Global Water Partnership

NATIONAL ADAPTATION PLAN PROCESS

Water Supplement to the Technical Guidelines Draftfinal (Apr 2015)

Supporting the national adaptation plan (NAP) process

Supplement to the Technical Guidelines for the national adaptation plan (NAP) process

The Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) established the national adaptation plan (NAP) process with the following agreed objectives[1] :

a) To reduce vulnerability to the impacts of climate change, by building adaptive capacity and resilience;
b) To facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.

Technical Guidelines for the NAP Process (Least Developed Countries Expert Group, 2012a) have been issued by the Least Developed Countries Expert Group (LEG), as part of the UNFCCC process, to provide technical guidance on the undertaking the NAP process. The Technical Guidelines are not specific to any one sector or sectors and supplementary materials were foreseen to give greater in-depth coverage of methods and approaches for adaptation planning in key sectoral and thematic issues.

The Water Supplement is intended for use by those leading the NAP process at a national level, by water planners and managers responsible for addressing adaptation in water resource management and key water use sectors, and by those who provide support to countries to achieve a coherent and strategic response to adaptation planning.

The Water Supplement does not seek to duplicate the Technical Guidelines rather it expands on elements and steps within the NAP process that have greatest relevance and specificity to water. It provides supporting material that focusses on the technical aspects of water and adaptation planning.

The Water Supplement is not, and indeed should not be, prescriptive. NAPs are developed in a way that seeks to enhance the coherence of adaptation and development planning within countries, rather than duplicating efforts undertaken or underway, to harness and build upon national-level processes and capacity.

[1] Decision 5/CP.17, paragraph 1.

Foreword

[To be inserted]

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B.5 Integrating climate change adaptation into national and subnational development and sectoral planning

Water in national adaptation plans

In order to build resilience to a changing climate, countries are now considering medium- to long-term planning through the national adaptation plan (NAP) process within the framework of national priorities for low emissions, climate resilient development and increased water security to sustain growth and poverty reduction.

NAPs can be instrumental in facilitating an in-country process for different sectors and their climate change adaptation strategies to become more integrated in national planning processes as well as to better integrate climate change in sectoral planning strategies and programmes.

Appropriate inclusion of water in the NAP process requires facilitating the engagement of different sectors' actors in the process, providing them with further insights into the elements of the NAP process, and highlighting methods and approaches to identify potential strategies and actions in the water sector.

The NAP process

The NAP process was formally established in 2010 at the 16th session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC)[2]. Consequently, a process was initiated to enable least developed countries (LDCs) and other developing countries to formulate and implement NAPs as a mean to address adaptation. The objectives[3] of the national adaptation plan process are:

- to reduce vulnerability to the impacts of climate change, by building adaptive capacity and resilience; and
- to facilitate the integration of climate change adaptation, in a coherent manner, into new and existing policies, programs and activities, in particular development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.

Guiding principles for the NAP process

The core principles of the NAP process include:

- Continuous planning process at the national level with iterative updates and outputs
- Country-owned, country-driven
- Not prescriptive, but flexible and based on country needs
- Building on and not duplicating existing adaptation efforts
- Participatory and transparent
- Enhancing coherence of adaptation and development planning
- Supported by comprehensive monitoring and review
- Considering vulnerable groups, communities and ecosystems
- Guided by best available science
- Taking into consideration traditional and indigenous knowledge
- Gender-sensitive

[2] Decision 1/CP.16
[3] Decision 5/CP.17, paragraph 1.

Supplementing the NAP Technical Guidelines

The UNFCCC LDC Expert Group (LEG) has prepared Technical Guidelines for the NAP process[4]. These provide an overall approach that can help countries identify and implement the adaptation measures that help respond to the effects of climate change. These NAPs guidelines are framed around the four elements of the NAP process:

- **Element A** focuses on how to lay the groundwork at country level for the NAPs process: this includes the participatory assessment of development needs, climate vulnerabilities and individual, organizational and institutional capacity needs. Its main objective is to ensure the development of a national mandate and strategy for the NAP process and to facilitate the appropriate involvement of relevant actors in the process.

- **Element B** proposes actions to be taken into consideration when doing in-depth impact, vulnerability and adaptation assessments. It presents the various options that all stakeholders involved in the different sectors could consider when involved in the preparation of a NAP.

- **Element C** is concerned with the design of implementation strategies of the national adaptation plans. The main output is a strategy for implementing the NAPs. Implementation would build on existing activities to the extent possible and the integration activities within national planning.

- **Element D** focuses on how to monitor the NAP development process, the progress of adaptation measures and the overall NAP process, from the design stage to the implementation on the ground. It would inform regular updates of the NAPs, and lessons learned would be integrated into subsequent actions of the NAP process.

The Water Supplement provides supplementary guidance on Element B of the NAP Technical Guidelines. This element focuses on the following actions in the NAP process:

1. Analysing current climate and future climate change scenarios;
2. Assessing climate vulnerabilities and identifying adaptation options at sector, subnational, national and other appropriate levels;
3. Reviewing and appraising adaptation options;
4. Compiling and communicating national adaptation plans;
5. Integrating climate change adaptation into national and subnational development and sectoral planning.

[4] http://unfccc.int/7279

About the Water Supplement

Aims and objectives

The overall aim of the Water Supplement is to strengthen the water sectors' contribution to, and coherence within, the NAP process. Specific objectives are:

- to facilitate the consideration and integration of water security and water concerns and perspectives into the NAP process;
- to enable water stakeholders to better identify and understand the issues at stake in a mid/long term perspective and to empower them to participate efficiently in the process; and
- to provide elements for non-water specialists to understand what are the issues at stake.

The Water Supplement applies a 'water lens' to the steps within the NAP process and provides guidance on interpreting the key questions and facilitating the engagement of water sector stakeholders in the process. It aims to strengthen the in-country process for integrating water sector strategies in the NAP planning process as well as to better incorporate climate change in sectoral planning strategies and programmes.

Target users

The Water Supplement is intended for use by water planners and managers responsible for addressing adaptation in water resource management and key water use sectors. It is also of interest to those leading the NAP process at a national level, and by those who provide support to countries to achieve a coherent and strategic response to adaptation planning.

Focus of the Water Supplement

The Water Supplement does not seek to duplicate the Technical Guidelines for the national adaptation plan process, developed by the UNFCCC LEG, rather it expands on steps within the NAP process that have greatest relevance and specificity to water. The focus is on Element B of the NAP Technical Guidelines referred to as the 'Preparatory Elements' in the NAP process. Preceding steps in the NAP process will have focused toward activities in the inception phase of the NAP process including: identifying the state of knowledge and capacity, and ensuring that a country has all the tools and means necessary to embark on the national adaptation planning cycle.

During the execution of the second element, Element B, countries are encouraged to conduct an in-depth impact, vulnerability and adaptation assessment. It is anticipated to involve all sector stakeholders in preparing a NAP that builds on, and is commensurate with, sectoral plans and strategies. During this process, capacity for integrating climate change adaptation into national and sectoral planning, as well as at other levels, would continue to be developed and enhanced. The main outputs anticipated include a climate risk analysis, vulnerability and adaptation assessments, plans at different subnational levels or sectors, and an appraisal of adaptation options, to be duly approved, endorsed and integrated into a national NAP process. Subsequent elements of the NAP process will address design of implementation strategies of the national adaptation plans, and reporting, monitoring and review of the NAP process itself.

Using the Water Supplement

Aligning with the Technical Guidelines for the NAP process (pp24-25), the key questions water planners and managers may address in Element B are given below. The Water Supplement is structured according to these key questions thereby directly cross referencing already identified steps in Element B. A chapter is dedicated to each of the five steps and individual sub-sections address each of the key questions. The content helps to guide users on how to address the key questions from a water sector perspective. The Water supplement highlights good practice, draws on case examples, and signposts key references and other materials to support implementation.

Steps	Key questions
B.1 Analysing current climate and future climate change scenarios	• Which climatic patterns are most important in terms of adaptation? • What risks does climate change hold for the water sector and sub-sectors? • What are major current water-related climate hazards? • What is the estimated range of uncertainty for possible future climate scenarios? • What are appropriate indices of climate trends which could support water sector planning and decision making?
B.2 Assessing climate vulnerabilities and identifying adaptation options at sector, subnational, national and other appropriate levels	• Which systems, regions, or groups work towards key development goals? • What are the main climate vulnerabilities of those systems/regions that are key to achieve the main development goals? • What are the expected impacts of climate change on water security? • What are viable cost-effective adaptation options to reduce the impacts of climate change or to exploit opportunities?
B.3 Reviewing and appraising adaptation options	• What are the costs and benefits of water sector adaptation options? • How best can the water sector adaptation options be implemented, and what are the conditions for success? • Is it possible to identify co-benefits between the water sector adaptation options and development?
B.4 Compiling and communicating national adaptation plans	• How will priority water sector adaptation options be aggregated into national adaptation plans? • How will inputs of relevant water sector stakeholders be incorporated into producing the national plans? • How can the national adaptation plans and related outputs best be communicated and disseminated at the national level?
B.5 Integrating climate change adaptation into national and subnational development and sectoral planning	a. How can adaptation in the water sector best be integrated into ongoing development planning processes? b. What kind of opportunities can be generated through the integration? c. How can the process of integration be facilitated?

Considerations for engagement in the NAP process

Consideration of adaptation in the NAP process needs to emphasise the central importance of water in the achievement of economic, social and environmental development. Adaptation is largely about adjusting the way development is undertaken by building resilience, safeguarding outcomes against uncertain climate risks, and capitalising on any potential opportunities that a changing climate may bring. The characteristics that differentiate water within the context of adaptation planning include:

Water as a cross-cutting issue and the various sectors and sub-sectors are extremely diverse, including in the way they will be impacted by climate change and their potential to adapt. Approaches to adaptation need to integrate programmes for managing water resources with strategies to promote sustainable production practices across water use sectors, and to align these with broader national policies for poverty reduction, social and economic development, health improvement, and disaster risk reduction. Sustaining development outcomes is heavily dependent on ensuring all sectors and sub-sectors (e.g. agriculture, energy, health and others) care for water, and make sustainable water management a key driver within their own sectoral adaptation activities

Water as a transboundary resource extends beyond national boundaries and into regional development agendas and goals. The international dimensions of water and adaptation will therefore require dialogue between riparian countries in transboundary basins, and coordination on their respective NAP processes and adaptation responses.

