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**Nairobi work programme on impacts, vulnerability and adaptation to climate change**

# Report on the technical workshop on water and climate change impacts and adaptation strategies

## Note by the secretariat

*Summary*

This report provides a summary of the technical workshop on water and climate change impacts and adaptation strategies organized under the Nairobi work programme on impacts, vulnerability and adaptation to climate change. The workshop was organized in collaboration with the National Water Commission of the Ministry of the Environment and Natural Resources of Mexico and was held in Mexico City, Mexico, from 18 to 20 July 2012. The workshop considered issues related to climate change impacts on water resources, including the multidimensional aspects of water in the context of livelihoods, related sectors and ecosystems, data and observation needs and opportunities, and adaptation planning and practices to reduce the vulnerability of water resources to climate change at multiple levels. Cross-cutting themes included the applicability of indigenous knowledge and coping strategies and the need for gender sensitivity when developing adaptation strategies involving water resources. The participants also discussed stakeholder engagement, knowledge-sharing and management, and collaboration at different levels, to enhance the resilience of water resources to climate change. The workshop report includes a summary of recommendations identified by the participants for follow-up and further consideration in the context of the Nairobi work programme.

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# I. Introduction

## A. Mandate

1. The Conference of the Parties (COP), at its seventeenth session, requested the secretariat to organize, in collaboration with partner organizations of the Nairobi work programme on impacts, vulnerability and adaptation to climate change, and other relevant organizations, a technical workshop on water and climate change impacts and adaptation strategies, under the Nairobi work programme, before the thirty-seventh session of the Subsidiary Body for Scientific and Technological Advice (SBSTA).[1]

2. By the same decision, the COP indicated that the workshop will be informed by the information contained in annex I to the report of the SBSTA on its thirty-fourth session and subsequent views of Parties,[2] and will include indigenous and traditional knowledge and practices for adaptation and gender-sensitive tools and approaches as cross-cutting issues.[3]

3. The COP, at its seventeenth session, also requested the SBSTA to reconsider, at its thirty-eighth session, the work areas of the Nairobi work programme with a view to making recommendations to the COP at its nineteenth session on how to best support the objectives of the Nairobi work programme. This process would further inform the organization of potential future areas of work that could also support the scientific and technical work under the Cancun Adaptation Framework, as appropriate.[4]

## B. Scope of the note

4. This report provides information on the workshop referred to in paragraph 1 above, drawing upon the presentations and discussions that took place.[5] It contains the following:

(a) A description of the workshop proceedings (chapter II);

(b) An analysis of the key issues addressed at the workshop (chapter III);

(c) Possible next steps, which includes a summary of recommendations for further action identified by the participants, including in the context of the Nairobi work programme (chapter IV).

## C. Possible action by the Subsidiary Body for Scientific and Technological Advice

5. The SBSTA may wish to consider this workshop report at its thirty-seventh session as part of its consideration of the outputs of activities completed prior to that session. This might assist Parties in their reconsideration of the work areas of the Nairobi work programme referred to in paragraph 3 above.

[1] Decision 6/CP.17, paragraph 4.
[2] FCCC/SBSTA/2011/2.
[3] Decision 6/CP.17, paragraph 4.
[4] Decision 6/CP.17, paragraph 1.
[5] The relevant documentation related to the workshop is available at <http://unfccc.int/6955>.

## D. Background

6. The overall objective of the Nairobi work programme is to assist all Parties, in particular developing countries, including the least developed countries and small island developing States, to improve their understanding and assessment of impacts, vulnerability and adaptation, and to make informed decisions on practical adaptation actions and measures to respond to climate change on a sound scientific, technical and socioeconomic basis, taking into account current and future climate change and variability.[6]

7. During the thirty-fourth session of the SBSTA, Parties agreed to discuss the impacts of climate change on water resources and integrated water resource management under the Nairobi work programme.[7] A technical paper on water and climate change impacts and adaptation strategies was developed and made available for consideration by the SBSTA at its thirty-fifth session.[8]

8. The objectives of the workshop were to:

(a) Assist all Parties, in particular developing countries, including the least developed countries and small island developing States, to improve and develop a shared understanding of:

(i) Vulnerability and the impacts of climate change on freshwater resources and water-related sectors;

(ii) Practical adaptation planning and practices that reduce the vulnerability of freshwater resources and water-related sectors;

(iii) Data, information and research needs, and opportunities, including on knowledge-sharing and management, and collaboration among stakeholders at all levels for integrated water resource management and building resilience to climate change;

(b) Provide recommendations for future work on water and climate change in the context of the Nairobi work programme.

# II. Proceedings

9. The technical workshop on water and climate change impacts and adaptation strategies was held in Mexico City, Mexico, from 18 to 20 July 2012. It was organized in collaboration with the National Water Commission (CONAGUA) of the Ministry of the Environment and Natural Resources of Mexico and was chaired by Mr. Richard Muyungi, Chair of the SBSTA.

10. Fifty-two representatives of Parties and relevant international, intergovernmental and non-governmental organizations that are active in the fields of climate change impact assessment and adaptation planning and practices related to water resources participated in the workshop.

