/AC.13/2005/3/Rev.1).

88. In addition, States should assist each other in capacity-building, in particular, States which are more advanced in terms of adaptation should assist the less advanced ones.

89. Education programmes and communication strategies should be designed and implemented to meet the need of target groups, taking into consideration such aspects as age, social roles and level of literacy. This apply as to the content so to the proposed framework for implementation. Persons at risk should be considered as a special target group. This can help to bring to people's attention that they should take adaptation and mitigation into account in their own life- decisions, e.g. whether to build in flood-prone areas and or to use climate-proof construction methods.

IV. INFORMATION AND MONITORING NEEDS FOR ADAPTATION STRATEGIES DESIGN AND IMPLEMENTATION

90. This chapter aims to clarify the additional requirements that climate change adds to information and monitoring needs for water policies, strategies, implementation and operation. This information is required mainly to support the modelling of scenarios to be able to assess vulnerability hot spots. Reference is made here to the UNECE Strategies on Monitoring and Assessment of Transboundary Rivers, Lakes and Groundwaters[§§§§], which elaborate general approaches to information and monitoring needs.

A. Definition of information needs

91. Information about climate change impacts is needed to help decide on both the urgency and the desirability of adaptive measures. As policymakers and managers working in health and water sectors should be able to understand and interpret the information, information needs should be identified by the policymakers and managers together with relevant experts.

92. Most frequently, water-resources information has been collected for a specific purpose, such as the design of a hydroelectricity scheme. The need for integrated water resources management that supports the understanding of interactions among different projects and users places a greater burden on the suppliers of information; the information needs to be relevant for and understandable to the various stakeholders in the different water-related sectors (e.g. navigation, hydropower, tourism, public health). Thus a variety of information is needed simultaneously, and has to be presented in different forms for different users.

93. Assessment agencies should therefore understand the needs of all their users, and not just those with whom they have traditionally dealt. For this reason, all users should be involved in the process of defining the information needs. Even more demanding is the need to look ahead to the possible needs of future data users and to commence collecting the information before an actual demand occurs.

94. The process of specifying information needs should be based on an analysis of the water management issues related to climate change. Needs should be defined for:

[§§§§] Available at: http://www.unece.org/env/water/publications/pub74.htm.

(a) Uses (e.g. drinking water, irrigation, recreation) and functions (maintenance of aquatic life) of the water resources that put requirements on the quality and availability of water;

(b) Impacts on these uses and functions caused by climate change;

(c) Measures taken to address the impacts or improve the use or functioning of the water resources, including environmental aspects.

95. The information needs should be clearly determined for the different target groups (policymakers, sectors, operators), dividing the information into the relevant levels of time (strategic, tactical and operational), space (river basin, local and national levels), and purpose (early-warning, recovery, long-term planning).

96. Translation must be enabled between climate models and scenarios, and the hydrological models and scenarios. This should ensure that the information produced is relevant for water management. Close cooperation between the climate and the water communities is therefore imperative.

B. Types of information

97. The most urgent need for information relates to the downscaling of climate models (global circulation models) to the river basin (catchment) and local levels. This requires long time series of hydrological data. Studies of trends provide improved understanding of the changes of the "natural" world relative to anthropogenic changes. This is achieved by comparing series of hydrological data from historical observation stations (usually established in areas influenced by human activity) with series of hydrological variables observed in pristine river basins (those river basins that are identified as characterized by minimal anthropogenic change).

98. Data needed for scenarios and subsequent vulnerability assessment at the national, subnational and basin levels include hydrological, meteorological and morphological data and data on water quality as well as the related statistics and statistics on diseases caused by water factors (taking into consideration age, sex, local geographical conditions).

Box 1: Examples of meteorological, hydrological, morphological data and data on water quality needed for scenarios and vulnerability assessment

Meteorological data:

(a) Precipitation, e.g., rainfall, snow, and fog-drip;
(b) Temperature;
(c) Evapotranspiration;

Hydrological data:

(d) River levels and flows, lake levels and reservoir storage, including steering rules;
(e) Sea level;
(f) Groundwater levels;
(g) Nationally generated water resources vis-à-vis transboundary water resources;

Morphological data:

(h) Sediment concentrations and loads in rivers;
(i) Area of glaciations;
(j) Coastal erosion;

Water quality data:

(k) Water quality (bacteriological, chemical, and physical) of surface water and groundwater;
(l) Coastal saline intrusion, especially in aquifers used for the production of drinking water;

Statistics related to these elements include:

(m) Mean annual, monthly, seasonal or daily values;
(n) Maximal, minimal, and selected percentiles;
(o) Measures of variability, such as the standard deviation;
(p) Continuous records in the form, for example, of a river-flow hydrograph.

99. Historical data should be used to identify trends, both gradual – i.e. able to recognize the change in climatic conditions – as well as extremes – i.e. identify the potential magnitude of climatic changes. For instance, lakes' levels are potentially useful for analysis of gradual climate impacts on surface waters, as they often reflect the effects of a changing ratio between evapotranspiration and precipitation. Similarly, predictions (projections) should include long-term trends for the development of adaptation strategies, seasonal variations to identify and develop tactical measures, and the magnitude of extreme events to identify and develop operational measures.

100. Climate change can lead to responses of groundwater systems that are difficult to predict. For example, while global scale predictions may suggest an increase in precipitation for a given region, if this precipitation occurs at a higher rate and over a shorter period of time, there may be

less recharge to the groundwater system. Special attention should therefore be targeted to monitoring these systems.

101. In addition to the more conventional measurements, there is the need to measure other aspects of the freshwater environment and of the wider environment of which freshwater is a component. These include:

(a) The volumes of water needed for industrial, domestic and agricultural use, and for navigation. These are significant modifiers of the hydrological cycle;
(b) Attributes of rivers and required volumes of water related to in-stream uses, (e.g. freshwater fishery habitats or recreation);
(c) Basin characteristics that may be related to hydrology, e.g. vegetation patterns, soil moisture, topography, and aquifer characteristics;
(d) Environmental problems, e.g. eutrophication of lakes and damage to natural freshwater and estuarine ecosystems.

102. Water supply systems may need additional monitoring for microbiological or chemical contamination following floods or drought periods (pipes infiltration, increased chlorination/increased concentration of contaminants).

103. Environmental media monitoring in long-term and short-term critical conditions should be linked with systems of surveillance of water-related disease to ensure prevention of health risks. Development of ad hoc indicators will provide information and assessment of progress as well.

104. Information needs related to climate change adaptation not only pertain to climate prediction but include, inter alia, geographic information and socio-economic information (from e.g. national census data). This data must be available that enables development of adaptation measures at a scale ranging from local to river basin to national and transboundary levels.

105. National data collection and management systems are often inconsistent at the international and even at the national levels. Especially for the monitoring of health effects of extended drought events and/or floods, appropriate indicators still need to be developed and adopted at the national level. The experience gained in the international Emergency Events Database (EM_DAT)[*****] of the WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED) can be exported and networked in countries.

106. Information is also needed to evaluate the effectiveness of adaptation measures (see chapter IX).

C. Sources of information

107. In terms of applying climate information to water resources management, a reliable monitoring system is of the utmost importance. Data reliability has many direct effects on the

[*****] Emergency Events Database (EM_DAT) of the Centre for Research on the Epidemiology of Disasters (CRED), 2007.

accuracy of numerical models, both climate prediction/projection and hydrological models. Therefore an integrated nationwide (or transboundary river basin-wide) observation system is necessary.

108. The scope and flexibility of monitoring systems should be such that they can gather the information important for the protection of human health in case of extreme events. Information should cover all possible exposure routes (e.g. direct ingestion, ingestion through contaminated food, skin contact and droplet distribution) that may constitute a risk to human health. Monitoring systems should be also adapted to changing scenarios of diffuse and scattered point-sources in case of flooding events. They can provide information for contaminated sources including irrigated crops and seafood and, in case of extensive chemical contamination, for redefinition of water and land use. The information resulting from such information systems should be used to re-examine the land- and water-use planning and to define and implement changes that will protect human health to the greatest extent possible. For example, if serious contamination is found on land zoned for agricultural purposes, it may be necessary to rezone the land for exclusively industrial use.