Implementing sustainable and integrated water resources management is important for adaptation to climate change providing mechanisms and approaches for managing changes to the quantity and quality of water, for capacitating organisations and communities to cope with climate variability and change, and for managing trade-offs and conflicts. Water and land management are inextricably linked and a combination of improved water and land management will play an important role in increasing climate resilient development.

Stakeholder engagement is key to sustainable and integrated water resources management and the cross-cutting nature of water and climate change adaptation requires partnerships to breakdown traditional silos of thinking. Coordination across all sectors and inclusion of all users within basins (both vertically and horizontally) is needed. Many climate change impacts will be most evident at the grass-roots level, and the NAP process should build adaptation from the village level to the basin-level, and vice versa.

Gender sensitive approaches are important to reduce the vulnerability of women in a changing climate. Women play a central part in the provision, management and safeguarding of water and have a key role in water resources management to enhance adaptive capacity to address climate change.

No/low regrets measures and actions which deliver benefits for a wide range of future uncertainties should be identified as a high priority for early implementation. No/low regrets measures help to manage current climate variability and increase resilience to future climate risks. Many activities that tackle existing climate issues and vulnerabilities will help to build adaptive capacity and enhance resilience to future climate change, and is a key factor in enhancing the livelihoods of rural, peri-urban and urban communities. Increased climate variability and longer-term trends in climate change will require actions to manage immediate climate risks such as floods and droughts as well as longer term adaptation of water resources management and use.

The economic value of water is important to acknowledge in achieving sustainable development. Adaptation actions need to emphasise water-use efficiency, value ecosystems and the services they provide, identify trade-offs and synergies between different water uses, and behavioural change in water-use sectors. Co-benefits and trade-offs among water, food and energy security will be important factors to consider in a coherent national approach to adaptation.

B.1 Analysing current climate and future climate change scenarios

Overview

A first step in the Preparatory Element B is to analyse current climate risks, including extremes, and evaluate how these determine current vulnerability to climate change. The analysis is then extended to identify future climate risks through the application of climate change scenarios. The results of this broad climate risk analysis would help to identify “adaptation deficits”, and would guide the adaptation planning process. Many countries have experience and expertise in these priority risk areas, developed through the UNFCCC National Communications process, for example. Therefore, where relevant analyses exist these can be used in the NAP process without the need for duplication.

Key questions to be addressed for the water sector include:

Aligning with the Technical Guidelines for the NAP process, key question for water planners and managers to address in Element B.1 will include:

- Which climatic conditions are most important in terms of adaptation?
- What risks does climate change hold for the water sector?
- What are major current water-related climate hazards?
- What is the estimated range of uncertainty for possible future climate scenarios?
- What are appropriate indices of climate trends which could support water sector planning and decision making?

Suggested further reading

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment report provides an overview of the global and regional climate change impacts and adaptation options. It should not replace national level climate change studies, but is useful to provide a general introduction to the types of issues relevant at a national level. The chapter on freshwater resources is of particular relevance to this supplement.

Jiménez Cisneros, B.E., T. Oki, N.W. Arnell, G. Benito, J.G. Cogley, P. Döll, T. Jiang, and S.S. Mwakalila, 2014: Freshwater resources. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 229-269. Available at http://www.ipcc.ch

The United Nations Development Programme (UNDP) has produced a guidance document providing technical guidance on the development of climate change scenarios for climate change impact assessments. It provides an introduction to the principles for developing climate change scenarios.

Puma, M.J. and Gold, S. 2011. Formulating Climate Change Scenarios to Inform Climate-Resilient Development Strategies: A Guidebook for Practitioners. UNDP, New York, NY, USA. Available at: http://www.undp.org/content/undp/en/home/ourwork/environmentandenergy/focus_areas/climate_strategies/green_lecrds_guidancemanualsandtoolkits.html

Which climatic conditions are important in terms of water and adaptation?

The NAP Technical Guidelines emphasise that characterizing current and past climate is an important step in understanding directions of climate change and climate variability. Daily temperature and precipitation are the two most common and important climate variables for analysing climate change. However, further analysis is required to elaborate indicators for interpreting potential climate change impacts to water dependent systems and sub-sectors.

Water is the prime medium through which climate change impacts will be realised. During the 21st century, climate change is projected to reduce renewable surface water and groundwater resources significantly (e.g. in most dry subtropical regions) and is likely to increase drought frequency (e.g. in presently dry regions). Climate change is also projected to reduce raw water quality.

According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014), rising temperatures, changes in rain patterns and increased frequency of extreme events will have direct and negative impacts on water dependent sub-sectors including water supply, disruption of food production, damage to infrastructure, alteration of ecosystems, and consequences for human well-being. Impacts from recent climate-related extremes already reveal significant vulnerability and exposure of many water-related or water-dependent systems to current climate variability.

Over the next 20 years, projections indicate that the most important impacts of climate change will be, and in some cases already are, increased variability, frequency and intensity of climate shocks, such as drought, flooding and extreme temperatures. In many countries, climate change will compound existing stresses on water resources. Competition for water resources in areas already facing significant strain from overexploitation, increased demand and water quality degradation will increase.

What risks does climate change hold for water sectors and sub-sectors?

Climate change will have impacts – positive, negative and varying in scale and intensity – on water supplies, water infrastructure and water demand. Key water-related risks include increased poverty and health impacts due to lack of access to safe drinking water, loss of rural livelihoods and income due to insufficient access to irrigation water, reduced agricultural productivity, loss of terrestrial and inland water ecosystems, reduced biodiversity and ecosystem goods, and the services they provide for livelihoods. In addition, the risk of more frequent and intense floods and droughts can have major economic costs. Key water-related risks identified in IPCC AR5 for three regions are given in Box 1.1.

Box 1.1 Example findings from IPCC AR5

In Africa, one of the key risks identified for Africa is compounded stress on water resources facing significant strain from overexploitation and degradation at present and increased demand in the future, with drought stress exacerbated in drought-prone regions of Africa (high confidence). Seasonal rainfall patterns, such as the onset or duration of rains, frequency of dry spells and intensity of rainfall, as well as delays in the onset of rainfall, have already changed. More frequent dry spells, coupled with more intense daily rainfall, have implications for surface water management and flood risk. As well as affecting agriculture and food production, changes in climate will amplify existing stresses on water in Africa (high confidence). Water resources are highly variable in space and time, and are one of the main constraints to economic development. The impacts of climate change will add to water stress in catchments already dealing with complex land use, engineered water systems and strong historical socio-political and economic footprints.

In Asia, key risks identified related to increased riverine, coastal and urban flooding leading to widespread damage to infrastructure, livelihoods and settlements (medium confidence); and increase risk of drought-related water and food shortage causing malnutrition (high confidence). Adaptation solutions can be adaptive/integrated water resource management, water infrastructure and reservoir development, diversification of water sources including water re-use, and more efficient use of water (e.g. improved agricultural practices, irrigation management, and resilient agriculture). Adaptation is being facilitated in some areas through mainstreaming climate adaptation action into subnational development planning, early warning systems, integrated water resources management, agroforestry, and coastal reforestation of mangroves.

In Central and South America, key risks include flooding and landslides in urban and rural areas due to extreme precipitation. Adaptation prospects include integrated water resource management, and urban and rural flood management (including infrastructure). In addition, ecosystem-based adaptation including protected areas, conservation agreements, and community management of natural areas is occurring. Resilient crop varieties, climate forecasts, and integrated water resources management are being adopted within the agricultural sector in some areas.

Examples of potential climate impacts on water related sectors (in Africa) are shown in Table 1.1. Changing water scarcity and competition for water may mean that water is not available in sufficient quantity or quality for some uses or in some locations thereby increasing cross-sectoral competition. In terms of water management, allocations should aim to to maximise co-benefits and balance trade-offs between water/food/energy security aspirations, whilst also protecting against environmental and ecosystem needs.

Table 1.1 Key impacts of climate on the major water-related sectors in Africa

Sector	Climate vulnerability (existing)	Climate change impacts (potential future)
Water resources	• Significant existing water stress. • Limited access to improved water sources for domestic supply. • One third of Africans are vulnerable to drought (especially in the Sahel, Horn of Africa and Southern Africa).	• **Increased water stress due to increasing demand, exacerbated by climate change in some regions (and ameliorated in others).** • **Reduction in groundwater recharge in some areas due to higher temperature, and reduction in rainfall in some regions.**
Health	• Significant disease problems, including vector-borne (e.g. malaria) and water-borne (e.g. cholera) diseases, which are influenced by climate.	• **Uncertainty is high on disease prevalence, as many other drivers have an influence. Potential changes in distribution and severity of outbreaks in future.**
Fisheries	• Aquaculture activities are key livelihoods in coastal areas and inland lakes and contribute significantly to dietary protein.	• **Long-term changes in flow rates within estuaries may affect fish species.** • **River flows and nutrient fluxes into lake systems may be impacted by climate change; 30% reduction in production anticipated in Lake Tanganyika.**
Agriculture	• Livestock health and disease influenced by heat and water-borne diseases. • Rain-fed agriculture and irrigated agriculture form the backbone of livelihoods and local economies in many areas. Both are highly dependent on climate.	• **Changes in rainfall and river flow patterns will alter crop yields and selection. Irrigation yields may change over time.** • **Pastoral agriculture distribution and viability may be affected.**
Energy	• Africa is heavily dependent on hydropower for electricity, although supplies are limited relative to developed nations.	• **Hydropower influenced by long-term changes in flows and also occurrence of droughts, which may cause outages.** • **Knock-on impacts for industrial productivity.** • **Reductions in generation, particularly in the sub-humid zones.**
Industry and infrastructure	• Industry is exposed to unreliable power supplies (often hydropower). • Infrastructure, particularly for transportation, is vulnerable to climate extremes such as storms.	• **Sea level rise and increasing prevalence of storm events may bring increased damage to infrastructure.**
Ecosystems	• Africa's rich ecosystems are influenced heavily by climate and by human activities.	• **Climate change may shift natural biomes towards the poles, which may result in an overall expansion of some and reduction in others – especially coastal biomes such as the fynbos in South Africa.**

Source: Compiled from Bates et al. (2008)[i]

At national level, vulnerability, impact and adaptation studies will be available to varying degrees. These will provide evidence on the current and future climate related risks. An example climate hazards for Burundi is provided in Box 1.2.