11. The opening of the workshop by the host government was followed by a framing session, during which the chair of the workshop provided an overview of the Nairobi work programme and the scope of the workshop. Three framing presentations were made to set the necessary context for the workshop: the first was an overview of climate change impacts on water resources, livelihoods, related sectors and ecosystems; the second was on

[6] Decision 2/CP.11, annex, paragraph 1.
[7] FCCC/SBSTA/2011/2, paragraph 6.
[8] FCCC/TP/2011/5.

the assessment of the impacts of climate change on water resources and how to adapt; and the third provided Mexico's perspectives on national adaptation planning and practices for water resources. The second session focused on access to and use of observational data and on promoting improvement of observations for understanding climate change impacts on water resources. Four presentations were made, which were followed by a plenary discussion to understand several aspects of observational data, including practical examples of efforts to enhance relevant capacity and lessons learned.

12. The second day was organized into two sessions. The first session focused on understanding and assessing climate change impacts and vulnerability of water resources and related sectors and ecosystems, and was aimed to enhance understanding of the multidimensional nature of water resources in terms of lives and livelihoods. Four presentations were made that provided different examples of tools and methods for assessing climate change impacts and vulnerability of water resources and related sectors and ecosystems. This was followed by an interactive session, in which the participants worked in small groups to discuss and share multidimensional aspects of water resources, applicability and availability of modern, indigenous and traditional knowledge and practices, gender-sensitive tools and approaches, and lessons learned.

13. The second session of the second day focused on understanding the different types of adaptation planning and practices to reduce vulnerability and enhance the resilience of water resources. Two presentations were made to provide an overview of the different types of adaptation planning and practices, including policy instruments for climate change adaptation. These were followed by four case study presentations on adaptation planning and practices at different levels.

14. Three breakout groups were organized in the latter part of this session, which focused on understanding adaptation planning and practices at multiple levels: group 1 focused on the transboundary and regional levels; group 2 on the national level; and group 3 on the subnational/community level. In the breakout groups, the participants exchanged experiences with regard to current adaptation planning and practices related to water resources, including consideration of indigenous and traditional knowledge, gender-sensitive tools and approaches on adaptation planning and implementation, and identified lessons learned, good practices and further needs. Key discussion points and conclusions from the breakout groups were presented and discussed at a subsequent plenary session.

15. The third day comprised two sessions. The first session focused on consideration by the participants of the key discussion points and on understanding the opportunities for communication, stakeholder engagement, knowledge-sharing and management and collaboration at different levels in order to enhance the resilience of water resources to climate change. Four presentations were made that provided examples from various regional and global initiatives to facilitate an understanding of such opportunities. These were followed by presentations of the key discussion points from the previous sessions held over the first two days. An interactive discussion session with the participants took place to share lessons learned, good practices and further needs.

16. In the final session of the third day, Parties and organizations made recommendations for potential further action on water and climate change impacts and adaptation strategies under the Nairobi work programme. The workshop concluded with a chair's summary of the proceedings.

# III. Analysis of key issues addressed at the workshop

## A. Introduction

17. Participants shared key issues related to the vulnerability of freshwater resources and the impacts of climate change on freshwater resources, related sectors and ecosystems.

18. Climate change poses a major challenge to water managers and users as well as to policymakers at different levels. Given the intrinsic linkage between freshwater resources and other sectors and ecosystems, increased vulnerability of freshwater resources owing to climate change may affect, inter alia, the following: ecosystems and biodiversity; agriculture and food security; land use and forestry; water supply and sanitation; health; urban settlements and infrastructure; and energy supply and electricity generation.

19. Impacts on regional water availability and accessibility could lead to regional water crises, resulting in destabilization, violence and conflict, which would affect poor and vulnerable people the most. Assessment of climate change impacts on water resources at the basin or catchment level allows for a comprehensive assessment of social, ecological and economic pressures.

20. Population growth, land-use change, demographic change, including migration, and urbanization are among several social stressors that exacerbate the vulnerability of water resources and have concomitant impacts on water availability and access. Climate change and variability therefore act as exacerbating agents on existing vulnerability. Without effective institutions and adaptive management practices, vulnerable countries will continue to experience adverse climate change impacts. An enabling environment for effective adaptation across multiple levels of intervention implies responsive, accessible, inclusive and equitable institutional capacity, especially in the context of governance, capable of promoting change at the local, provincial, national and regional levels and beyond. Transboundary cooperation is also crucial to limit the vulnerability of water resources.

21. Adaptation strategies may include different components: integrated water resources management (IWRM), risk assessment and analysis; improving methods, management and decision-making capacity; and engaging decision makers and policymakers, practitioners, researchers and vulnerable communities, among other stakeholder groups. Resilience-building involving a combination of bottom-up and top-down approaches, early warning systems and disaster risk management strategies offer development benefits in the short to mid term and reduce vulnerability over the long term.

## B. Observational data and their interpretation for understanding climate change impacts on water resources

### Collection, management and use of observational data, as well as indigenous knowledge and practices

22. Climate observations and services are important at various levels for different reasons, including, inter alia, the following: forecasts of water supply; input to climate, weather and water models; calibration of models; verification and ground truthing of satellite data; and advanced understanding of natural processes. Data obtained from these observations need to be converted into useful information for decision-making and policymaking, planning and programming.

23. Climate observations could include routine weather observations collected over extended periods of time, highly precise continuous observations collected to document long-term change, observations of climate proxies for historical records, etc.

24. The essential climate variables (ECVs) that describe the climate system are presented in table 1, which shows 50 ECVs for the three domains: atmospheric, oceanic and terrestrial.