109. The design and updating of data collection networks, especially the main stations, should be coordinated to ensure that stations for monitoring the different elements of the water cycle are sufficiently related, both in number and location, to achieve an integrated network. Such an approach enhances the information content of the data sets for both present and unforeseen future needs.

110. Hydrological or hydro-meteorological services or related agencies have been established in countries for the systematic water-resources data collection, archiving, and dissemination at the national level. Their primary role is to provide information to decision makers on the status and trends of water resources.

111. The existing sources of information are data sources maintained for example by relevant United Nations agencies, such as UN GEMS and FAO AQUASTAT. When focusing on transboundary rivers, often information is available from the river basin commissions where data sources are established.

112. Information technology implementation should provide open source exchange of information among sectors for preventive (early-warning), response, and long term planning purposes. Integration between in situ and satellite information (e.g. the Global Monitoring for Environment and Security (GMES), the Infrastructure for Spatial Information in the European Community (INSPIRE)) is also advisable.

113. For geographic information and socio-economic information, other sources need to be considered, such as…[to be completed].

D. Joint information systems and exchange of information

114. In a transboundary context a comparison of climate change projections as well as predicted impacts on water resources is extremely important. At present, those developed by

riparian countries are usually different. Common scenarios for a river basin should be developed. To support effective cooperation in climate adaptation at the river basin level, the development of joint information systems (such as databases or GIS systems) is recommended. Such systems should be based on agreement on the relevant information to be shared and on which country will be responsible for producing what information. Existing systems should be adapted to include climate change issues. Where they exist, joint bodies should account for this. Joint or harmonized impact assessments are very important to avoid potential conflict of policies due to diverging predictions.

115. If a joint information system is not feasible, exchange of data and information between different countries, bodies and sectors is needed. This includes exchange of information on adaptation plans and measures to enable riparian countries to harmonize their adaptation activities, including the exchange of data enabling improvement of climate prediction models.

116. Exchange of transboundary information is a main obligation of the Water Convention and is required by many international agreements. WMO member countries also provide, on a free and unrestricted basis, those hydrological data and products necessary for the provision of services in support of the protection of life and property and for the well-being of all peoples.[†††††]

117. Data should also be made publicly available, except for cases where disclosure to the public might negatively affect confidentiality provided for under national law; international relations, national defence or public security; the course of justice; the confidentiality of commercial and industrial information (where such confidentiality is protected by law to protect a legitimate economic interest); intellectual property rights; etc. In such cases, data should be processed so that it cannot be used for purposes other than climate change adaptation.

E. Design of adaptive monitoring systems

118. Because of the inherent uncertainties of predictions, adaptation to climate change is a process that requires continuous modification to account for improved insights. In addition, cooperation between water management and many different sectors is needed, as is the involvement of the public at large. Monitoring systems consequently must be developed in such a way that they support these characteristics.

119. The information as collected should be made available for other audiences than the policymakers and water managers (e.g. other sectors, the public). A significant problem in disseminating information to a wide audience is that translating the information produced by one community into a form that the other community can utilize is often difficult. To overcome this problem, dialogue is necessary between the relevant communities to about the needs and possibilities of the available information. The involvement of media and education sector is also needed.

[†††††] WMO Congress General XIII adopted Resolution 25.

120. The monitoring or information-producing systems supporting the inherent uncertainties should be adaptive, focusing not only on the state of different variables, but also on the links and feedbacks between them. In addition, the information producing system must support the complete process, from problem identification to evaluation of measures, including all the in-between steps.

V. SCENARIOS AND MODELS FOR IMPACT ASSESSMENT AND WATER RESOURCES MANAGEMENT

A. Introduction

121. Adaptation of water management to climate change implies balancing water demands and resources in an uncertain and changing situation. Scenarios and models handle this uncertainty by providing information on possible futures; these in turn depend on policy choices. This chapter aims to describe how scenarios and models support water management in the light of climate change, by describing the steps involved in the process of developing scenarios and using models for prediction. These predictions build on available information and feed into the vulnerability assessments. Figures 2 a and b provide an overview of how data, scenarios and models are used to develop an adaptation strategy to climate change.

122. Scenarios are alternative images of how the future might unfold and are an appropriate tool for analysing how driving forces may influence future emissions and for assessing associated uncertainties. **Climate scenarios** are developed to describe different possible futures, based on certain choices and assumptions about greenhouse gas emissions. Climate scenarios should be developed through a participatory approach.

123. The Intergovernmental Panel on Change (IPCC) has developed four different narrative storylines (climate scenarios) to describe the relationships between emission driving forces and their evolution and to add context for the scenario quantification. Each storyline assumes distinctly different direction for future developments, such that the four storylines differ in increasingly irreversible ways. The Special Report on Emissions Scenarios (SRES)[‡‡‡‡‡] scenarios developed by IPCC assist in climate change analysis, including climate modelling and the assessment of impacts, adaptation and mitigation.

[‡‡‡‡‡] IPCC 2000. Emissions Scenarios – A Special Report of IPCC Working Group III.

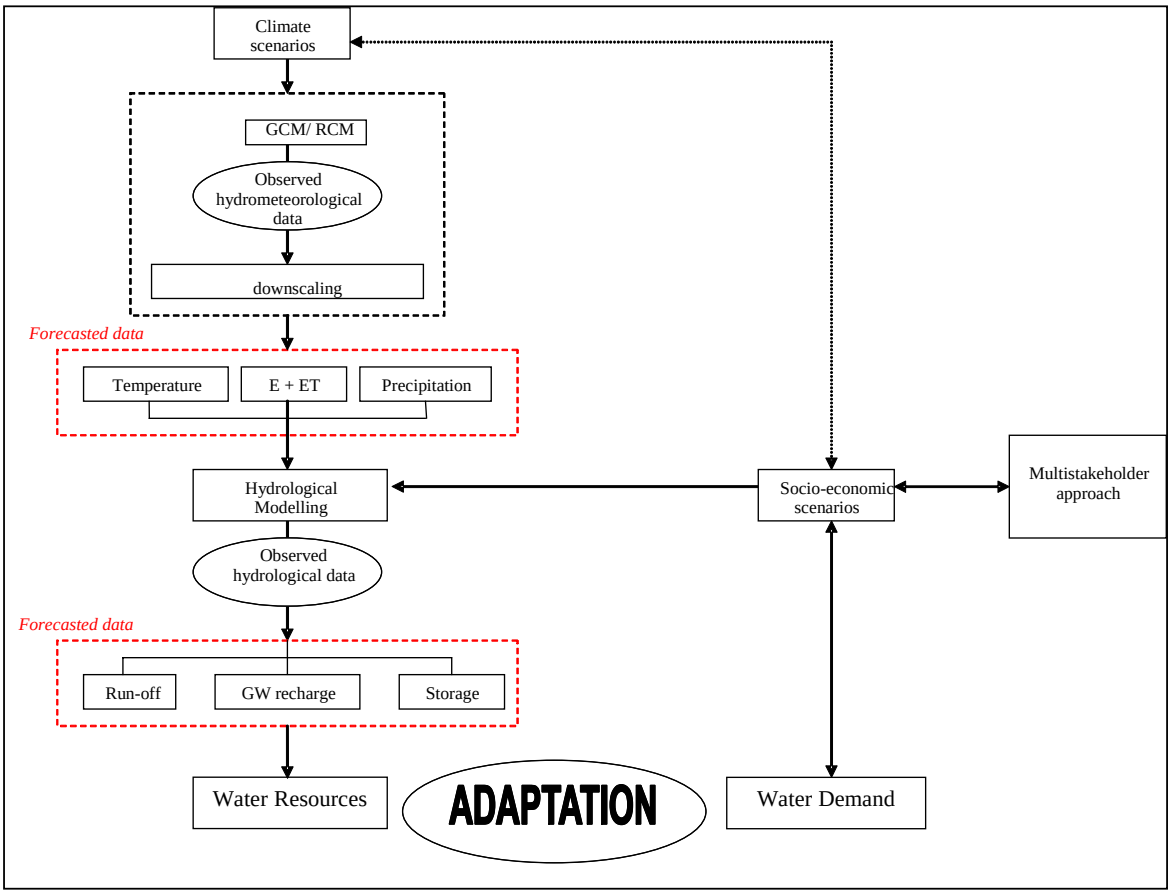

Figure 2a: The relationship between different types of scenarios, modelling and adaptation