Box 1.2 Climatic hazards in Burundi

In Burundi climate variability and frequent climatic extreme events (floods in 2006 and 2007, droughts in the Northeast in 1996, 2000 and 2005) already present great challenges to the population and hamper socio-economic development of the country. Annual economic loss due to climatically induced extreme events is currently estimated at 5-17% of Burundi's GDP, largely due to a reduction in agricultural production, and highlights the vulnerability to climate change impacts in Burundi. The future negative economic consequences of climate change in Burundi are estimated to about 1% of the GDP by 2030, not taking into account climatic extreme events.

Global climate models for the East Africa region show (IPCC 2007) a very likely increase in annual mean temperature of 3-4° C (2080 to 2099) compared to the normal period 1980 to 1999 (equivalent to 1.5 times the global average), a likely increase in precipitation averages over the same period, a very likely increase the intra-annual climate variability, and a very likely increase in extreme weather events (droughts, floods).

The most sensitive sectors include agriculture (increased soil erosion, loss of harvest and livestock, destruction of land), water (reduction of spring discharge and groundwater recharge, contamination of drinking water resources), environment (increased risk of forest fires, loss of biodiversity), energy (reduction of hydroelectric potential due to sedimentation as a result of heavy rainfall and increased erosion and lower water levels in the dry season) and health (spread of infectious diseases such as cholera and diarrhea, and malaria due to shifting climatic altitude levels).

Generally, at the political and institutional level, the relevance of climate change for socio-economic development has been recognized and given a high priority. This manifests itself particularly in the convening of an expert group in 2012 charged with the development of a national climate policy, strategy, and a climate action plan (Politique Nationale, la Stratégie et Plan d' action pour l' Adaptation au Changement Climatique, PNSPACC) and provides a good entry point for systematically mainstreaming climate change into the political and legal framework.

What are the current water related hazards?

Analysis of recent climate-related extremes such as droughts, floods, and cyclones, can reveal significant vulnerability and exposure to current climate variability. Impacts of water and climate-related extremes can include loss of life, disruption of water supply, reduced irrigation and rainfed production, damage to infrastructure, and impacts on ecosystems.

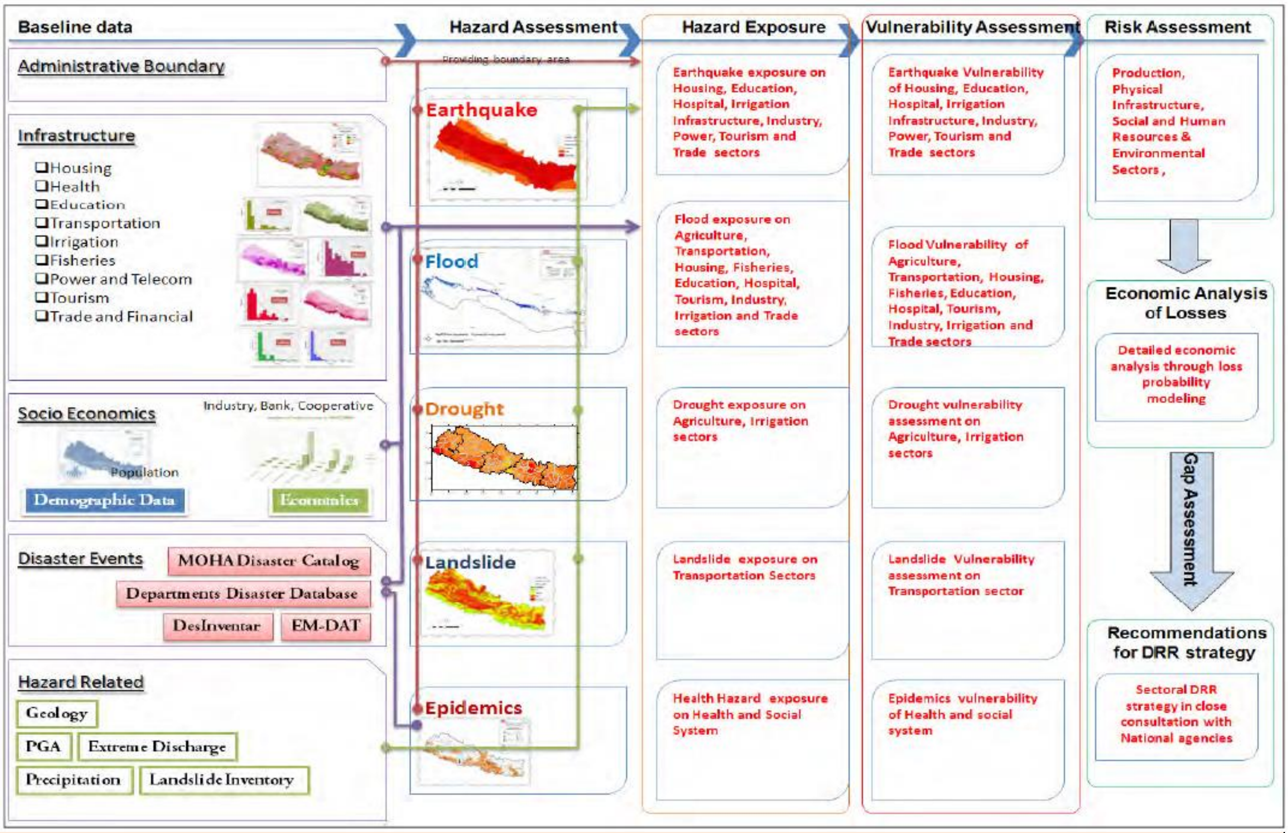
A good start point to assess the current levels of water related hazards is to review the work of National Disaster Management Agencies to determine the effects which water related hazards are already having on economic sectors and livelihoods. Bringing in water dependent sector stakeholders from a range of priority sectors dependent on water, such as agriculture, energy and industry (amongst others) will provide a forum for collating past and current experiences of water related hazards on sectoral activities. This should ideally be supplemented with engagement at local levels to capture the impacts of water related hazards on communities reliant on water for ecosystems services and livelihood functions.

In many countries, national and sectoral studies on water related hazards will already be available and can be reviewed accordingly. Box 1.3 provides an example of a national level natural hazard risk assessment, this provides a prioritisation of the current levels of risk which Nepal is exposed to from a range of natural hazards including floods and droughts. This type of assessment can form a valuable baseline to project future climate changes on to give an estimate of future levels of risk.

Box 1.3 – Prioritising natural hazards in Nepal

Nepal faces a range of water-related and other natural hazards including earthquakes, major flooding in key river basins (e.g. Khosi) , frequent landslides during the monsoon season, storms and regular seasonal flooding in terai areas. The combination of these multiple hazard events poses a severe threat to national development processes.

A comprehensive natural hazards assessment was undertaken and included collecting and analyzing existing data and reports of historical losses due to catastrophic events; mapping the natural hazard risks; detailing exposure to droughts, floods, landslides, and other hazards; analysing and quantifying the projected losses; and identifying possible information gaps and outlining the need for further analytical work to develop a comprehensive quantitative risk assessment for Nepal.



At the time, the study provided a comprehensive assessment of hazards to multiple sectors – including health, agriculture, irrigation, transport and others – and was used to inform a national strategy for disaster risk reduction, and the assessments also provide valuable input into adaptation planning processes.

Source: Nepal hazard risk assessment:
http://www.gfdrr.org/sites/gfdrr.org/files/documents/Nepal_HazardAssessment_Part2.pdf

Where national studies are not available, there are an increasing number of global datasets and analyses that can be drawn upon as a first step. For example, the AQUEDUCT Water Risk Atlas Global Maps (available online at http://www.wri.org/publication/aqueduct-metadata-global) provides GIS-based mapping tools to assess different indicators such as baseline water stress, inter-annual variability, seasonal variability, flood and drought occurrence.

What is the estimated current range of uncertainty for possible future scenarios?

Addressing climate change uncertainties

Climate change will affect the long-term outcomes of many development interventions. Indeed, interventions that are beneficial today may prove to be damaging in the long term if they do not take account of climate change. This gives a strong rationale for ensuring that programmes and projects are robust and adaptable to climate change. Importantly, climate change and its uncertainties should not be an after-thought in development interventions – they must be addressed from the outset of the process and throughout the project cycle.

The specific challenge is that the future climate is deeply uncertain. This is not just a scientific issue – it has real implications for national development and adaptation outcomes. If uncertainty is not tackled properly from the outset there is a significant risk of taking not enough, too many or the wrong types of interventions. Accounting for the changing and uncertain climate need not be complicated and should not paralyse action. A range of concepts and tools for dealing with the changing and uncertain climate in designing and implementing development interventions are available[5].

The design life of the project or programme measures in question is a critical factor in determining levels of uncertainty. Small-scale, local water supply and sanitation schemes will have a relatively short design life and long-term changes in climate may be less critical. On the other hand, when assessing adaptation for long-lived infrastructure it is important that studies are carried out with the commensurate level of detail.

Figure 1.1 presents global climate change projections for temperature for two emissions scenarios, showing the range of possible futures, with uncertainties increasing further into the future. Indicative infrastructure lifetimes (based on construction in the year 2000) are plotted on to the projections showing the range of climate futures which the infrastructure may be subjected to over its lifetime.