Table 1
**Essential climate variables**

| *Domain* | *Essential climate variables* |
|---|---|
| Atmospheric (over land, sea and ice) | Surface: air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget[a] |
| | Upper air: temperature, wind speed and direction, water vapour, cloud properties, Earth radiation budget (including solar irradiance)[b] |
| | Composition: carbon dioxide, methane and other long-lived greenhouse gases;[c] ozone and aerosols, supported by their precursors[d] |
| Oceanic | Surface: sea surface temperature, sea surface salinity, sea level, sea state, sea ice, surface content, ocean colour, carbon dioxide partial pressure, ocean acidity, phytoplankton[e] |
| | Subsurface: temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers |
| Terrestrial | River discharge, water use, groundwater, lakes, snow cover, glaciers and ice caps, ice sheets, permafrost, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation, leaf area index, above-ground biomass, soil carbon, fire disturbance, soil moisture |

*Source*: World Meteorological Organization. *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)*. Available at <http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf>.

[a] Including measurements at standardized but globally varying heights in close proximity to the surface.

[b] Up to the stratopause.

[c] Including nitrous oxide, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, sulphur hexafluoride and perfluorinated compounds.

[d] In particular nitrogen dioxide, sulphur dioxide, formaldehyde and carbon monoxide.

[e] Including measurements within the surface mixed layer, usually within the upper 15 m.

25. Different types and combinations of climate observation may be relevant. For example, Costa Rica considers the use of rainfall information both from rain gauges and automatic networks.[9]

26. Examples from the United States of America include atmospheric observations such as the Climate Reference Network, the Cooperative Observer Program and terrestrial observations such as the Soil Climate Analysis Network and the Snopack Telemetry Network.[10]

27. The Global Climate Observing System (GCOS) is an internationally coordinated network of observing systems with the goal of providing continuous, reliable and comprehensive data and information on the status of the global climate system.[11] GCOS consists of the climate-relevant components of existing atmospheric, oceanic and terrestrial observing systems and aims at enhancing them in order to meet users' needs for climate observations.

28. The Global Framework for Climate Services (GFCS) was established by the World Meteorological Organization to enable better management of the risks of climate variability and change and adaptation to climate change through the development and incorporation of science-based climate information and prediction into planning, policy and practice at the global, regional and national levels.[12] The GFCS intends to close the gap between those that need to know climate-related information and those that have such knowledge, thus empowering the vulnerable in particular.

29. Mexico, for example, is creating its first regional hydrometeorological centre in south-eastern Mexico with the aim of bringing together hydrologists and meteorologists to work on early warning systems at a regional scale.

## C. Assessment of climate change impacts on water resources and on related sectors and ecosystems

### 1. Vulnerability and the impacts of climate change on water resources and on related sectors and ecosystems

30. Vulnerability and the impacts of climate change on water resources are manifested through the following:

(a) Increasing temperatures and inter-annual changes in precipitation resulting in changed run-off and flood regimes and triggering slow onset events, such as desertification, sea level rise, salinization of freshwater resources and melting of glaciers;

(b) Increased intensification of extreme events, such as an increased frequency and severity of storms and floods, an increased risk of glacial lake outburst floods (GLOFs) and a lack of physical capacity to manage or attend to the risks associated with these events;

(c) Variability and uncertainty in water availability, for example owing to shifts in seasonality, increasing variability of rainfall both during and outside of expected rainy seasons, less snow in winter, and water deficit impacts on related sectors and ecosystems resulting from drought and the drying up of natural springs and water resources.

[9] More information is available at <www.imn.ac.cr>.
[10] More information is available at <www.climate.gov>.
[11] More information is available at <http://www.wmo.int/gcos>.
[12] More information is available at <http://www.wmo.int/gfcs>.

31. The participants shared examples demonstrating the multidimensional aspects of water resources affecting lives and livelihoods in their countries and the significance of climate change impacts in this context. Climate change impacts on water resources and on related sectors and ecosystems could include, inter alia, the following: increased scarcity of surface water and diminishing levels of water tables, leading to loss of cultivable lands and pastures and a reduction in agricultural yield; increased incidence of forest fires, leading to habitat loss for wildlife and productive lands for livestock; an increase in waterborne diseases, such as cholera, and other health impacts; population displacement and loss of livelihoods; aggravation of conflict in transboundary river basins; and impacts on infrastructure and transportation.

32. Subsequent impacts on sectors such as food, energy, biodiversity and health security at multiple levels have exacerbated stress between the competing needs of people and have had an associated economic consequence. In Haiti, vulnerability of water resources owing to increased agricultural demand is further amplified by the impacts of climate change. Gonaïves and Cap-Haïtien in Haiti are projected to experience a deficit in water resources that would translate into a higher pressure on water reserves.

### 2. Tools and methods for assessing climate change impacts and assessment results

33. The participants shared several examples of tools and methods for assessing climate change impacts on water resources and ecosystems at various levels, including assessment results. Many of the assessments discussed are still under way, and some results are preliminary. Nonetheless, the participants were able to identify lessons learned and good practices that can be applied across other regions.