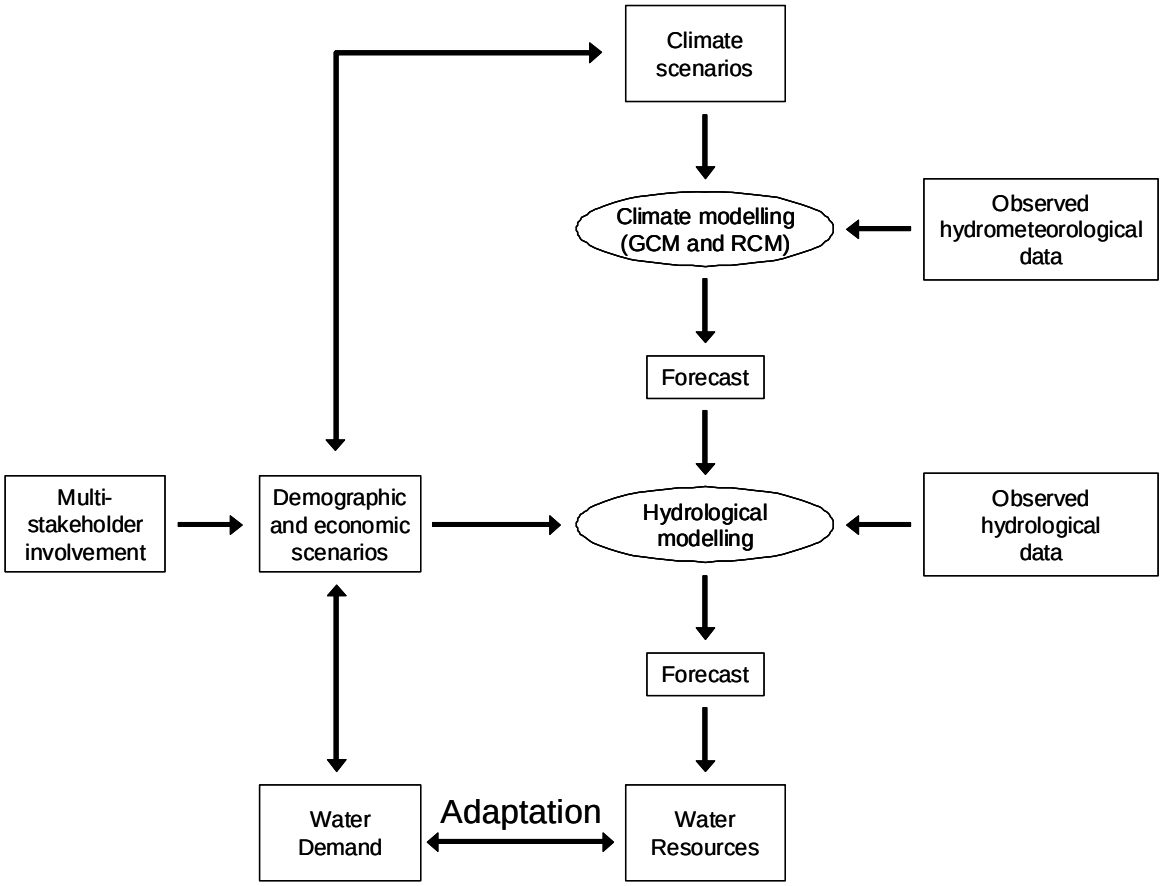

Figure 2b: Scenarios, data, models and adaptation strategies

124. Based on the different climate scenarios, **climate models** can be run to provide information on possible future climate conditions in a certain region. General circulation models (GCMs) estimate the effect that greenhouse gas and aerosol emissions have on global climate. GCMs describe important physical elements and processes in the atmosphere and oceans and on the land surface that make up the climate system. Regional Climate Models (RCMs) provide similar information, only at a smaller resolution. These are therefore more suitable for developing water resource projections and adaptation strategies at the river basin level.

125. To conceptualize and investigate the link between climate and water resources, it is necessary to combine RCMs and hydrological models. The main issue of coupling these models, as stated below, is that climate scenarios should be compatible with the catchment scale.

126. Demographic changes, economic and socio-economic developments influence the hydrological cycle and at the same time have impacts on water demands. Based on the current and future social and economic goals set out by countries, demographic and economic scenarios have to be developed that will be very different in various regions and have to be combined with different climate scenarios. The developed scenarios, together with the projected data from the climate models, are the basic input for hydrological models. These models calculate the

hydrological responses to rainfall based on local characteristics such as soil characteristics, the type and density of vegetation cover, and land-use characteristics. The models provide output on the future hydrological conditions in a river basin /catchment. The model output includes information on available water resources as well as water demands, thus providing background information for assessing the vulnerability of water resources in a basin.

127. Development of common scenarios and agreement on selected models to be used will help to develop and streamline a common understanding between countries on the effects of climate change. This in turn will support the development of joint adaptation strategies that will benefit of all concerned parties.

B. Criteria for the development of socio-economic scenarios

128. Based on the current and future social and economic goals set out by the countries different demographic and economic scenarios have to be developed. Scenarios will have to be developed through a multi-stakeholder approach, including through initiatives such as the National Workshops on Climate Change Adaptation. In the process of scenario development, different driving forces determining the extent of future climate change and its impacts, should be considered, e.g. economic development and human impacts on ecosystems.

129. Many drivers need to be taken into account when developing scenarios. Some include demographic developments and land-use changes such as population growth which can result in increased water demand in quality and quantity, or urbanization and intensification of land use, which shortens the run-off travel time and may cause floods and flash floods. Economic development is another driver likely to put greater pressure on natural resources, particularly water and energy.

130. Driving forces for the construction of scenarios should be chosen according to the local conditions and in consultation with relevant stakeholders, considering different controversial interests. To construct alternative scenarios, these driving forces should be given different weights and initial modelling conditions, for example a temperature increase of 2 degrees.

C. Downscaling of models

131. Models have proven to be extremely important tools for understanding and simulating climate. Models need to be calibrated, which means comparing output data (projected temperature, evaporation, evapotranspiration, and precipitation) with observed meteorological data.

132. General Circulation Models (GCMs) are mathematical models, used to simulate both the present climate and the projected future climate changes. GCMs have a data resolution typically of a 100–200 km grid size. This resolution does not permit an appropriate estimation of hydrological responses to climate change and consequently does not provide sufficient information to develop adaptation strategies on a river basin scale. Because of this difficulty of representing local basin-scale features and dynamics, there is a need to convert the GCM outputs into at least a reliable precipitation and temperature time series at the basin scale (downscaling).

133. This process of downscaling GCMs into local-to-regional- scale meteorological variables appropriate for hydrologic impact studies can be done by simulating physical processes at sub-grid level (dynamically) (figure 3) or by transforming coarse-scale climate projections to a smaller scale based on observed relationships between climate at the two spatial resolutions, and comparing projected data from the GCM with observed meteorological data (statistically). The choice of the most appropriate downscaling technique partly depends on the variables, seasons and regions of interest.

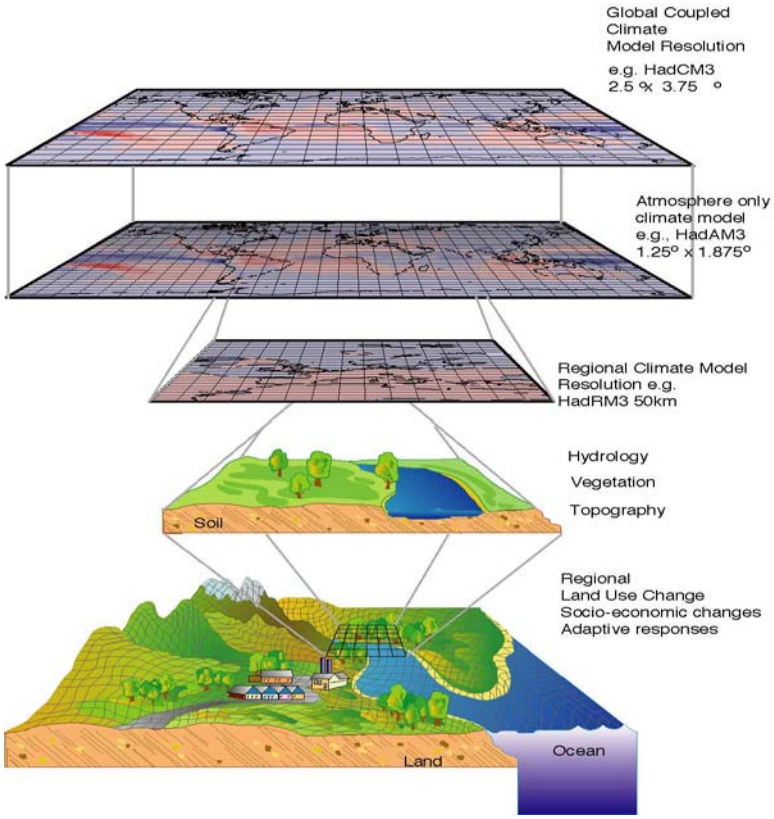

Figure 3: Dynamic downscaling

134. Statistical downscaling requires access to large data sets and considerable expertise to derive the statistical relationships, and is therefore difficult to apply. Statistical downscaling may be used whenever impacts models require small-scale data, provided that suitable observed data are available to derive the statistical relationships.