[5] Ranger, N. Topic Guide. Adaptation: Decision making under uncertainty. Evidence on Demand, UK (2013) 86 pp. [DOI: http://dx.doi.org/10.12774/eod_tg02.june2013.ranger]

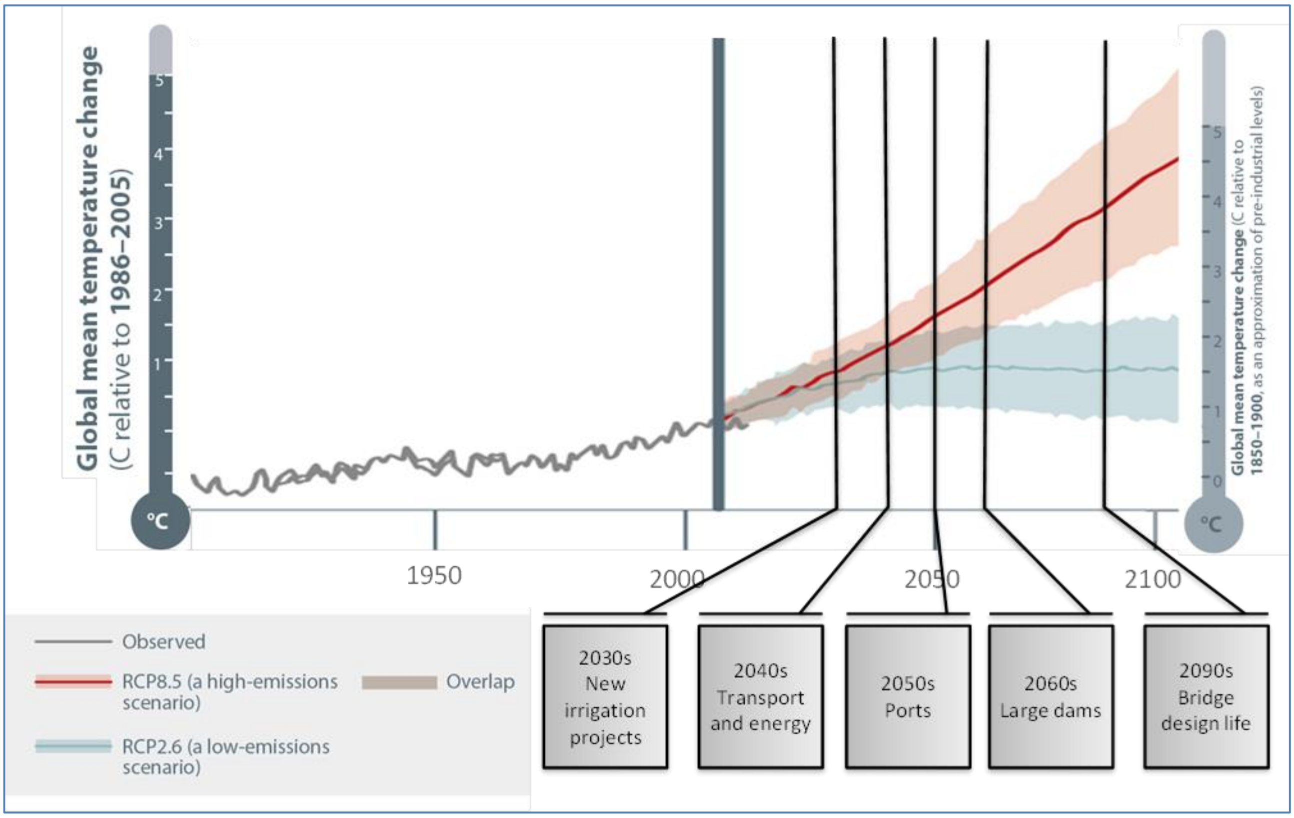


Figure 1.1 – Indicative design lives of long-lived infrastructure compared with timescales for climate change [Source: Adapted from IPCC (2014)]

Developing climate change scenarios for water

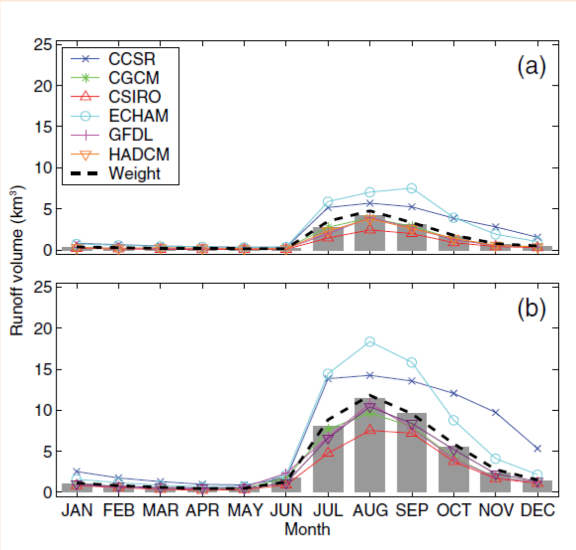
Climate change scenarios related to water resources management and water supply require consideration of the different physical climate and water variables which may be impacted by climate change. These variables include temperature and rainfall, which are directly derived from Global Circulation Models (GCMs) as well as dependent water related variables such as soil water, groundwater recharge, river flows and lake or reservoir levels. These dependent variables typically require additional modelling studies using hydrological or hydraulic modelling tools to understand how changes in temperature and rainfall will affect river flows for example. In addition, the pattern of change is often important which may include changes in seasonal precipitation or extremes such as heatwaves, floods and droughts. An example of the use of climate scenarios to assess impacts on hydrology and water resources within a basin context is given in Box 1.4.

Box 1.4 - Case study of the use of scenarios for climate change impacts on hydrology and water resources of the Upper Blue Nile River Basin, Ethiopia[ii]

This study is an example of a technical, modelling-based climate change impact assessment. It constrains the number of scenarios by using only one emissions scenario, one future time slice and no additional non-climate scenarios. The GCMs show a wide and conflicting range of outputs, indicating that confidence in future river flows is low and highlighting the need for a robust and flexible decision making approach to planning for climate change in the basin.

The study is relatively technical and uses quantitative modelling to assess future impacts of climate change. It is also focused on the impact of climate on hydrology and does not address the potential range of non-climatic drivers on water resources within the basin.

- **Climate change data** – Climate change scenarios were developed using six GCMs (for one emissions scenario) with data extracted via the IPCC Data Distribution Centre.
- **Scenarios** – A baseline scenario and seven scenarios of future climate change, using the mean monthly changes for each GCM model and one set of monthly changes for the combined GCMs. Only one future time slice was used (2050s).
- **Non-climate scenarios** – No non-climate scenarios were needed as this study focused on potential supply rather than demand for electricity.
- **Regions** – Six basins were modelled in the Upper Blue Nile catchment.
- **Modelling** – The climate change scenarios were applied to rainfall-runoff models of the basins to assess the changes in river flow regime for each scenario. This modelling required time series data of temperature and rainfall for the baseline and future scenarios to drive the runoff models.
- **Further analysis** – The scenarios were also used to assess future drought frequency and to investigate the operation of potential future multi-purpose dams.



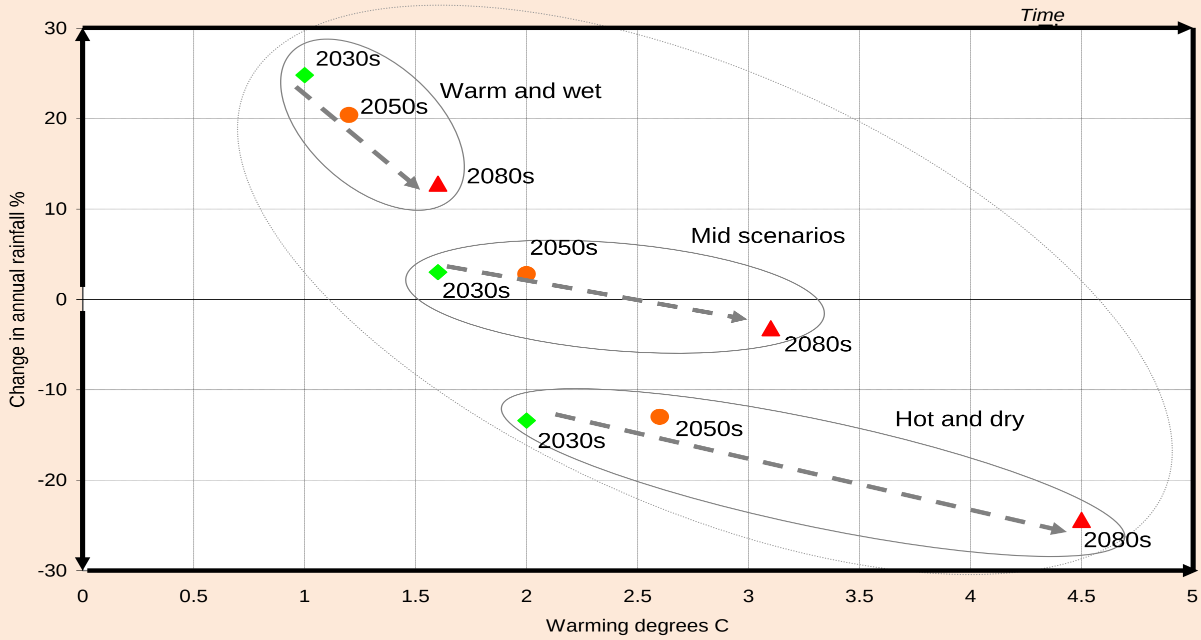
Baseline and future runoff volumes at two flow gauging stations on the Blue Nile

Simplifying complexity

In many countries, climate change estimates vary significantly across GCMs and ensemble approaches are generally used to cater for these variations. Where the ranges of uncertainty are large however representative climate storylines can be used to define a spread of climate futures, and to provide a practical means of condensing large amounts of data into a format suitable for interpretation and analyses, see Box 1.5.

Box 1.5 Example of climate futures; simplifying complexity and recognising uncertainty

In Yemen, climate change is dramatically affecting three areas - water resources, agriculture and coastal areas. A study was commissioned in 2010 to quantify the impacts of climate change and variability (both in physical and in economic terms) on agricultural and water sectors. The study addressed the impacts of climate change on water balance of major basins in Yemen (including on recharge to major aquifers), climate change affects on the yields of rain-fed crops and water availability requirements of irrigated crops, and the impacts on farmer livelihoods. The study was used recommended priorities for government adaptation policies, strategies and investments in the agriculture and water sectors, in support of part of the World Bank Pilot Program for Climate Resilience (PPCR).



Yemen is a region where climate futures are high variable and uncertain. The study defined three climate futures from ensemble GCM runs representing a spread of possible futures over time, from the 2030s to the 2080s. The defined climate futures or storylines represented 'hot and dry' / 'mid' / 'warm and wet' scenarios, and these were applied to hydrological rainfall-runoff models, and subsequent adaptation studies, to ensure a realistic spread of uncertain climate futures were considered.

The approach provides a pragmatic and practical means of simplifying often dense and complex ensemble GCM results, is entirely compatible with subsequent hydrological analysis across a range of futures, and also has the added advantage of being highly transparent and readily understandable by non-climate specialists.

What are the appropriate indices of climate trends which could support water sector planning and decision making?