34. A comparative assessment of the vulnerability and resilience of 10 river deltas offered an example for understanding the current and future state of deltas at the global scale. The 10 deltas in question were the Mekong, Ganges–Brahmaputra–Meghna, Ciliwung, Yangtze, Rhine–Meuse, Nile, Danube, California Bay, Mississippi and Incomati deltas. The assessment used the drivers–pressure–state–impact–response and the spatial layers approaches. The scenarios used were downscaled to different deltas in order to identify how the delta would score in the future with regard to vulnerability and resilience to climate change. The assessment results varied across the deltas, but some general results indicated the following:

(a) An imbalance between demand and supply with regard to land and water use;

(b) Inadequate or ageing infrastructure in the deltas;

(c) Disruption to the natural delta processes;

(d) Inadequate governance to address problems and implement solutions;

(e) Challenge in defining a comprehensive (multisectoral) delta plan;

(f) Potential for collaboration across deltas.[13]

35. HydroBAT, a basin-level assessment model, was presented that comprise three elements: Evaluate (elevation, gradients, water resources distribution, connectivity and population distribution), Analyze (aquatic classification, ecosystem services, connectivity analyses and climate vulnerability) and Visualize (visualization of basin and analysis of data).

36. Flowing Forward was another tool highlighted that integrates and organizes information from a variety of other tools and methodologies. Appropriate at the landscape and watershed level, this framework approach combines participatory approaches with desk

[13] More information is available at <www.delta-alliance.org>.

studies and scientific analyses and looks both at communities and at the environment. Since it is not restricted to data-heavy analysis, this tool could be also used in data-poor regions.[14]

37. Some examples of assessing the vulnerabilities of glaciers, water resources and mountain ecosystems include a regional flood information system in the Hindu Kush–Himalaya region established by the International Center for Integrated Mountain Development (ICIMOD), glacial lake mapping and GLOF risk assessment.

38. The Himalayan Climate Change Adaptation Programme (HICAP), a collaboration programme involving the Center for International Climate and Environmental Research – Oslo, ICIMOD and the United Nations Environment Programme GRID-Arendal undertaken in the Hindu Kush–Himalayas, aims at enhancing the resilience of mountain communities, particularly women, through improved understanding of vulnerabilities, opportunities and potentials for adaptation. HICAP aims to generate knowledge of climate change impacts on natural resources, ecosystem services and the communities dependent on them and to contribute to the implementation of policy and practice for enhanced adaptation based on scientific and evidence-based knowledge in the Hindu Kush–Himalayas.[15]

39. Joint transboundary analysis for countries is important in terms of the sharing of data, models and experiences, and for the joint development of policies and measures to develop coping strategies.

### 3. Incorporating local knowledge and gender perspectives

40. Traditional and indigenous knowledge and coping strategies handed down from generation to generation are important, albeit often insufficient in the face of the increasing pace of climate change and variability, to understanding both climate change impacts on water resources and how to adapt to extreme events. This knowledge should be tapped into in order to inform and calibrate modern assessment tools and methods.

41. Community perceptions of climate variability and climate change and changes in ecosystem indicators such as flora and fauna are important for better understanding climate change impacts at the local level. Indigenous and traditional knowledge can often validate local indicators of change observed at the regional level using observational systems. It was noted that wide disparities exist in the means of understanding, integrating and deploying local and scientific knowledge between communities and across national boundaries.

42. There is a need to combine climate science and community knowledge (e.g. comparing local perceptions with observational data) and to integrate a gender dimension into the community climate change assessment tools.

43. In mountainous areas, local knowledge is important for capturing differences in impacts owing to spatial variation (such as irregular terrain).

44. The health sector provides a very good example of how traditional and indigenous knowledge has been used to inform modern science and public health policy.

45. The participants suggested the following ideas of how to integrate local knowledge to better inform assessments of the impact on water resources owing to climate change:

(a) Map, catalogue (e.g. in a database) and disseminate good practices of local knowledge in relevant sectors and in different languages;

(b) Integrate local knowledge into early warning systems.

[14] More information on this tool is available at <http://www.flowingforward.org/>.
[15] More information on HICAP is available at <http://www.icimod.org/?q=7277>.

## D. Adaptation planning and practices related to water resources at different levels

### 1. Integrated approaches

46. Given the cross-cutting nature of water resources, a holistic management approach was proposed as essential. Participants presented and discussed IWRM, which is a useful framework through which countries can incorporate climate change impacts and vulnerabilities and introduce adaptation strategies. IWRM is described as a process that promotes the coordinated development and management of water, land and related resources in order to maximize economic benefits and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment.[16] IWRM provides an important framework to achieve adaptation measures across socioeconomic, environmental and administrative systems; to be effective, integrated approaches must occur at appropriate scales.[17]

47. Sustainable river basin management is essential to strengthen equitable economic development, food security, climate resilience and protection of the environment.

48. Ecosystem-based approaches to adaptation were presented as another example of building adaptation solutions for water resources management. These approaches involve the services that biodiversity and ecosystems provide as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change. Such approaches to adaptation "use the range of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change."[18] An example given by the International Union for Conservation of Nature on an ecosystem-based adaptation strategy in the Sixaola river basin described how it aims to reduce the vulnerability of livelihoods affected by intense rain and recurrent floods at the transboundary level.

### 2. Community-based and indigenous approaches

49. A community-based adaptation initiative undertaken in Bangladesh involved establishing safe drinking water systems and security for the poor and women in five climate vulnerable zones (Rajshahi, Gaibandha, Gopalganj, Bagerhat and Rangamati). Key approaches in this community-based initiative included the following:

(a) A community-led process based on community perceptions, priorities and needs (e.g. community mapping, a baseline and participatory vulnerability assessment, and a participatory needs assessment);

(b) Incorporating climate change information, including consideration of local and scientific knowledge and information;

(c) Enhancing local knowledge and capacity to plan for and adapt to climate change impacts (e.g. social mobilization and local institution building for the poor and women, promoting a gender role in water, sanitation and health, capacity-building, linkages and networking).