135. Both methods give comparable results in terms of their capability to reproduce the variability of present-day climatic or river flow conditions, on both daily and monthly time scales. Statistical and dynamical downscaling complement each other, and, where possible, both should be carried out in parallel.

D. Criteria for the selection and application of models

136. Models are roughly divided into statistical (black box) models and physical-based models (deterministic or conceptual models). The latter are generally considered to be more reliable, particularly in assessing the impacts of climate change. A range of conceptual models has been developed for operational hydrological forecasting.

137. Unless the national institutions in charge of hydrological computations and forecasting develop a suitable model themselves, they are faced with the difficulty of choosing between the many models proposed for operational use. The selection of a particular model will depend on specific conditions and the objective of modelling, When selecting a model, the purposes of the model, the climatic and physiographic characteristics of the basin, the quality of the data available, both in time and space, the possible need for reducing model parameters from smaller catchments to larger catchments, and the ability of the model to be upgraded on the basis of current hydrometeorological conditions and climate scenarios need to be taken into account. Also, the selection should focus on the particular models that have proven to be effective in the past.

138. Once the model is selected its calibration is necessary to ensure that the simulated data are in line with observed run-off data. If a model is capable to accurately calculate historical variables, it is more likely that the model projection will be accurate.

139. Historical data collected during routine operations are useful to calibrate the model and improve its performance. Calibration and effective operation of a conceptual model require reliable, accurate, consistent, and sufficiently long data sets that include the necessary observations. Input data for operation of a model may come from observations and/or output from other models, such as the data coming from downscaled GCMs. By using observations rather than model output, uncertainties inherent in the modelling procedure, such as simplifying assumptions and concepts, are avoided.

140. Applied models should be evaluated and revised with regard to the previous approach and in accordance with new technologies, the real impact of the driving forces, and any other changes which influence the model structure itself.

E. Uncertainty

141. Uncertainties in projected changes in the hydrological system arise from internal variability of the climate system, uncertainty in future greenhouse gas and aerosol emissions, the translation of these emissions into climate change by general circulation models, and hydrological model uncertainty. Due to this uncertainty, different scenarios are elaborated. One possibility to deal with the uncertainty is to build flexibility into new transboundary agreements, laws and infrastructure.

VI. VULNERABILITY ASSESSMENT FOR WATER RESOURCES MANAGEMENT AND WATER SERVICES

142. This chapter aims to help decision makers to assess the vulnerability of a basin. Vulnerability assessments (VAs) provide decision makers with information that guides choices related to where and when interventions should be made, and in what form. VAs are based on scenarios and model outcomes, and are the first steps to better understanding the potential impacts of climate change and move to more effective and adaptive management and finally, climate proofing.

A. Vulnerability

143. Vulnerability is considered a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity. The vulnerability of a system to climate change consequently includes both an external dimension, represented by its exposure to climate variations, and an internal dimension; represented by its sensitivity to climate variations and its adaptive capacity. A highly vulnerable system is one that is very sensitive to modest changes in climate, where the sensitivity includes the potential for substantial harmful effects, and for which the ability to cope is limited.

144. People's vulnerability is not only physical but also social and psychological. The psychological effects of surviving traumatic climate events are not to be underestimated and can persist long after physical scars have healed. This is especially so for vulnerable groups with no or very weak social support systems, such as elderly people living in virtual social isolation.

145. The social vulnerability of peoples' livelihoods is determined by how weak or strong the livelihoods are (feel), how good their access is to a range of assets that provide the basis for their livelihood strategy, and how successful different institutions are in providing social protection. Socio-economic factors can make people and societies (feel) more or less vulnerable to climate change. By building up preparedness, resistance and resilience to climate change, vulnerability can be reduced, which in turn improves sustainable livelihoods.

146. Some current practices actually increase the vulnerability to a changing climate. For example, allowing further residential and commercial development on riverine flood plains subject to inundation substantially increases the likelihood of detrimental impacts and costs of climate change.

147. The functions or systems of different basins will respond differently to the same degree of climate change, depending largely on catchment physio-geographical and hydro-geological characteristics and the amount of lake or groundwater storage in the catchment.

148. Many river basins that are already stressed due to non-climatic drivers are likely to become more stressed because of their vulnerability to climate change. Of particular relevance is the vulnerability to climate change of costly water infrastructures (e.g., dykes and pipelines), which have to serve for decades but were designed on the assumption of stationary climatic conditions.

149. Ecosystems are expected to adjust to some level of future climate change and, in some form or another, will continue to persist or evolve, as they have done repeatedly with paleo-climatic changes. A primary key issue, however, is whether ecosystem resilience will be sufficient to tolerate the very rapid future anthropogenic climate change. In any case, climate change will alter the supply of ecosystem services.

150. Environmental systems tend to respond to changes in a gradual way until they cross some threshold or the tipping point. Beyond this point, change becomes sudden rather than gradual causing irreversible environmental (extinction of species) and societal (disappearance of an island) dislocation. The change leads to a transition to a new state. The existing rate of change is therefore not an indicator for the severity of the potential change. The extent of warming needed to trigger these changes is not precisely known. Moreover, there is a strong possibility of such switches coming as a surprise to affected societies that had been prepared (at best) for the gradual growth of already-observed impacts.

151. Depending on the subsurface characteristics, the effects of climate change on groundwater resources can be either immediate or take a long time to materialize. These characteristics should therefore be assessed and accounted for when performing vulnerability assessments.

B. Vulnerability assessments

1. Defining vulnerability assessment

152. Vulnerability assessment (VA) delineates the places, human groups, and ecosystems that are at highest risk, the sources of their vulnerability, and how the risk can be diminished or eliminated. Therefore, identifying the regions and peoples at greatest risk and assessing the sources and causes of the vulnerability is critical for designing and targeting adaptation. This effort guides the prioritization of intervention and adaptation action and provides decision makers with information on where and when interventions are needed.

153. VAs should be predictive, conceptualizing what might happen to an identifiable population or ecosystem under conditions of particular risk and hazards. They should therefore be capable of seeking ways to protect and enhance peoples' livelihoods, assist vulnerable people in their own self-protection, and support institutions in their role of adaptation.

154. VAs should cover physical aspects such as land use and risk to infrastructures, including the health system infrastructure in areas that present a hydrological risk, but should also incorporate social vulnerability assessments. Such social aspects of vulnerability should take into account not only personal behaviour, but also explore existing differences in liability coverage (e.g. State disaster management funds, obligatory individual insurance coverage) and reserves for the immediate safeguarding of human life and the speedy recovery of critical infrastructure including health systems in the event of climatic catastrophes.

2. Methodologies for vulnerability assessments

155. There is no ”one size fits all” VA methodology. VAs should be tailor-made for the water resources management or water services of a particular basin. Typically, a VA includes the following steps:

(a) Scope and structure of the VA. This includes the objectives of the VA, the definition of the scenarios and models to be applied, and the stakeholders who will guide the use of the VA;
(b) Identification of vulnerable groups and areas of potential climate change damage. With the use of scenarios and models, the exposure of livelihoods and areas to climate changes are assessed;
(c) Assessment of the vulnerability of the selected system and vulnerable group. How resilient are the groups and areas to current and possible future stresses;
(d) Use of the VA outputs in the adaptation policy and in planning the adaptive strategies and measures.