High-level core indices for analysing daily data of temperature and precipitation at the regional and global levels are available (e.g. see Annex 4, Technical Guidelines). Although some of these are directly relevant to water systems analysis, further interpretation (for example through the application of hydrological models) will provide greater insights on exposure to climate change, and typical examples of indicators directly relevant to water systems for use in adaptation studies are given in Box 1.6.

Box 1.6 - Example water system indicators

Examples of high-level Indices of relevance to the water sector will include changes and projections (with and without climate change) for the following:

Water system	Proxy indicators
General	• Changes in runoff projections • Changes in basin yield projections • Changes in low flow projections • Changes in high flow projections • Changes in base flow projections • Water deficit indices
Irrigation and drainage	• Change in annual net irrigation deficit
Urban water supply and sanitation	• Change in runoff reliability
Rural water supply and sanitation	• Change in minimum base flow
Flood control	• Change in runoff reliability
River basin management and multi-purpose infrastructure	• Change in basin yield

Source: http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2010/02/01/000333038_20100201020244/Rendered/PDF/529110NWP0Box31ge0web0large01128110.pdf

More refined and detailed indices can also defined for each water system/sub-sector by considering exposure levels (low/medium/high) and are usually based on confidence or exceedance levels. For example runoff reliability is determined using flow duration curves but the upper and lower bounds are generally most useful as a criteria to assess the level of exposure to change. For example, the flow that is exceeded 90% of the time (q90) indicates a 10% chance in each time period of a flow lower than this. If this q90 flow decreases, as a result of climate change, it means the likelihood of low flows and droughts will likely increase.

The climatic and hydrological indicators which are selected for use in the NAP process should be driven by the country and basin specific vulnerabilities and be selected on the basis of their relevance to the sector or sub-sector under investigation. For example, Box 1.7 illustrates indices that can be developed of specific ecological relevance.

Box 1.7 – Example of flow indicators used to inform an ecological impact assessment

indi-cator	question	definition	specific ecological relevance[a]
I_{LTA}	How are long-term average river flows affected?	differences between long-term average annual river discharges under altered and unaltered conditions, in percent of long-term average un-altered river discharge	number of endemic fish species, groundwater-dep. floodplain vegetation
I_{LF}	How are statistical low flows affected?	difference between long-term average Q_{90} (monthly river discharge that is exceeded in 9 out of 10 months) under altered and non-altered conditions, in percent of unaltered Q_{90}	habitat conditions, like temper-ature and oxygen concentra-tion, connectivity, compatibil-ity with life cycle of organisms, wastewater dilution
I_{SA}	How is the seasonal amplitude affected?	difference in seasonal amplitude (maximum mi-nus minimum long-term average monthly river discharge) under altered and unaltered condi-tions, in % of unaltered amplitude	habitat availability in particular on floodplains, increase in non-natives
I_{SR}	How is the seasonal regime affected?	mean over 12 monthly values of absolute differ-ences between long-term average monthly river discharges under altered and unaltered condi-tions , in % of unaltered discharge	habitat conditions, compatibil-ity with life cycle of organisms
I_{TS}	What seasonal flow shifts (will) have occurred?	temporal shift of month with maximum river discharge, in months (if negative, this month oc-curs earlier due alteration)	compatibility with life cycle of organisms, e.g. disruption of spawning, assemblage struc-ture, food availability for detri-tivorous macroinvertebrates

Similarly, Box 1.8 provides an example of the use of river flow indicators used in a climate change impact assessment for the Okavango delta in Southern Africa.

Box 1.8 – Case study of using water related indices to assess risks posed by climate change in the Okavango delta, Southern Africa

The World Wide Fund for Nature (WWF) and the World Bank produced a report detailing a methodology for assessing the impact of climate change on freshwater ecosystems. This comprises impact and vulnerability assessments in the context of an overall risk framework that is used to identify adaptation options. The vulnerability and impact assessments use top-down assessments based on climate and development futures as well as bottom-up vulnerability assessments of the resilience of ecosystems to existing stressors.

Eight indices were developed for climate change impacts, related to water. These included low flows, timing of flood flows, evaporation losses, peak flood flows, lake stratification, saltwater intrusion, surface runoff and water temperature. These types of indicator can be used as a proxy to assess the types of climate change impacts which could potentially occur in a basin.

Relevant indices will depend on the type of impacts being considered, although indicators for average, flood and low flows are generally useful. Other more specific indicators such as saltwater intrusion are likely only to be relevant in certain basins.

The table below shows how each indicator is assessed for level of risk in the basins draining into the Okavango delta.

Table 3.2: Key risks in the Okavango system

High risk | Medium risk | Low risk

		1. Cubango	2. Cuito	3. Kavango	4. Delta	5. Boteti
Eco-hydrological Impacts	Low-flow impacts on ecosystems	Low risk	Low risk	Low risk	High risk	High risk
	Shifts in timing of floods and water pulses	Low risk	High risk	High risk	Medium risk	Low risk
	Evaporative losses from shallower water bodies	Low risk	Medium risk	Medium risk	Medium risk	High risk
	Higher and/or more frequent storm flows	Low risk	Low risk	Low risk	Low risk	Low risk
	Shifts in thermal stratification in lakes	Low risk	Low risk	Low risk	Low risk	Low risk
	Saltwater encroachment in coastal and deltaic systems					
	Increased runoff, increasing pollutants	Low risk	Low risk	Low risk	High risk	Low risk
	Hot or cold-water conditions, DO levels	Low risk	Low risk	Low risk	Low risk	Low risk

Source: World Bank / World Wide Fund for Nature. 2010. Flowing Forward: Freshwater Ecosystem Adaptation to Climate Change in Water Resources Management and Biodiversity Conservation. Water Working Note No. 28. World Bank, Washington D.C., USA.

B.2 Identify and categorise adaptation options

Overview

The NAP process seeks to enhance the coherence of adaptation and development planning, rather than duplicating efforts already undertaken or underway, whilst also learning lessons from the experiences of the earlier generations of adaptation planning and activities.

Key questions to be addressed for the water sector include:

Aligning with the Technical Guidelines for the NAP process, key questions for water planners and managers to address in Element B.2 include:

- Which systems, regions, or groups work towards key development goals such as food security, poverty alleviation, economic development, etc.?
- What are the main climate vulnerabilities of those systems/regions that are key to achieve the main development goals?

a. What are the expected impacts of climate change on water security?
b. What are viable cost-effective adaptation options to reduce the impacts of climate change or to exploit opportunities?
c.

Suggested references and further reading

The Global Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) has produced guidance on selecting methods for vulnerability, impact and adaptation assessment. Although not specific to the water sector it provides a useful primer on the diverse range of tools and methods which are available to carry out these types of assessments.

The guidance is available on the PROVIA website http://www.unep.org/provia

The United Nations Economic Commission for Europe has produced a primer on adapting water resources management to climate change. This provides useful background information on the key risks which water resources face and approaches to manage these risks. It should be used to give an overview of concepts, rather than providing tailored guidance for national risks.

United Nations Economic Commission for Europe. 2009. Guidance on Water and Adaptation to Climate Change. Available at http://www.unece.org/fileadmin/DAM/env/water/publications/documents/Guidance_water_climate.pdf

Which water-related systems work towards key development goals?

Improved water services and water resources management are an essential and necessary condition for economic development and growth. However, it is also clear that the interaction runs both ways. Economic growth itself can also drive increasing investments in improved water management and services. Thus, it can be argued that the interaction between improved water supply and sanitation and economic growth is mutually reinforcing and has the potential to start a “virtuous cycle” that improves the lives of poor people[6].

Society’s economic sectors, including agriculture, industry and services, rely on water resources and related services. Improved access to water services and improved management of water resources contribute substantially to economic growth through increasing business productivity and development. It also

[6] http://www.siwi.org/documents/Resources/Reports/CSD_Making_water_part_of_economic_development_2005.pdf

improves human health, productivity and dignity considerably. There is also a positive correlation between increased national income and the proportion of population with access to improved water supply. For example, a 0.3% increase in investment in household access to safe water is associated with a 1% increase in GDP[7]. At the individual/household level, enormous savings in time and increased livelihood opportunities for the poor are gained through improved access. Interventions also give sectoral and cross-sectoral economic benefits. Presenting the macro-economic case for the benefits of water can be a powerful argument investing in water, and hence in adaptation in water-dependent economic sectors.

A variety of metrics for economic, social and environmental impacts can be developed, and some examples are set out in Table 2.1 below. Economic impacts make a powerful case especially amongst those in positions of budgetary decision making, Where it is not possible to estimate economic impacts proxy metrics may be used, for example number of persons impacted. A further source of guidance on presenting the macro-economic case for water is given in Box 2.1.

Table 2.1 - Example metrics for supporting evidence on development impacts.

Economic costs	Social costs	Environmental costs
Loss of revenue to utilities **Increased cost due to trucking and emergency operations** **Loss of revenue to businesses including critical economic sectors such as agriculture and tourism** **Cost of replacing / repairing damaged infrastructure** **Insurance and legal costs**	Number of persons impacted by loss of supply (municipal and business) Health effects (cases of water borne diseases for example) Number of adverse media articles representing a reputational cost Change in food and other household expenses	Area of important habitat lost or damaged Reduction in ecosystem services (supporting tourism, food security, flood protection etc) Area of watersheds suffering from degradation such as erosion or pollution

Box 2.1 – Presenting the macro-economic case

Stockholm International Water Institute - Making Water A Part Of Economic Development

Presenting the macro-economic case for the benefits of water can be a powerful argument amongst financial planners. This report set out some high level arguments for investing in water and would be a useful resource for water planners to identify the types of facts, figures and methodologies which can be used to present a case for resilience.

Source: Stockholm International Water Institute (SIWI) Making Water A Part Of Economic Development (SIWI, undated) http://www.who.int/water_sanitation_health/waterandmacroeconomics/en/

Consideration of water in the NAP process will be important to ensure that achievement of high-level development goals and targets are not undermined by negative climate change impacts. The post-2015 Sustainable Development Goals (SDGs) include a specific water goal '*Ensure availability and sustainable management of water and sanitation for all*' yet achievement of all of the other goals will also be underpinned by water-related adaptation measures in one way or another.

[7] World Bank (1994). World Development Report 1994 - Infrastructure for Development. Washington D.C.