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[16] Global Water Partnership Technical Advisory Committee. 2000. *Integrated Water Resources Management*. Background paper No. 4. Stockholm: Global Water Partnership.

[17] Bates B, Kundzewicz Z, Wu S and Palutikof J (eds.). 2008. *Climate Change and Water*. Intergovernmental Panel on Climate Change (IPCC) technical paper VI. Geneva: IPCC Secretariat.

[18] Convention on Biological Diversity. *Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change.* Technical series No. 41. Montreal: Convention on Biological Diversity.

50. In order to adapt to a decrease in the average annual rainfall, rapid water run-off and ecosystem degradation in Landou village, located on the foothills of Ndiass in Senegal, some useful indigenous water resources management practices have been put into place, including the following:

(a) The construction of stone bunds to slow the speed of surface run-off and to facilitate recharging of the water table;

(b) Digging open trenches to slow the speed of run-off, which fosters infiltration and recharging of the water table and enables the collection of water for horticulture and fruit arboriculture;

(c) Digging a hole at the foot of a tree, or a little behind, depending on the topography, to collect water run-off, to reduce heat and promote tree growth.

### 3. National approaches

51. Mexico's national strategy for water resources and climate change has three targets: to systematically improve the knowledge of climate change and its impacts; to reduce other non-climate stressors; and to strengthen the resilience of aquatic ecosystems and environmental services.

52. The creation of water reserves is another example of national to basin-level adaptation implemented in Mexico by the World Wildlife Fund in partnership with CONAGUA and the Inter-American Development Bank, which targets the natural flow regime of 189 sub-basins throughout the country.[19] Water reserves offer multiple benefits, including preventing over-allocation of water resources, reducing the vulnerability of water resources and increasing the adaptive capacity of both people and nature.

53. Examples of national adaptation programme of action projects from Burkina Faso include anti-erosion works such as bank protection of watercourses and revegetation in north-central Burkina Faso and sand dune fixation in the Burkina Sahel, which has helped to improve water infiltration and contributes to restoration of the water table, restoring soil fertility and improving crop yields.

### 4. Transboundary approaches

54. The United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention), in effect since 1996, enables more effective and efficient transboundary adaptation through a wider knowledge base.[20] The UNECE guidance on water and adaptation to climate change was presented as a unique tool that provides advice to decision makers and water managers on how to assess the impacts of climate change on water quantity and quality, how to perform risk assessment, including health risks, how to gauge vulnerability, and how to design and implement appropriate adaptation strategies based on the concept of IWRM.

55. Some preliminary lessons learned from pilot UNECE projects in transboundary river basins include the following:

(a) Climate change impact assessments are done nationally in most basins, but often use different methodologies;

[19] More information on water reserves in Mexico is available at <www.wwf.org.mx/water-reserves>.

[20] The Water Convention has been ratified by 38 Parties. More information on the UNECE is available at <www.unece.org/env/water/>.

(b) Joint scenarios, modelling and vulnerability assessments are important in transboundary contexts; however, the extent of harmonization depends on resources and the availability of time;

(c) A thorough baseline study is essential to identify completed or ongoing projects;

(d) Relevant stakeholders, including the general public, need to be involved in transboundary river basin management;

(e) Joint working groups and regular meetings are useful mechanisms to facilitate dialogues between policymakers and technical experts;

(f) Institutional and cultural differences in the transboundary context can be overcome through a facilitated focus on common interests, expert cooperation, etc.

56. Flood risk management responses in the Rhine–Meuse floodplain include unbreachable dykes and better management of new development in this transboundary delta. A 200 km delta dyke, for example, reduces flood risks by 50 per cent.

## 5. Policy instruments and monitoring and evaluation approaches

57. Failure to consider the policy context can constrain or undermine adaptation or result in maladaptation. Scaled-up funding for adaptation could provide the means to invest in improving the policy framework, including in terms of helping to ensure that adaptation investments are well spent.

58. In order to facilitate timely and cost-effective adaptation, the following options could be considered:

(a) Exploit 'no regrets' and 'low regrets' options (e.g. prioritize the options viable under all plausible futures);

(b) Identify and facilitate low-cost and flexible (possibly reversible) options (e.g. consider the full range of options early in the planning/project cycle);

(c) Consider the expected costs and benefits;

(d) Minimize timing error (e.g. adopt a flexible or real options approach to capital investments for permanent/semi-permanent infrastructure with long lead times, such as flood defences);

(e) Promote risk reduction and equitable risk sharing by assessing and managing climate risks, reducing or removing barriers to internalize climate risks and addressing the risk implications of water policies.

59. Table 2 presents some policy instruments for adapting water systems to climate change.[21] For example, ecosystem-based adaptation often offers a more flexible, less capital-intensive and more easily reversible option than building infrastructure. However, this approach does require a thorough understanding and assessment of the value of ecosystem services and requires adequate institutional capacity to establish, monitor and enforce them. Insurance schemes are another set of policy instruments that provide incentives for adaptation and for reducing risk exposure and vulnerability (through a price signal) by efficiently spreading risk and by providing compensation in the event of extreme events and providing finance to restore depleted capital.

[21] More information is available at <www.oecd.org/water>.