156. The following criteria can be used to identify key vulnerabilities:

(a) Magnitude of impacts;
(b) Timing of impacts;
(c) Persistence and reversibility of impacts;
(d) estimates of uncertainty of impacts and vulnerabilities, and confidence in those estimates;
(e) Potential for adaptation;
(f) Distributional aspects of impacts and vulnerabilities;
(g) Importance of the system(s) at risk.

157. The coping capacity of livelihoods and individuals can be assessed through various social, geographic and environmental parameters such as differences in health status, economic standing, and educational achievement. Combining such variables in development models allows making comparisons to determine the most critical regions or hot spots.

158. Determining which impacts of climate change are potentially of the utmost importance and which are the most dangerous is a dynamic process involving, inter alia, a combination of scientific knowledge with factual and normative elements.

159. Assessment of vulnerabilities can include vulnerabilities without adaptation and vulnerabilities with adaptation, or residual vulnerabilities.

VII. MEASURES

160. Measures to cope with climate change are based on the VA. Measures aim to counteract negative effects of too much water, too little water, impairment of water quality and effects on health. Five different types of measurement form an adaptation chain: prevention, improving resilience, preparation, response, and recovery (figure 4). Measures for prevention and

improving resilience are related both to the gradual effects of climate change and extreme climate events. Preparation, response, and recovery measures are relevant for extreme events. As categorization is considered within a continuum of adaptation measures, it is not always feasible to categorize certain measures as one specific type (see tables 1 and 2).

161. Besides the more centralized, often government-initiated measures described in this chapter, an essential measure is to raise the awareness of stakeholders about risks of water impacts of climate change and mobilize the stakeholders, as described in Section 0. This provides stakeholders with the opportunity to adapt directly in response to changes.

162. As will be discussed in more detail below (see section VII.B), climate change effects occur at different time horizons, while catastrophic events occur at comparatively short time horizons. Effects of climate changes playing out over longer time periods will become better understood as more information becomes available. Thus there will never be one definitive and final set of measures. Rather, measures will need to be developed to address the effects that pose highest risk to human health first, and efforts will continuously need to be made to better understand ongoing climate change and to develop appropriate adaptation measures to new risks as they become better understood.

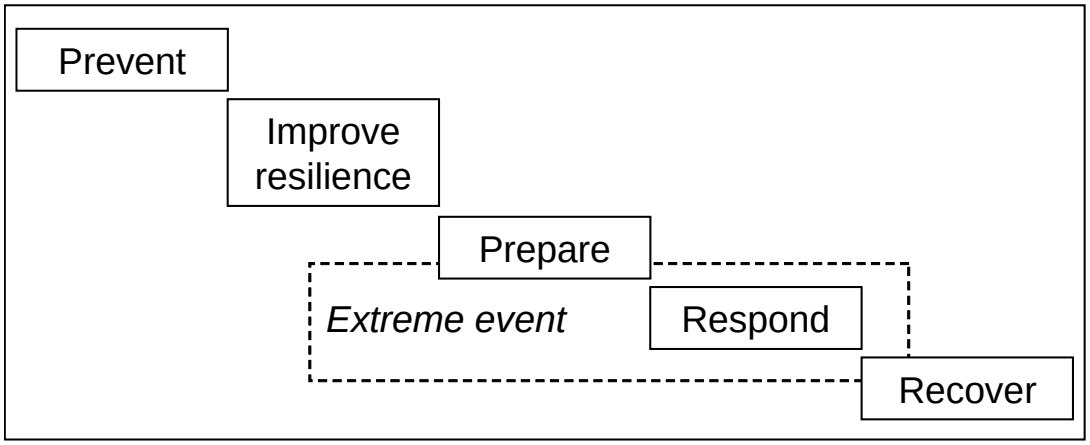

Figure 4: The adaptation chain

A. Types of measures[§§§§§]

163. *Prevention measures* are measures taken to prevent the negative effects of climate change and climate variability on water resources management. Prevention measures are based on risks, hazards and vulnerability maps under different scenarios. To support them, projections are needed both on a seasonal and a long-term basis. Monitoring systems should be designed to capture early signals of climate change impact and differentiate them from signals of impacts from other pressures. Existing management practices need to be revised and amended, where appropriate, to adapt and respond to climate change impact.

[§§§§§] Examples of measures are included in tables 1 and 2.

164. Prevention measures can include, for instance, the prevention of urban development in flood-prone areas or development of water efficient methodologies in water-dependent sectors, but also measures such as afforestation to improve the retention of water or prevent landslides. Prevention measures target long-term developments and are therefore of a strategic nature.

165. Where the threat of climate change makes continuation of an economic activity impossible or extremely risky, consideration can be given to changing the use. For example, a farmer may choose to substitute a more drought-tolerant crop or switch to varieties with lower moisture. Similarly, crop land may be returned to pasture or forest, or other uses may be found such as recreation, wildlife refuges or national parks.

166. *Measures to improve the resilience* are measures that aim to reduce the negative effects of the climate change and climate variability on water resources management by improving adaptive capacity. Such measures are based on risks, hazards and vulnerability maps under different scenarios. To support resilience measures, forecasts are needed on a seasonal basis.

167. Measures to improve resilience target long term developments such as changing agriculture to crops that are less water-demanding or salt-resistant. Improving resilience can also be done at a tactical level, for instance by operating dams in such a way that sufficient water is retained in the wet season to balance for the water needs in the dry season.

168. *Preparation measures* are measures that aim to reduce the negative effects of extreme events on water resources management. Such measures are based on risk maps under different scenarios. To support preparation measures, short-term weather forecasts are needed as well as forecasts on a seasonal basis.

169. Preparation measures comprise the establishment of early-warning systems, emergency planning, and raising awareness as well as increasing storage, demand management and technological development. Preparation measures have a strategic and operational character. They are established to run over a long period, but are often only active at the operational level.

170. *Response or reactive measures* are measures that aim at alleviating the direct negative effects in the aftermath of extreme events. To support resilience measures, short term weather forecasts are needed.

171. Response measures include for instance establishment of safe drinking water and sanitation facilities in affected areas. Response measures target at the operational level.

172. *Recovery measures* aim at restoring the societal and natural system after an extreme event has taken place. To support recovery measures, forecasts are needed both on a seasonal and a long-term basis. Recovery measures include, for instance, activities for the reconstruction of infrastructure. Recovery measures operate at the tactical level.

B. Measures at different time scales

173. Measures can be developed at different time scales depending on their characteristics. Table 1 provides some examples of different types of decisions at the strategic, tactical and operational levels.

(a) *Strategic measures* are related to decisions to address long-term (decadal) climate changes and are based on long-term projections. They usually exceed the scope of water sector planning, because they affect the development model and the socio-economic background through institutional and legal changes;

(b) *Tactical measures* relate to decisions aiming at addressing medium-term (within one or two decades) climate trend projections, introducing the required corrections in the framework through hydrological planning measures such as risk management;

(c) *Operational measures* relate to decisions addressing identified problems under the current climate. They correspond to measures that can be adopted in the current institutional, legal and infrastructural frameworks, and usually refer to risk assessment, preparedness and vulnerability reduction.

Table 1: Types of decisions aiming at different time scales

Type of decision	**Future climate**		**Current climate**
	Long term (25–50 years)	**Medium term (5–25 years)**	**Short Term (0–5 years)**
	Climate scenarios	**Climate trend**	**Current climate**
Strategic	- Institutional framework - Legal framework - Development model - Land use planning - Socio-economic activity planning		
Tactical		- Capacity-building - Hydrological plans - Infrastructure planning - Drought and flood management plans - Infrastructure construction	
Operational			- Monitoring - Demand management - Operating rules for current infrastructure - Dam operations - Water allocations to agriculture - Flood and drought warning

C. Development of measures

174. Climate risk should be considered as an integral element of decision-making. Adaptation options should not be developed separately from other dimensions of strategic planning and risk management. Reaching this point requires awareness-raising and development of science and of techniques for applying scientific knowledge in practical situations.

175. Decision-making criteria for selecting adaptation options will vary depending upon who is making the decision, the objectives of decision makers and stakeholders, which stakeholders are affected by the decision and what role they play in the decision-making process. Such aspects as uncertainty about decisions' outcomes, consequences of errors made in the decision-making process and irreversibility of consequences should be also considered. Another crucial factor is the ability of populations to adapt to climatic variability, which is heavily influenced by the degree to which people, finance, goods, services and information can move across local and national borders.