Table 2.2 below sets out the links between water and the SDGs and it is evident these serve to strengthen the importance of the role played by water in the global development agenda.

Table 2.2 – Water in support of the Sustainable Development Goals

SDGs	Supporting achievement of the SDGs
1. End poverty in all its forms everywhere	Water is essential to economic development, which can create productive livelihoods for the poor. Management of water related hazards reduces the economic and social burden of floods, droughts and other water related disasters
2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	Water and land management are inextricably linked and a combination of improved water and land management will play an important role in increasing climate resilient agricultural production, and food security.
3. Ensure healthy lives and promote well-being for all at all ages	Better management of water at local levels can help combat waterborne and water-related diseases. Access to safe water and sanitation reduces child mortality and increases maternal health
4. Ensure inclusive and equitable quality education and promote life-long learning opportunities for all	Collecting water, and the effects of water related disease, can consume time children otherwise spend in school. The provision of sanitation in schools can encourage attendance by children, especially girls.
5. Achieve gender equality and empower all women and girls	Women are disproportionately affected by the household tasks involving collecting and using water. Provision of water can increase time available for women to participate in other social and economic activities
6. Ensure availability and sustainable management of water and sanitation for all	Availability and sustainable management of water and sanitation for all reflects water's fundamental importance for human development, the environment and the economy.
7. Ensure access to affordable, reliable, sustainable, and modern energy for all	Water is key to hydropower development and remains fundamental throughout the lifecycle of other energy infrastructure development and operation
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Water is essential to economic development, which can create productive livelihoods for the poor. Management of water related hazards reduces the economic burden of floods, droughts and other water related disasters.
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	Resilient infrastructure can protect against water related hazards and disasters. Technological innovation can improve water use efficiency, enhance wastewater quality and increase water re-use
10. Reduce inequality within and among countries	Coordination across sectors and inclusion of all users within basins (national and transboundary) underpins sustainable and integrated water resources management and promotes benefit-sharing

SDGs	Supporting achievement of the SDGs
11. Make cities and human settlements inclusive, safe, resilient and sustainable	Management of water related hazards reduces the economic burden of floods, droughts and storms to urban and built environments
12. Ensure sustainable consumption and production patterns	Water is essential to many economic sectors and enhanced water use, efficiency and stewardship has benefits for all.
13. Take urgent action to combat climate change and its impacts	Water is the primary medium through which climate change will be felt and action to minimise negative impacts and to seize any potential opportunities is essential
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Improved management of water resources, from source to sea, enhances the quality and quantity of waters reaching the marine environment
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Sustainable management and use of water resources supports ecosystems services, green growth and underpins sustainable development.
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Effective water governance is a cornerstone on how to develop and manage water resources, and the delivery of improved water services at different levels of society
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development	The transboundary nature of many river, lake and aquifer systems requires collaboration and partnerships for efficient and effective management. Partnerships are also required across water dependent sectors and users.

What are the main climate vulnerabilities of those systems / regions that are key to achieve the main development goals?

The Technical Guidelines highlight that the approaches for assessing vulnerability vary depending on such factors as major climate hazards and risks for the country, the levels identified in the framework and strategy for the NAP process (whether to take a national assessment approach, or whether to address issues by sector or other subnational levels), and the nature of existing knowledge on impacts, vulnerabilities and risks. This section considers vulnerability and adaptive capacity assessment in the context of water at a range of scales and how it can be assessed as a precursor to identifying adaptation options to reduce vulnerabilities and build adaptive capacity.

As highlighted in Box 2.2, vulnerability is a broad concept, which can mean different things to different stakeholders. Arriving at a common view of what vulnerability means in the context of the NAP process helps to minimise confusion due to varying interpretations of these concepts. Adaptive capacity is also important to measure. It is the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. Assessing and building adaptive capacity supports the ability to adapt to an uncertain future.

Box 2.2 – Defining vulnerability and adaptive capacity

The Intergovernmental Panel on Climate Change (IPCC) define vulnerability as follows: "The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts including sensitivity or susceptibility to harm and lack of capacity to cope and adapt." Within this broad concept contextual vulnerability is defined as follows: "A present inability to cope with external pressures or changes, such as changing climate conditions. Contextual vulnerability is a characteristic of social and ecological systems generated by multiple factors and processes".

The Technical Guidelines notes that taking a vulnerability approach focuses on the social factors that determine the ability to deal with climate impacts. It uses a more subjective and qualitative approach, with an emphasis on interactions between climate and society. Many so-called bottom-up approaches explore these interactions.

Adaptive capacity represents the converse of vulnerability and is defined by the IPCC as follows: "The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences".

Scoping vulnerability and adaptive capacity assessments

A clear vision of the questions which the vulnerability assessment should address is essential to ensuring it is targeted and fit for purpose. The nature of the questions should ideally be guided by the development objectives which are relevant in the country context. For example, if a national target for expanding irrigated agriculture is in place, a vulnerability assessment could ask 'How vulnerable is the expansion of irrigated agriculture to water-related climate change?' By framing the questions in the context of achieving and sustaining development efforts, the vulnerability assessments will generate targeted information to guide adaptation planning. Bringing together stakeholders from policymaking, technical specialists (from both the water sector and other water dependent sectors), climate specialists and community representatives will be useful in framing the questions to be addressed. A summary of guiding questions which should be considered at the outset of a vulnerability assessment are given in Figure 2.1.

Vulnerability and adaptive capacity assessment

What is the purpose of the assessment?
A clear and agreed vision on the purpose of the assessment is important to ensure its findings are relevant to the NAP process. This requires defining the types of answer which the assessment should provide such as:

- Is the focus on the social, economic or environmental impacts of climate change (or all three)?
- What are the strategic development objectives will the assessment align with?
- What are the planning processes which the assessment should feed in to?
- Are quantitative or qualitative conclusions required or preferred?
- Is the assessment focussing on risks posed by current climate variability or long term climate change?

What resources are available ?
Practical considerations are important in determining the most appropriate assessment approach. Some key considerations include:

- How much time is available for completing the assessment?
- What financial and human resources are available?
- What are the capacity gaps and needs for undertaking the management of the assessment and its quality assurance?
- Who are the stakeholders involved and how will they be engaged with the process?

What tools are available and appropriate?
Some systems such as managed water resources systems may be readily modelled quantitative while others such as community level livelihood systems may be more complex and suited to a narrative and qualitative assessment of climate risks. A hybrid of such approaches is often used, with qualitative stakeholder narrative case studies supporting a quantitative assessment. Key questions include:

- What existing sources of information and evidence are available?
- How has the system been assessed or modelled in the past and what were the results?
- What types of tools are available for assessing the system, are these quantitative or qualitative?
- How can the correct tool be selected or adapted based on existing tools?

What data is available?
Data constraints are a key consideration when carrying out technical studies. This should be borne in mind when defining methodologies for undertaking assessments, and alternative approaches for filling data gaps should be considered, such as expert elicitation and stakeholder engagement. Key questions include:

- What type of data is needed (physical, economic, social)?
- How can the data be obtained, what are the restrictions on its use?
- How can data gaps be filled?
- What opportunities exist for integrating data from different sources (for example quantitative and qualitative data)?

Figure 2.1 - Summary of guiding questions which should be considered at the outset of a vulnerability assessment.

A good starting point for assessing vulnerability is to work with stakeholder to identify the systems, regions, or groups which work to support key development goals, as set out above. This will frame the scope of the assessment. The next step to guide the identification of the drivers of vulnerability is to ask the broad question; ‘When a climate hazard such as a flood or drought occurs, what causes negative impacts to occur?’ This may sound like an obvious question, but unpicking the various causes of vulnerability with a broad base of stakeholders will reveal underlying drivers of vulnerability.

Indicators and hot spot mapping

Once the broad drivers of vulnerability have been identified, it may be helpful to develop indicators of vulnerability. Mapping indicators identifies those areas of highest vulnerability, which should be targeted for adaptation. A wide range of vulnerability indicators have already been developed, they may be used at a variety of scales, to compare countries, basins, sub-national areas or communities. While some such as the Human Development Index (HDI) are a general measure of vulnerability, a wide range of indicators focussed specifically on water have also been developed.

Water security indicators need to connect indicators of basic water needs (‘small’ water challenges) with indicators of water sharing and risk management at national and transboundary levels (‘big’ water challenges). Indicators have been developed to capture an expanding range of water security challenges at multiple scales. There has been an evolution from indicators of basic needs and food security (e.g.the Falkenmark Water Stress Index and the Gleick Basic Water Requirements) to more complex composite indices (e.g. the Water-Poverty Indicator) or specialised indices to address risk, water sharing and variability (e.g. Basins-at-Risk). Table 2.3 provides examples of water indicators and their diverse purposes and sub-components.

In practice indicators for the NAP process at a national level should be tailored towards the drivers of vulnerability which have already been identified. The data behind indicators must also be feasibly available, this may highlight existing gaps in data collection and management which could be addressed under the NAP process. Simple indicators can be a valuable tool in making a rapid assessment of both vulnerability to climate and the impacts of climate change. Indicators have the advantage of allowing the combination of several vulnerability factors, using weightings to assign their relative magnitude or severity

Table 2.3 – Examples of water related vulnerability indicators

Indicator	Challenges	Scale	Components (Data)	Thresholds
Drawers of water[iii] **Drawers of water II**[iv]	Basic needs	Urban/rural sites	Water-use behaviour Cost of water Factors affecting use Environmental health effects of use	n/a
Falkenmark Water Stress Indicator[v]	Basic needs Food security	Country	Annual renewable water resources Population Sample of water use by country	**m^3/person/year** Stress (1000-1700) Scarcity (500-1000) Absolute scarcity (<500)
Basic Human Needs Index[vi]	Basic needs	Country	Domestic water use Population	**50 litres/person/day** Minimum drinking water (5) Basic sanitation (20) Basic bathing (15) Basic food prep (10) *all have ranges*
Relative Water Scarcity[vii] **Economic water scarcity**[viii]	Basic needs Food security	Country Country/regional/admin units	Water demand Water availability	*Physical scarcity* 75% of available water withdrawn *Economic scarcity* Malnutrition despite < 25% of available water withdrawn

Indicator	Challenges	Scale	Components (Data)	Thresholds
Water Poverty Indicators[ix]	Basic needs Food security Managing risk Protecting ecosystems	Country/community	Measures of access Water quality and variability Water for food and other productive purposes Capacity to manage water Environmental aspects	Weighted index of components for each category
Seasonal Storage Index Interannual Shortfall Index[x]	Managing risk	Country	Food production requirements Water balance estimate Intra-annual variability Inter-annual variability	n/a
Virtual water/water footprinting[xi, xii]	Food security Sharing water	Country	Internal water use External water use	n/a
Basins at risk[xiii]	Sharing water	River	Event data on conflict and cooperation	Event intensity scale
Water Security Threat Indices[xiv]	Basic needs Protecting ecosystems	8 km and 0.5 degree grids	Catchment disturbance Pollution Water resource development Biotic factors	Domestic, industrial and agricultural demand is 40% of local discharge

Simple indicators are a valuable tool in making a rapid assessment of both vulnerability to climate and the impacts of climate change. Indicators have the advantage of allowing the combination of several vulnerability factors, using weightings to assign their relative magnitude or severity. Mapping these indicators provides a powerful tool for locating vulnerability hotspots and for disseminating information in a format that non-technical staff understand. Indicators may encompass the exposure of populations to climate risks, their sensitivity, and their capacity to adapt. An example of vulnerability mapping base on an assessment of the distribution of vulnerabilities across the Zambezi basin is provided in Box 2.3, similar analyses could be undertaken using country and climate risk specific vulnerability indicators to provide NAP planners with an overview of how vulnerabilities are distributed, and target adaptation actions where needs are greatest.