Table 2
**Overview of some policy instruments for adapting water systems to climate change**

| *Select policy instruments* | *Regulatory* | *Economic* | *Information-based* |
|---|---|---|---|
| Risk of water shortage (including drought) | Restriction on water use (e.g. hosepipe ban)<br>Administrative allocation of water | Water pricing<br>Water trading<br>Abstraction taxes, charges<br>Dry-year options<br>Payments for ecosystem services (PES)<br>Insurance schemes, Microfinance schemes | Information and awareness campaigns to promote water saving |
| Risk of inadequate quality | Water quality standards<br>Pollution discharge permits | Pollution taxes, charges<br>Tradeable pollution permits<br>PES | Information and awareness campaigns<br>Technical assistance for improved farming techniques |
| Risk of excess (including flood) | Land-use planning/zoning restrictions<br>Building codes/standards | Insurance schemes<br>Public–private partnerships (e.g. for flood defence structures)<br>PES<br>Microfinance schemes | Flood risk mapping<br>Early warning systems |

*Source*: Organisation for Economic Co-operation and Development. Forthcoming. *Adapting Water Systems to Climate Change: Economic Instruments and Financing Mechanisms*.

60. A recent survey by the Organisation for Economic Co-operation and Development (OECD) revealed that the results-based management and logical framework approach is the most common monitoring and evaluation approach across the six development cooperation agencies. The findings of the survey include the following: setting baselines and targets may require a more systematic use of climate projections; the timing of monitoring and evaluation must be revised to 20 years or more, although at present most evaluations occur 5–10 years after project completion; and most agencies use a combination of process and impact indicators.

## E. Communication, stakeholder engagement, knowledge-sharing and management

61. Presentations and interactive discussions led to an exchange of examples and lessons learned with regard to communication, stakeholder engagement, knowledge-sharing and management to enhance the climate resilience of water resources.

62. The European Union water framework directive calls for the public to be informed of and involved in the preparation of river basin management plans.[22] Public participation

[22] <http://ec.europa.eu/environment/water/water-framework/index_en.html>.

includes non-governmental organizations representing water users, such as local and national environmental groups, and other stakeholders, such as key organizations and citizens' groups. Participatory methods presented by experts from 15 member States, including representatives of non-governmental organizations, local governments, the water industry and the agricultural sector, and policymakers, were studied and a handbook based on examples of best practice to improve participation in water management was published.[23]

63. The ClimDev Africa programme is based on building solid science and observational infrastructure in order to enable strong working partnerships between government institutions, the private sector, civil society and vulnerable communities and the creation and strengthening of knowledge frameworks to support and integrate the actions required. The African Climate Policy Centre (ACPC), a component organ of the ClimDev Africa programme, focuses on the development of climate policy through knowledge generation, advocacy and advisory services. The ACPC interfaces with stakeholders at multiple levels, from policymakers to researchers and practitioners.

64. Another collaborative example of stakeholder engagement is UN-Water, which is the United Nations coordination mechanism for all freshwater-related issues. Involving 30 UN-Water members and 25 UN-Water partners, its strategic objectives are the following: to bring further coherence among its members and partners; to play a major role in ensuring that water is included in global policy debates; and to support its members and partners at all levels, with a particular focus at the country level. Of the other thematic priority areas under UN-Water, the thematic priority area on water and climate change is central to strengthening United Nations system coordination on activities related to water and climate change.[24]

65. One way of sharing knowledge with the target audience could include the production of policy briefs for policymakers. One such example is the six themed policy briefs distilling key messages on strategic frameworks for water security and climate-resilient development implemented by the African Ministers' Council on Water. The strategic framework for water security and climate-resilient development provides guidance on the development of 'no regrets' and 'low regrets' investments and financing strategies for water security and climate-resilient development and on their integration into development planning processes.[25]

# IV. Possible next steps

## A. Summary of recommendations

66. Based on the presentations and discussions at the workshop, participants identified a range of priority activities to be undertaken in order to advance work on water resources, climate change impacts and adaptation strategies.

[23] Further information on the handbook is available at <http://www.harmonicop.uos.de/handbook.php>.

[24] More information on UN-Water is available at <www.unwater.org>.

[25] More information on the strategic framework for water security and climate-resilient development is available at <http://www.gwp.org/Global/About%20GWP/Publications/CDKN%20publications/SF_WaterSecurity_FINAL.pdf>.

### 1. Observational data and their interpretation for understanding climate change impacts on water resources

67. **High-quality observations** are essential. For example, the need for more accurate observational data to better assess the impacts of climate change in the Nile basin was demonstrated.

68. It is essential to identify which **types of data** are needed and with what **level of precision** for assessing the impacts of climate change on water resources. Awareness about the types of data and data availability and needs is essential at all levels. In situ, non-satellite remote sensing and satellite observations provide complementary hydrometeorological data. In addition to hydrometeorological data, there is also a need to include data that come from other global change drivers and to determine the data uncertainty.

69. **International standards for data monitoring and collection** should be established at the international level. In practice, however, countries use different standards, therefore there is a need for harmonization of data collection and monitoring. There is a significant difference in data observation and data management between developed and developing countries.

70. **Investment in the appropriate coverage of monitoring systems** at different scales is necessary and mechanisms need to be established for filling data gaps in data scarce areas with advanced tools where needed.

71. There are wide disparities in infrastructural, technical and institutional capacities to provide high-quality climate services, particularly in developing countries, exacerbated by a lack of capacity sharing. Therefore, it is crucial to **enhance international cooperation** in terms of enhancing such capacities in regions where there is a gap in order to establish national data information systems and to find the most appropriate international funding mechanism to enable developing countries to comply with established procedures for data collection and management and to reinforce capacity-building in data management through North–South, South–South and triangular cooperation. It is equally important for developing countries to invest in delivering high-quality climate services.