176. The participatory approach should be a basis for developing and implementing measures. Persons at risk should be involved in the adaptation process. This helps: (a) focus attention on the risks that are priorities; (b) learning from risk management practices currently in use at the local level; and (c) identifying opportunities and obstacles and applying evaluation criteria that are relevant and credible to at-risk groups. Use of local knowledge and expertise, garnering support and mobilizing local resources, increases the effectiveness of adaptation.

177. The development of measures should take into account the above statements, the described categorization approach and be in line with the required time scale. Depending on their purpose measures can be of different nature, e.g. legislative, financial, structural, non-structural or related to capacity-building.

178. The implementation and maintenance costs of adaptation measures and their technical feasibility should be compared to the costs of non-action.

179. Currently, many adaptation strategies are mainly focusing on structural aspects such as protective dams etc. However, non-structural measures should also be considered such as behavioural measures, capacity-building activities etc.

1. Enhancing resilience of ecosystems

180. Measures to enhance the resilience of the ecosystems and to secure the essential ecological services to human society should receive priority. These include:

(a) protection of adequate and appropriate space;
(b) limitation of all non-climate stresses; and
(c) use of active adaptive management and strategy testing.

181. Conservation of keystone species, planning along climate gradients (e.g. mountain altitudes), promoting connectivity (e.g. protected areas and corridors), fragmentation avoidance

and protection of climate refuge with especially resistant habitats should be covered under habitat protection.

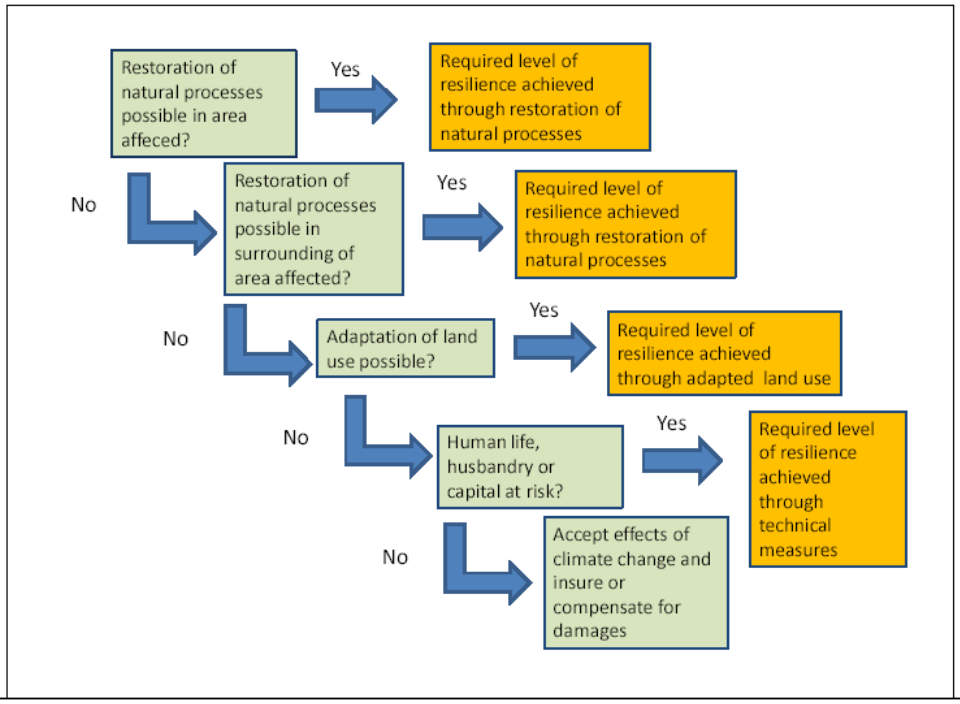

Fig. 5 : Decision-making tree for building climate resilience of an affected area through restoration of natural processes (adapted from Stroming 2007)

2. Development and maintenance of infrastructure

182. Conservation of water resources demands the rehabilitation and expansion of existing water-use systems, new construction (e.g. of dams, canals, dykes, aqueducts, etc.) and improvement of water consumption (through irrigation or by industry) and water supply. It is necessary to improve the technical condition of infrastructure, to carry out timely maintenance and repair waterworks and to equip them with modern water-saving devices.

183. Construction of new reservoirs will considerably improve conditions of run-off regulations and lessen the danger of severe floods. Planning procedures for the design of new infrastructure will need to undergo a philosophical change since the past hydrological characteristics may no longer apply.

3. Reducing effects of extreme events

184. The prime objective of the United Nations programme International Strategy for Disaster Reduction (ISDR) is to build disaster resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development, thus reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters. The many report and guidelines published under the

Hyogo Framework for Action[******] aim to both build up the resilience of nations and communities to disasters and integrate disaster risk reduction with climate change strategies. Adaptation measures such as early-warning systems, risk assessment and sustainable natural resources use are considered in practice as disaster risk-reduction activities. Disaster reduction should be integrated in any adaptation strategy.

4. Preventing and responding to negative health outcomes

185. Health systems[††††††] have the dual role of taking all necessary measures to ensure that water-related diseases linked to climate change are prevented as much as possible, but also ensuring that a system is in place to monitor the incidence of such diseases and detect outbreaks and that contingency plans are in place to deal with such outbreaks.

186. Countries should take a number of common actions to strengthen capacity of health systems and their preparedness to respond climate change challenge. These include[‡‡‡‡‡‡]:

(a) Strengthening health security, maximizing synergy with existing instruments such as the IHR, preparing the health workforce to deal with climate-related events (e.g. offer appropriate mental care during climate events as well as adequate care for extended periods after climate events to the survivors), and ensuring that the logistic aspects of the health system infrastructure can withstand climate events (e.g. availability of stand by generators, capacity to ensure safe running water and adequate removal/disposal of sanitary and medical waste, etc.);

(b) Building the capacity of the workforce: health professionals should be prepared for new challenges of protecting health from the effects of climate change;

(c) Providing intelligence: ensuring that information systems and communication strategies serve the needs of the health care system in a multi-sectoral context. A robust information structure should be capable of:

(i) providing reliable and timely information;
(ii) issuing warnings;
(iii) acting on early warnings received from other partners;
(iv) building trust and improve public perception, and
(v) better overall management of climatic events.

[******] Hyogo Framework for Action 2005-2015: ISDR International Strategy for Disaster Reduction. Available at: www.unisdr.org/wcdr.

[††††††] Health systems comprise all organizations, institutions and resources devoted to improving, maintaining and restoring health.

[‡‡‡‡‡‡] Menne, B. et al. (2008), “Protecting HEALTH in Europe from climate change”, WHO-Europe.

Table 2: Overview of possible measures

	Flood prone situation	Drought prone situation	Impaired water quality	Health effects
PREVENTION **Measures** include…	• Restriction of urban development in flood risk zones • Measures aiming at maintaining dam safety, afforestation and other structural measures to avoid mudflows • Construction of dykes • Changes in operation of reservoirs and lakes • General land-use management *->Various legal/financial/economic instruments are available.*	• Reducing need for water • Water conservation measures/ effective water use (industrial and other sectors' practices and technologies) • Water saving (permit systems for water users) • Improved irrigation efficiency • Land-use management *->Various legal/financial/ economic instruments are available.*	• Prevention of and cleaning up of dump sites in flood risk zones • Improved waste water treatment • Regulation of wastewater discharge • Improved drinking water intake *->Various legal/financial/economic instruments are available.*	• Strengthen and use a capacity for long-term preparation and planning, especially to identify, address and remedy the underlying social and environmental determinants that increase vulnerability
IMPROVING RESILIENCE **Measures** include…	• Operation of reservoirs/lakes (surplus of water can be handled without causing damage) • Implementation of retention areas • Improved drainage possibilities • Structural measures (temporary dams, building resilient housing, modifying	• Enlarging the availability of water (e.g. increase of reservoir capacity) • Improving the landscape water balance • Introduction or strengthening of a sustainable groundwater management strategy • Joint operation of water supply and water management networks or building of new	• Safety and effectiveness of waste water systems • Isolation of dump sites in flood risk zones • Temporary wastewater storage facilities	• Use existing systems and links to general and emergency response systems • Ensure effective communication services for use by health