Box 2.3 – Case study of vulnerability mapping in the Zambezi basin

This mapping of the Zambezi Basin involved risk and vulnerability hotspot mapping for the region. A wide range of environmental and social datasets were used to build composite indicators of exposure, sensitivity, climate impact, adaptive capacity and vulnerability, both for the current and future (2050) climate. These calculations were carried out on spatial datasets using a GIS, which allowed manipulation and mathematical operations to be carried out on large spatial datasets. The study used a definition of vulnerability that aggregates exposure and sensitivity into an impact score; impact and adaptive capacity are then aggregated as a measure of vulnerability.

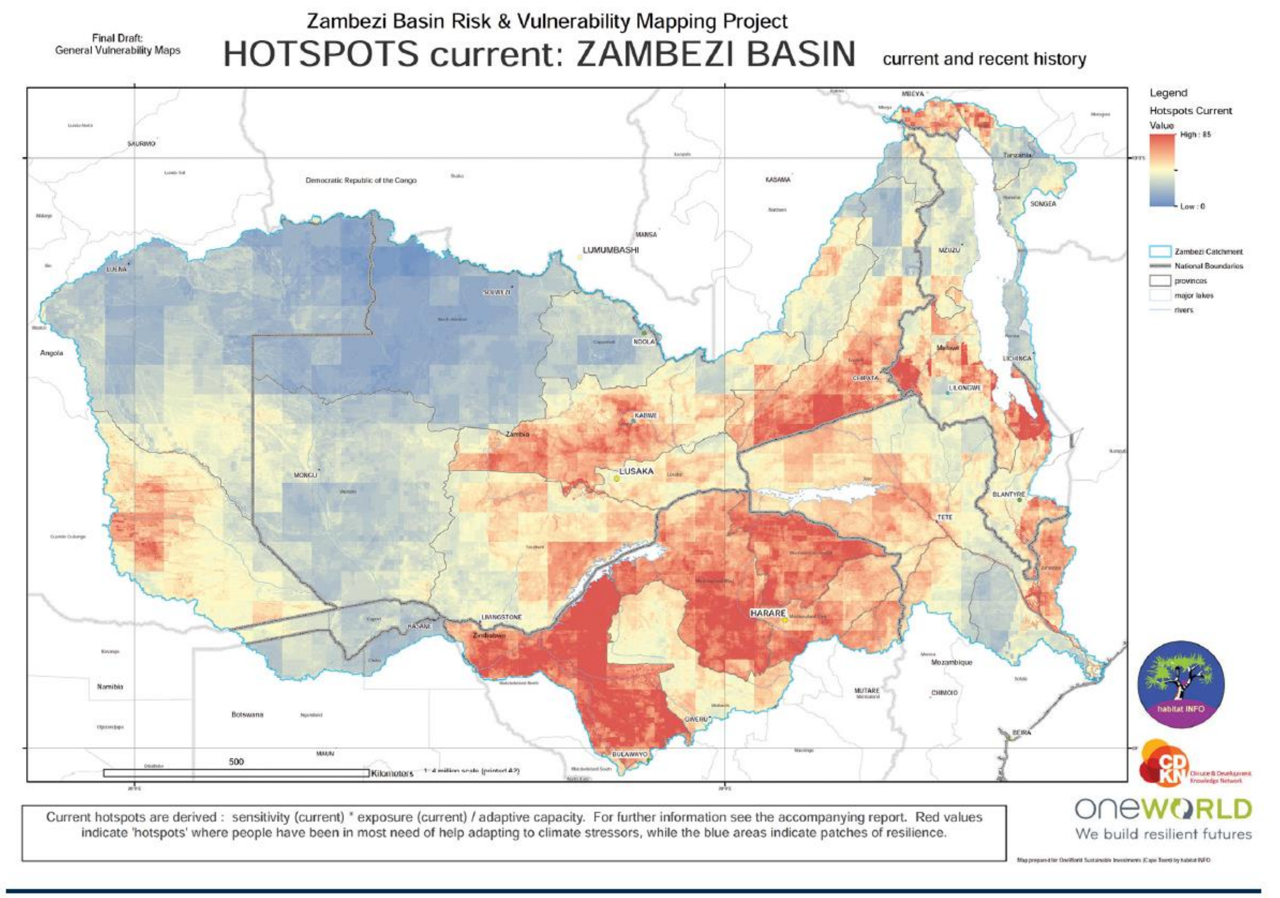


Figure 5.4 Current vulnerability hotspots in the Zambezi Basin

Source: Midgley, S.J.E., Davies, R.A.G., Wroblewski, T., Hope, E. and Chesterman, S. 2012. Mapping Climate Risk and Vulnerability in the Zambezi River Basin: Synthesis Report. For the Climate and Development Knowledge Network (CDKN). OneWorld Sustainable Investments and habitatInfo, Cape Town, South Africa.

Bottom up vulnerability assessment for water resources management are likely to be most appropriate when considering the social and environmental factors which make water resources systems vulnerable to climate change. A bottom up assessment may include elements such as an analysis of the social or political constraints to climate change adaptation. Such assessments are often designed to use a participatory rather than a technical modelling approach, relying on the use of stakeholder knowledge and expert elicitation. This allows bottom up methods to be coupled with awareness raising, stakeholder engagement and capacity development activities.

Methods for vulnerability assessment are generally non-sector specific and approaches such as the CARE Community Vulnerability and Capacity Analysis (CVCA)[8] and the CRiSTAL (Community-based Risk Screening Tool – Adaptation and Livelihoods)[9] are intended to be used at the community level. These types of bottom

[8] Available online at http://www.careclimatechange.org/tk/integration/en/quick_links/tools/climate_vulnerability.html
[9] Available online at http://www.iisd.org/cristaltool/

up vulnerability approaches may be valuable to complement technical impact assessment approaches to ground truth results and provide context around the findings of impact studies.

A wealth of further information on vulnerability assessment is available, and the Water Supplement will not attempt to duplicate the guidance here. The PROVIA Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change (PROVIA, 2013) provides a useful synthesis of bottom up vulnerability assessment approaches which may be applied in the context of water, as well as other sectors and thematic areas for vulnerability assessment.

Assessing adaptive capacity

Adaptive capacity is broadly defined as the ability of systems to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. Assessing adaptive capacity answers the question ‘What supports or limits the ability of my sector to adapt to climate change?’ The assessment of adaptive capacity therefore feeds directly into the identification of adaptation options, and is usually a ‘bottom up’ process.

Assessing adaptive capacity is carried out using a mixture of participatory approaches and expert technical input. Expertise in climate change adaptation will be required to design a framework the assessment which is appropriate to regional, national and sub-national decision making processes. This will build on existing principles of adaptive capacity assessment which are well established, such as the four principles for adaptive water management below (based on Gain et al (2007):

- Adequate **supply of resources, technologies, infra- structure, knowledge and skills** that enables social actors to respond to evolving circumstances
- An **effective innovation and capacity-building system** based on adaptive cycles and experimentation of local and scientific knowledge
- A **flexible decision-making system** that enables local self-determination, while ensuring synergistic interventions and avoiding conflicting ones between scales
- Accessible **participatory mechanisms** that support fair exchange between social actors and encourage the sharing of resources and power

Using expert support, these broad characteristics can be used as a starting point to develop a framework for adaptive capacity which reflects the decision making processes being considered. Engaging with water stakeholders will be required to understand in detail the regional, national and sub-national decision making processes which the framework will be applied to. The framework should be straightforward for stakeholders to understand and not excessively resource intensive to implement.

Table 2.4 provides a useful example of contrasting characteristics of an adaptive management regime against those of a more predication and control regime. It illustrates the types of contrast which can be drawn between decision making processes which support climate change and those which inhibit adaptation. This type of framework could help stakeholders understand the characteristics of the decision making processes being assessed. Box 2.4 provides a grounded example of an adaptive capacity assessment for water resources management decision making in Nepal.