72. Participants expressed a need to **establish synergies between different networks, as well as between international conventions and mechanisms** (e.g. the UNFCCC, UNECE, GCOS and GFCS), research and scientific institutions (e.g. the United States Geological Survey), universities, the private sector, bilateral cooperation and river basin commissions, with respect to sharing data and relevant information. The European Climate Adaptation Platform (CLIMATE-ADAPT), for example, provides a web-based platform for sharing adaptation practices and data, involving all 27 European Union countries.[26]

73. Some participants mentioned the **potential role of regional centres and organizations** (e.g. the Caribbean Community Climate Change Centre, ACPC, the Ibero-American Network of Climate Change Offices (RIOCC) and ICIMOD) in fostering such cooperation. It was, however, also noted that the tasks for regional centres and organizations need to be defined and that governments need to be informed of these tasks.

74. It is crucial to enhance the **establishment of data information systems** through data platforms, clearing houses and metadatabases on observational data.

75. **Improved and multiple modelling techniques** should lead to data collection consolidation, interpretation and dissemination.

[26] Further information on CLIMATE-ADAPT is available at <http://climate-adapt.eea.europa.eu/web/guest/home>.

### 2. Assessment of climate change impacts on water resources

76. **Non-climatic drivers** should be taken into account in conjunction with climate change in order to understand the impacts of climate change on water resources.

77. **Sociocultural impacts** need to be incorporated when assessing the vulnerability of water resources.

78. **Local knowledge and coping strategies** are useful and relevant for assessing the vulnerability of water resources. However, they do not take full consideration of climate change and hence need to be systematized and complimented by climate science.

79. **Ecosystem and gender considerations** need to be integrated into tools and methodologies for assessing climate change impacts on water resources.

80. **Transboundary water cooperation** needs to integrate an understanding of the vulnerabilities of both upstream and downstream water user communities.

81. **Addressing issues surrounding water and climate change impacts in the context of the UNFCCC process** is a useful step for their inclusion into policy considerations. Local knowledge, gender considerations and climate science need to inform policymakers.

### 3. Adaptation planning and practices at the local, national and transboundary levels

82. Participants stressed that 'water adaptation' provides challenges and opportunities in various sectors. As climate-related impacts on water resources vary according to the ecosystem, local context and social stressors, there is no one size fits all approach. Adaptation requires striking an iterative balance between short-term priorities and long-term gains, which is often a challenge. Participants shared a number of examples of good adaptation planning and practices at the local, national and transboundary levels, including gaps and needs for further actions.

83. Participants identified the following elements central to facilitating effective adaptation action related to water resources at different levels:

(a) **Gender sensitive strategies** need to be integrated into all sectors, not just water resources, and performance-based national-level gender indicators need to be integrated into development and adaptation programmes. Gender perspectives could be most effectively integrated into adaptation practices by gender-balanced participation in the planning and design process, for example involving women throughout, and by empowering and educating women and girls;

(b) A design methodology (e.g. using ecosystem-based adaptation or community-based approaches) was recommended to capture and leverage **indigenous and traditional knowledge and practices**. The design of an integrated and inclusive consultative process with local communities will help to incorporate such indigenous technologies and traditional know-how into building water management plans, policy and strategies;

(c) Understanding **social dimensions** is very important to fully understanding the vulnerability of water resources and related impacts on lives and livelihoods. Sociocultural norms affect people's adaptive behaviour and, despite being deeply rooted, can shift over time in response to changing needs;

(d) **Livelihood diversification** emerged as a central adaptation strategy, but support through networked institutions and integration in policy considerations is needed to ensure the required concomitant sustainability of water availability as different livelihoods have different water requirements;

(e) **Effective governance and integrated planning** that take into account climate risk, water-use efficiency, infrastructure development and socioeconomic conditions contributes to enhancing water and food security and to disaster management. Integrated water planning is also important over the short and long term and should be carried out across sectors. Water adaptation requires good spatial planning in both urban and rural areas, including good land-use planning and wise infrastructure investments;

(f) **Policy deficit analysis** involving assessment of current water-relevant adaptation policies and aspects concerning sustainable water management, and addressing long-term impacts to ensure coherence and prioritizing adaptation actions at the national level, is important;

(g) Performing a **potential economic analysis** in terms of the costs and benefits related to adaptation needs and actions is useful for demonstrating the value of adaptation needs to policymakers.

84. Participants identified **a bottom-up approach and trust-building between communities and policymakers** as necessary in order to establish common goals to facilitate adaptation actions at the community/subnational level.

85. Some useful lessons learned shared by participants to facilitate adaptation actions at the national level include the following:

(a) There is a need for **interministerial coordination and cooperation** to provide a useful institutional foundation at the national level for linking policies and practices;

(b) **A climate-resilient framework** (e.g. for water reserves in Mexico) helps enable subnational and local institutions to plan, implement and sustain adaptation-related projects;

(c) There is an urgent need for **policy considerations** on climate change impacts on water resources and adaptation strategies in the **UNFCCC process**.