	Flood prone situation	Drought prone situation	Impaired water quality	Health effects
IMPROVING RESILIENCE (cont'd)	transport infrastructure) • Migration of people away from high-risk areas	networks • Identification and evaluation of alternative strategic water resources (surface and groundwater) • Identification and evaluation of alternative technological solutions (desalinization; reuse of wastewater) • Increase of storage capacity (for surface and ground waters) both natural and artificial		officials
PREPARATION **Measures** include…	• Flood warning (incl. early warning) • Emergency planning (incl. evacuation) • Flash-flood risks, (measures taken as prevention, as the warning time is too short to react)	• prioritization of water use • restrictions for water abstraction for appointed uses • emergency planning • awareness-raising • risk communication to the public • training and exercise	• Restrictions to wastewater discharge and implementation of emergency water storage	• Strengthen the mechanism for early warning and action
RESPONSE **Measures** include…	• Emergency medical care • Safe drinking water distribution • Safe sanitation provision • Prioritization and type of distribution (bottled water, plastic bags, etc.)			
RECOVERY **Measures** include…	• Clean-up activities • Rehabilitation options such as reconstruction of infrastructure • Governance aspects such as legislation on, inter alia, insurance, a clear policy for rehabilitation, proper institutional settings, rehabilitation plans and capacities, and information collection and dissemination.			

VIII. FINANCIAL MATTERS

187. Studies by the World Bank, the Stern Review, the Human Development Report research team, the UNFCCC and Oxfam estimate global adaptation costs to be in the order of tens of billion dollars per year. Ensuring adequate financial means to implement the adaptation measures is therefore an important precondition for success.

188. To accurately assess the costs of implementing measures that are necessary and the revenues of these investments in terms of risk avoidance or reduction, it is essential to understand the long-term value of having adequate financial means in place. The cost of implementation should, in general, be borne by each country. Governments should therefore ensure that appropriate resources are available. Many of the proposed actions here can be incorporated into ongoing development work in the water sector, e.g. no-regret measures. Some actions can be more easily carried out as sub-regional or region-wide projects.

189. Several funding possibilities exist from international funding agencies. Among these funds are the Global Environment Facility (GEF) [*], the Adaptation Fund [†], several grants to assist Parties in implementing the Ramsar Convention [‡]: a Small Grants Fund for Wetland Conservation and Wise Use (global program), Wetlands for the Future (program for Latin America and the Caribbean), and the Swiss Grant Fund for Africa, and two specific climate investment funds (CIFs) [§] approved by the World Bank: the Clean Technology Fund, and the Strategic Climate Fund.

190. Where global adaptation funds can support countries in developing adaptation measures, sustainable financing of climate change adaptation should draw from other funding sources. Such sources may also be better tuned to local needs, draw upon existing structures and expertise, and be targeted at essential sectors. As, for instance, governments are responsible for 10 - 25 % of the investment in new physical assets [**] shifting funding to climate change related investments could increasingly take social and development priorities into account.

191. Putting a price on water can help maintain the sustainability of the resource itself when the price of water reflects its true cost. In this way, water pricing can help to balance between supply and demand. Price policies in the water sector range from direct pricing to green taxes, to effluent fees, to direct subsidies to utilities or the users. The choice of the appropriate policy depends upon the local political and social conditions. Care should however be taken that water pricing does not interfere with providing access to water supply and sanitation.

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[*] http://www.gefweb.org.
[†] http://www.adaptation-fund.org.
[‡] For more information, see http://www.unep.org/dec/onlinemanual/Compliance/NationalImplementation/CapacityBuilding/Resource/tabid/685/Default.aspx.
[§] http://www.worldbank.org/cif.
[**] UNFCCC, 2007. Investment and Financial Flows to Address Climate Change. Background paper on analysis of existing and planned investment and financial flows relevant to the development of effective and appropriate international response to climate change. Bonn, Germany, 273 pp. See http://unfccc.int/resource/docs/publications/financial_flows.pdf.

192. Public sector financing alone will not suffice to reduce vulnerability to climate risks. Therefore it is important to explore how the private sector can engage in adaptation mechanisms. Governments should introduce policies or incentives that support adaptation. These policies include regulations and standards that improve resilience, taxes and charges (e.g. polluter pays principle), and subsidies and incentives for risk reduction. Governments can also seek partnership with the public sector to overcome the barriers to entry for the private sector and to benefit from the private sector's need to innovate and be efficient.

193. Insurance can be regarded as an adaptation measure, as it transfers risk from localities to regional and global insurance and capital markets. Setting a price on risk through insurance premiums can also help to identify vulnerable areas, and promote the reduction of risk, by providing incentives such as reduced premiums or reduced deductibles. The engagement of the private sector that calculates risk, such as the insurance sector, could provide opportunities to gain insight in risks, and ways to either transfer or reduce risks. Moreover, innovative insurance products, such as catastrophe bonds, and weather index insurance systems (*e.g.*, providing payments during drought), can play a viable role if tied to efforts aimed at vulnerability reduction.

194. Various mechanisms can be deployed to finance biodiversity. Finance can be raised directly from biodiversity, such as through the sustainable use or trade of biological resources including goods such as timber and non-timber forest products and the pharmaceutical, agricultural and industrial applications of biological resources. Finance can also be raised indirect through services such as water provision, climatic regulation, tourism and scientific research [††]. Such financing mechanisms operate at many levels between and within countries, from and to governments, the private sector and local communities.

195. Finance can also be raised by making sure that charges are levied on economic activities which contribute to biodiversity degradation and loss such as pollution taxes, land reclamation bonds and waste disposal charges. Other financing mechanisms include the transfer or redistribution of funds between individuals, groups or countries as through measures such as investment promotion, trust funds, loans, swaps and offsets.

196. In a transboundary context, riparian countries should focus on generating basin-wide benefits and on sharing those benefits in a manner that is agreed as fair. A focus on sharing the benefits derived from the use of water, rather than the allocation of water itself, provides far greater scope for identifying mutually beneficial cooperative actions. Payments for benefits (or compensation for costs) might be made in the context of cooperative arrangements. Measures that support adaptation in one country can be more effective if they are taken in another country. Prevention of flooding, for instance, can be realized by creating retention areas upstream and such areas may be located in the upstream country. Financing should be equally shared, where the party that gains most, pays most. In some instances, it might be appropriate to make payments to an upstream country for management practices of the basin that bring benefits downstream (e.g. reduced flooding and sediment loads, improved water quality). This solidarity

[††] Also see UNECE, 2007. Recommendations on payments for ecosystem services in Integrated Water resources Management. ECE/MP.WAT/22. United Nations Economic Commission for Europe, Geneva, Switzerland http://www.unece.org/env/water/publications/documents/PES_Recommendations_web.pdf.

in the basin might entitle upstream countries to share some portion of the downstream benefits that their practices generate, and thus share the costs of these practices.

197. Raising funding in a transboundary situation can be done through national measures as described above. Next to this, trust funds offer a plausible option for sustaining transboundary river institutions and longer term planning and programming**.** The private sector investment most relevant to transboundary water management has been in hydropower where transboundary concerns frequently exist.

IX. EVALUATION OF ADAPTATION STRATEGIES

198. This chapter will introduce frameworks to evaluate adaptation strategies. Evaluation is a process for determining systematically and objectively the relevance, efficiency, effectiveness and impact of the adaptation strategies in the light of their objectives. Evaluating adaptation strategies is imperative to assessing the effectiveness of adaptation strategies and thereby identifying and measuring the ability to cope with short- to long-term threats. Evaluation should guide and support governmental decision-making and policymaking, as well as international aid and investment. It should support decisions prioritizing strategies and initiatives that reduce vulnerability.

A. Objectives

199. As explained in the previous chapters, analyses of current and future vulnerabilities and risks as well as of existing policies are the basis for the developing good adaptation strategies. Evaluation and monitoring activities are essential for verifying the efficiency of the measures taken and facilitate adjustments.

200. Evaluation is carried out during implementation (ongoing evaluation), at the completion of a project (final evaluation), and some years after completion (post evaluation). Much of the evaluation activity can be based on self-assessment of the responsible operational staff, but external evaluation is also a common and beneficial practice.

201. Evaluating adaptation strategies includes evaluating the constituent elements of a given strategy; the policy, legal and institutional setting, vulnerability assessment; and the choice of measures. It also includes monitoring the adaptation progress.

202. Evaluation of an adaptation strategy starts off with assessing the progress achieved towards the objectives of the strategy. The next step is to determine if the policy as formulated is implemented and if it functions as intended. The legal framework as well as the institutional setting of the strategy should be assessed concerning their contribution to the strategy. Next to that, the financial arrangements should be evaluated.

203. Evaluating vulnerability assessment includes assessing if sufficient relevant information was available. Also the extent to which the scenario that was selected as the basis for the vulnerability assessment has enfolded in reality and if the output of the models reflects the actual situation transpiring. Finally, the relevance of the assumptions for the vulnerability assessment should be assessed.

204. Monitoring the progress in adaptation includes collecting information on all these elements as well as on the progress made vis-à-vis achieving objectives. Table 3 provides an overview of possible indicators that can be applied to assess the progress made. It distinguishes between the national adaptation strategy level and the level of concrete measures. The latter can also be linked to projects. On the measure or project level, distinction is made between the outcomes of the measures (in terms of effects on the reduction of vulnerability and increased adaptive capacity) and the output of the measures (in terms of the strategy chosen, the developed or implemented policy, and the concrete activities).

Table 3: Illustrative matrix mapping the strategy level goal, objective and indicators to measure level outcomes, outputs and indicators

Strategy level			**Measure/project level**			
Goal	**Objective**	**Strategy Indicators**	**Outcomes**	**Outcome Indicators**	**Outputs**	**Output Indicators**
Climate proofing	Vulnerability reduction Adaptive capacity enhanced	Coverage Impact Sustainability Replicability	Outcome 1 Outcome 2 Outcome x	Coverage Impact Sustainability Replicability	Strategies	…
					Policies	…
					Activities	…

205. The four types of outcome indicators shown measure the success of projects:

(a) *Coverage*: the extent to which projects reach vulnerable stakeholders (e.g. individuals, households, businesses, government agencies, policymakers) and the ecosystem;

(b) *Impact*: the extent to which projects reduce vulnerability and/or enhance adaptive capacity (e.g. through bringing about changes in adaptation processes: policymaking/planning, capacity-building/awareness-raising, information management).

(c) *Sustainability*: the ability of stakeholders to continue the adaptation processes beyond project lifetimes, thereby sustaining development benefits;

(d) *Replicability*: the extent to which projects generate and disseminate results and lessons of value in other, comparable contexts.

206. Sound evaluations can be carried out with simple, careful examinations of success, relative to what was expected. The following list provides examples of questions that can contribute to this evaluation:

(a) If, for instance, adaptation involved investing in a protection project in response to a climate hazard, then the evaluation should determine if losses have continued, grown or been abated;

(b) If the protection project simply tried to reduce sensitivity to extreme events, has it worked, and how?

(c) Have episodes of intolerable exposure become more or less frequent?

(d) Has the definition of “intolerable” in terms of physical effects changed?

(e) Has the investment expanded the coping range, reduced exposure to intolerable outcomes that exceed the range, or both?

(f) Have things stayed the same or grown worse because the adaptation was ineffective, or because unanticipated stresses have aggravated the situation?

(g) Is there a causal relationship between the vulnerability and the strategy/measure?

207. The purpose of this exercise is to determine whether or not the objectives of an adaptation project have been satisfied. More complete evaluations of specific adaptations should identify the root causes of both successes and failures. A questionnaire specific to the particular adaptation can be constructed to understand the reasons why an adaptation succeeded or failed to meet its objectives.

B. Learning by doing

208. Uniploring the success or failure of the adaptation process depends on more than just the success or failure of implemented projects or strategies. More significantly, it depends upon the concept of learning by doing. This approach enables users to:

(a) Undertake midcourse corrections in implemented adaptations, so that they meet their objectives more efficiently;

(b) Improve their understanding of the determinants of adaptive capacity, so that capacity development activities can be more successful from the start.

209. To learn from mistakes and successes, it is important to combine these insights to:

(a) Compare actual experience with the initial characterization, and with the criteria;

(b) Construct a revised adaptation baseline that describes how the system would have performed in the absence of the implemented adaptation.

C. Participatory evaluation

210. Participatory processes in support of adaptation can add value and enhance feasibility. Engaging as many stakeholders as possible can democratize the overall process of adapting to climate change, including variability. It follows that participatory evaluation can be productive, but care must be taken to note the potential pitfalls. For example, stakeholder engagement can uncover obstacles such as a healthy degree of initial scepticism on the part of stakeholders about the information provided by government.

D. Social, economic, political, financial and ethical considerations

211. In evaluating adaptation strategies, it is necessary to (re)consider the social, economic, political and ethical implications of each adaptation measures. The impacts on all stakeholders need to be considered.

212. Evaluation of adaptation strategies includes also cost-benefit analysis. Adapting to climate change entails costs (at least those of implementation), but should also yield significant benefits – those of reduced impacts or enhanced opportunities. Any assessment of the economic efficiency of adaptation actions requires consideration of the distribution of their costs and

benefits; the costs and benefits of changes in those goods that cannot be expressed in market values; and the timing on adaptation actions (Adger et al., 2005).

X. ISSUES RELEVANT TO OTHER WATER-RELATED SECTORS

213. Issues relevant to other water-related sectors have been addressed, as appropriate in all other chapters; it will be decided at a later stage whether there is a need to include them in a separate chapter or leave them as an integral part of other chapters.

APPENDIX

DEFINITIONS

For the purpose of this guidance, the following definitions should be considered:
Adaptability / Adaptive Capacity: in the context of both social and natural systems, adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences[*].
Adaptation strategy: The adaptation strategy for a country, a basin, or part thereof, refers to a general plan of action for addressing the impacts of climate change, including climate variability and extremes. It will include a mix of policies and measures with the overarching objective of reducing the country's vulnerability[†].
Climate model: A numerical representation of the climate system based on the physical, chemical and biological properties of its components and their interactions and feedback processes, accounting for all or some of the system's known properties[‡].
Climate scenario: A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models[§].
Coping capacity: The means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. In general, this involves managing resources, both in normal times as well as during crises or adverse conditions. The strengthening of coping capacities usually builds up the resilience to withstand the effects of natural and human-induced hazards[**].
Downscaling: A method that derives local- to regional-scale (10 to 100 km) information from larger-scale models or data analyses.
Emission scenario: A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g., greenhouse gases, aerosols), based on a coherent and internally consistent set of assumptions about driving forces (e.g. demographic and socio-economic development, technological change) and their key relationships[††].
Hydrologic model: A simplified, conceptual representations of a part of the hydrologic cycle, primarily used for hydrologic prediction and for understanding hydrologic processes. Hydrological models can be based on statistical approaches (black box systems) or based on process descriptions (known as deterministic hydrology models), in the effort to represent the physical processes observed in the real world.
Local: refers to all relevant levels of territorial unit below the level of the State[‡‡].

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[*] IPCC, 2007.
[†] UNDP, 2004: Adaptation Policy Frameworks for Climate Change. Developing Strategies, Policies and Measures. Annex A. Glossary of Terms.
[‡] IPCC, 2008: Fourth Assessment Report, Working Group II, Appendix 1- Glossary.
[§] IPCC, 2008: Fourth Assessment Report, Working Group II, Appendix 1- Glossary.
[**] ISDR Terminology of disaster risk reduction, viewed June 2008, http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm.
[††] IPCC, 2008: Fourth Assessment Report, Working Group II, Appendix 1- Glossary.
[‡‡] Protocol on Water and Health.

Mitigation: is an anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and to enhance greenhouse gas sinks[§§].
Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.[***]
Scenario: A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships.
Socio-economic scenarios: Scenarios concerning future conditions in terms of population, gross domestic product and other socio-economic factors relevant to understanding the implications of climate change.[†††]
Vulnerability: Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.[‡‡‡]

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[§§] IPCC 2008: Fourth Assessment Report, Working Group II, Appendix 1- Glossary.
[***] IPCC 2008: Fourth Assessment Report, Working Group II, Appendix 1- Glossary.
[†††] IPCC 2008: Fourth Assessment Report, Working Group II, Appendix 1- Glossary.
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Conclusions from the International Symposium “Time To Adapt. Climate Change and the European Water Dimension”, organized under the German Presidency of the EU (http://www.climate-water-adaptation-berlin2007.org/).

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