86. Participants identified several ways to facilitate effective planning and implementation of adaptation actions at the transboundary and regional levels:

(a) Participants proposed establishing **basin and region-wide databases and frameworks**, such as the European Water Archive, the Shared Environmental Information System (developed by the European Environment Agency) and GFCS, to address gaps such as lack of and/or inadequate data-sharing between countries, insufficient data availability, lack of joint data management, inadequacy of networks of monitoring stations and insufficient data capture/storage;

(b) Participants called for **further research on extreme events and longer-term climate change and their transboundary dimensions** to raise awareness on the need for transboundary cooperation in adaptation. Disasters with transboundary and/or subregional/regional impacts, such as transboundary floods, demonstrate the need for international cooperation in adaptation. It is also important to raise the awareness of local communities;

(c) There is a need for **enhanced international cooperation** with regard to facilitating financial and technical resources, as well as capacity-building for developing countries in addressing climate change impacts on water resources. Regional organizations and the private sector could be further engaged in supporting the implementation of transboundary and regional adaptation actions;

(d) Since there is a lack of agreement on priorities for adaptation among different riparian countries and also a lack of coordination mechanisms and institutions that could

deal with transboundary cooperation in adaptation (e.g. river basin commissions are not present in many transboundary basins, and, even where they are, differ widely in their ability to influence national and international decision-making), participants stressed the importance of **ensuring synergy between adaptation strategies developed at different levels**;

(e) **International obligations and conventions** such as the Convention on the Law of the Non-navigational Uses of International Watercourses and the Water Convention could help facilitate transboundary cooperation.

#### 4. Communication, stakeholder engagement, knowledge-sharing and management

87. **Knowledge-sharing and brokering** through effective stakeholder engagement using good communications strategies was seen as instrumental to reduce the knowledge gap. However, owing to the diversity of capacities and understandings among groups of stakeholders, different types of communication tool are needed. For example, engaging local communities through different forms of dialogue is often effective.

88. A recommendation was made and supported for a **water and adaptation helpdesk** to be accessible globally to a wide variety of stakeholders in order to facilitate information and knowledge sharing at different levels when information and knowledge on issues relating to water, climate change impacts and adaptation are often stuck in national and institutional silos.

89. **Engagement of all interested and relevant stakeholders** should start at an early stage of project cycle and policy formulation and enough time should be allowed for decision-making. Multi-stakeholder advisory committees (e.g. as in Maldives) and interministerial committees on climate change or other types of climate change committees at the national level (e.g. in Mexico, Brazil and Zambia) are useful examples to follow.

## B. Issues for follow-up and further consideration in the context of the Nairobi work programme

90. The areas of work mentioned below can be undertaken in order to address needs and gaps as well as to build on lessons learned as articulated during the workshop. They could also be utilized by Parties to inform their discussions on future work areas of the Nairobi work programme as per the mandate referred to in paragraph 3 above.

91. Participants shared their thinking on ways to further advance the discourse on water, climate change and adaptation in the context of the Nairobi work programme and proposed a set of activities to be undertaken under the programme, as outlined below.

92. With regard to potential future work areas of the Nairobi work programme, **water** was proposed as **a thematic work area**, with account to be taken of the current water-related work undertaken by other organizations.

93. As an **information and knowledge broker**, the Nairobi work programme could serve as a mechanism to match the supply and demand needs of developing country Parties, adaptation experts, practitioners and policymakers. The value added of the Nairobi work programme will lie in its potential to also consider cross-sectoral approaches or other sectoral themes, such as agriculture and ecosystem-based approaches. This will be useful to ensure synergy across various themes.

94. With regard to functioning as a '**platform of platforms**', several participants promoted the notion of the Nairobi work programme developing an overarching superstructure to identify and coordinate several aspects of work in relation both to water,

climate change impacts and adaptation and on climate-resilient development issues more generally. Under this heading, the participants proposed that the Nairobi work programme should:

(a) Exchange good practices from multiple levels, in particular those that have the potential to be scaled up and that are science- and evidence-based;

(b) Exchange experience on transboundary and regional cooperation in adaptation;

(c) Include a water and adaptation helpdesk to facilitate information sharing at multiple levels.

95. In terms of **stakeholder engagement**, participants mentioned the value added of the Nairobi work programme in engaging multiple stakeholders, in particular strengthening its engagement with regional networks and centres and national focal points. Taking a holistic approach, the Nairobi work programme could interface with scientific communities, water experts (practitioners and universities engaged in adaptation work and disaster risk reduction communities) and development communities to inform relevant policy processes and facilitate the implementation of adaptation actions on the ground.

96. In terms of **capacity-building** and **awareness-raising**, participants proposed that the Nairobi work programme could build awareness of the value of undertaking economic analyses, demonstrating the economic impacts of climate change and adaptation actions (i.e. the costs and benefits of adaptation options and the costs of non-action), using a variety of communication tools and could disseminate the results of such undertakings to diverse groups of stakeholders, including policymakers.

97. The Nairobi work programme could also help to **foster international cooperation** with regard to both financial and technical resources, as well as **capacity-building** for developing countries, including South–South capacity-building, in addressing climate change impacts on water resources.

98. Participants also identified the role of the Nairobi work programme in **providing relevant scientific and technical advice to relevant processes under the Convention**, such as national adaptation plans and climate finance (e.g. recommendations for considering climate finance for transboundary adaptation projects).

99. **Monitoring and evaluation,** in particular identifying and disseminating relevant strategies and methodologies, was seen as another potential cross-cutting area for the Nairobi work programme in its mission to provide high-quality information and knowledge to better understand impacts and vulnerability to climate change and to catalyse action on adaptation.