Table 2.4 –Comparison between traditional predict and control and an integrated, adaptive regime for water management (Pahl-Worst, 2007)

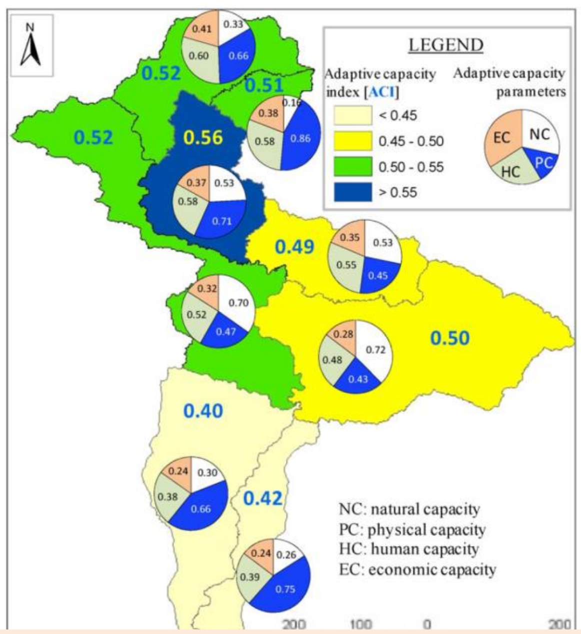
	Prediction and control regime	Integrated, adaptive regime
Management paradigm	Prediction and control based on a mechanistic system's approach	Learning and self-organization based on a complex systems approach
Governance	Centralized, hierarchical, narrow stakeholder participation	Polycentric, horizontal, broad stakeholder participation
Sectoral integration	Sectors separately analysed resulting in policy conflicts and emergent chronic problems	Cross-sectoral analysis identifies emergent problems and integrates policy implementation
Scale of analysis and operation	Transboundary problems emerge when river sub-basins are the exclusive scale of analysis and management	Transboundary issues addressed by multiple scales of analysis and management
Information management	Understanding fragmented by gaps and lack of integration of information sources that are proprietary	Comprehensive understanding achieved by open, shared information sources that fill gaps and facilitate integration
Infrastructure	Massive, centralized infrastructure, single sources of design, power delivery	Appropriate scale, decentralized, diverse sources of design, power delivery
Finances and risk	Financial resources concentrated in structural protection (sunk costs)	Financial resources diversified using a broad set of private and public financial instruments
Environmental factors	Quantifiable variables such as Biological Oxygen Demand (BOD) or nitrate concentrations that can be measured easily	Qualitative and quantitative indicators of whole ecosystem states and ecosystem services

Box 2.4 – A framework to assess adaptive capacity of the water resources system in Nepalese river basins

This paper discusses an indicator-based framework – consisting of seven indicators, four parameters, and an index – to assess adaptive capacity of the water resources system in the Nepalese context and applies this framework to the Bagmati River Basin (BRB) in Nepal.

The indicators of adaptive capacity included; fraction of area under vegetation and wetlands, irrigation coverage, drinking water coverage, literacy rate, economically active population, GDP index and non-agricultural employment
These were used as proxies of natural, physical, human and economic capacity.

The study results show variations in adaptive capacity of the water resources system across the river basin (eight districts within the BRB), at different geographical (district, river basin and national level) as well as temporal (over decades) scale. Such variations suggest a need of differential policy interventions at different spatial scale to achieve adaptive management of the water resources. The adaptive capacity index was used to categorise the basins according to adaptive capacity, to identify the broader areas of intervention, and to inform the degree of attention required to strengthen adaptive capacity of the water resources systems in the each basin.



Adaptive capacity parameters and indices in the Bagmati River Basin districts

Source: Pandey, V.P., Babel, M.S., Shrestha, S. & Kazama, F. 2011. A framework to assess adaptive capacity of the water resources system in Nepalese river basins. Ecological Indicators. 11. 480-488

Workshops with relevant stakeholders and experts provide a mechanism to apply the adaptive capacity frameworks to water related decision making processes. Conducting adaptive capacity assessments in following areas of decision making can be used to identify adaptation options to build resilience:

- Policies and strategies governing water management and use, either at the regional, national or local levels for each sector
- Legislation and regulation including for example environmental protection, water allocation and pricing, land management
- Strategic plans and planning guidelines such as water resources management plans, sectoral development plans, investment plans and all supporting planning guidelines
- Project preparation processes and design guidance for infrastructure
- Data and knowledge management processes, including data collection and management, capacity development and operational processes
- Financing and budgetary processes including budget preparation processes and the financial incentives and disincentives

Workshops provide an opportunity for those working on the NAP process to gain evidence on the current status of adaptive capacity. Perhaps more importantly it allows stakeholders to identify constraints and opportunities for enhancing adaptive capacity which develops their capacity and can directly feed into identifying adaptation options under the NAP process.

What are the expected impacts of climate change on water security?

In addition to the underlying vulnerabilities, assessing the potential future impacts of climate change can provide valuable evidence to support the identification of adaptation options to manage future risks. This section looks at approaches to identify water related impacts of climate change.

Initial framing of priority climate change impacts

An initial step in the impact assessment process is a stakeholder engagement with relevant specialists in order to broadly scope the potential climate impacts on water resources by sector. Water management is a cross sectoral issue and requires coordination, however, many of the institutional water management tools and specialisms operate at a sectoral level. Therefore it is vital to engage with water dependent sectors in the NAP process.

Table 2.5 presents direct climate impacts on water resources by sector. These have been defined pragmatically on the basis of commonly used sector led management arrangements related to water. However, these definitions will need to be adapted to accommodate national arrangements.

Holding workshops with sector specialists, water management and climate change specialists and using this table as a starting point, identify those impacts which are relevant and of high priority to development objectives. The table is indicative and should be refined and added to on the basis of national intuitional structures and priority water issues. This will result in a refined table of potential climate change impacts at the national level which are relevant to the national context. Very simple climate change scenarios can be used to pose 'what if' type questions, such as what would happen to irrigated agriculture if droughts became a more frequent occurrence. These types of very simple scenarios avoid the need for complex a time consuming downscaling of GCM outputs and allow a quick exploration of potential issues which may arise as climate changes. In some circumstances it may prove more straightforward to discuss the impacts of past natural variability such as floods and droughts with stakeholders, and use this evidence from past events to consider how future changes may alter levels of risk.

Such workshops will need to be aligned with national NAP processes to avoid duplication or replication. It will be more resource effective to integrate the aims of the workshop into planned workshops being undertaken as part of the NAP process, as appropriate.

Classifying potential impacts as high / medium / low risk can be undertaken on the basis of consensus amongst stakeholders on their perceived severity and the climate change scenarios which have been developed. Further information on the criteria which can be applied to assess level of risk are provided in the Technical Guidelines (Section B.2.B), and these should be adapted to suit individual country priorities. Engaging with a wide range of stakeholders, including a cross section of water users relevant to the country context will be required to gain a comprehensive picture of the different impacts at local / national / regional level and amongst communities, businesses and public sector user groups.

Table 2.5 - Synthesis of climate change impacts on water at a sectoral level

	Municipal water use (Industry / public supply)	Rural water supply / smallholder irrigation	Irrigated agriculture	Hydropower	Ecosystems services	Inland fisheries	Inland navigation	Drainage and sanitation
Temperature / Evaporation rates	Change in demand for water	Change in demand for water for irrigation and public supply	Change in demand for irrigation water to maintain yields	Change in evaporation from hydropower reservoirs	Changes in viability of habitats and ecosystems services	Changing viability of fisheries, evaporation from lakes and reservoirs	Change in evaporation from lakes and reservoirs	
River flow	Change in availability of water for supply from rivers and reservoirs	Change in availability of water for rural communities from rivers and reservoirs	Change in availability of water for irrigation from rivers and reservoirs	Change in availability of water for hydropower	Change in in availability of water for ecosystems dependent on river flows	Change in availability of water for fisheries	Change in availability of water for navigation	
Groundwater recharge	Change in availability of water for supply from groundwater	Change in availability of water for rural communities from groundwater	Change in availability of water for irrigation from groundwater		Change in availability of water for ecosystems dependent on groundwater sources			
Extreme rainfall and river flooding	Risk of water supply infrastructure damage and system contamination	Risk of water supply infrastructure damage and system contamination	Risk of irrigation infrastructure damage and sedimentation	Risk of hydropower infrastructure damage and sedimentation	Risk of ecosystem damage and reduction of ecosystem services	Risk of damage to infrastructure and stocks	Risk to vessels and ports, sedimentation of river and lake systems	Risk of drainage infrastructure damage, sedimentation and inadequate capacity
Storm surge / sea level rise	Risk of water supply infrastructure damage and system contamination	Risk of water supply infrastructure damage and system contamination	Risk of irrigation infrastructure damage and sedimentation		Risk of ecosystem loss/damage and reduction of ecosystem services	Risk of damage to infrastructure and stocks	Risk to vessels and ports, sedimentation of river and lake systems	Risk of drainage infrastructure damage, sedimentation and inadequate capacity

Quantitative and qualitative impact metrics

Impacts can be measured using a number of approaches depending on the question being posed and the availability of data and information to support the assessment. The most useful and appropriate unit of measurement should be considered when defining the scope of an impact assessment.

- **Economic units** – This can be a powerful tool for communicating impacts in terms which decision makers can easily identify with. Often high level assessments measure impacts of damages in percentage of Gross Domestic Product (GDP). In the context of water, the economic impacts of drought or other climate change risks to key economic sectors can be reported, however, this requires substantial modelling and assumptions in order to support the quantification of impacts. Box 2.5 gives an example of an impact assessment on the economy of Kenya.
- **Other quantitative units** – Impacts can also be measured in terms of a wide range of units depending on the modelling approach applied. Basin water resources impacts can be measured in terms of a percentage reduction in river flows, flood risk in terms of increased areas at risk, hydropower and energy in terms of reduced production capacity. Box 2.6 presents the example of an assessment of climate change impacts on hydropower production, which measures impacts in percentage change in power generation as well as looking at macro-economic impacts.
- **Semi-quantitative indicators** – Where it is difficult to measure impacts quantitatively, or it is not possible to reasonably compare different types of impacts, indicator scores may be used. These can be developed on the basis of stakeholder or expert perspectives on the relative severity and likelihood of impacts.
- **Narrative impacts** – Where it is not possible to develop indicators, simply qualitatively identifying and describing potential impacts can be useful. A narrative approach can capture impacts which are difficult to measure such as environmental, cultural, legal or reputational impacts. Combining a narrative discussion of impacts with a more quantitative approach can help to deal with complexity while also providing quantitative evidence where this is possible. Box 2.7 presents an example of how a participatory approach has been used in SADC to qualitatively assess the impacts of climate change on water resources.

Box 2.5 Economics of climate change in Kenya[xv]

To better understand the economic impacts of climate change in Kenya, the UK's Department for International Development (DFID) and Danish International Development Agency (DANIDA) funded studies by the Stockholm Environment Institute (SEI) to assess the economic impacts of climate change in Kenya and two other East African countries.

The aims of the Kenya study included to assess the impacts and economic costs of climate change for Kenya, considering key sectors of the economy as well as non-market sectors such as health and ecosystems, and to analyse the costs and benefits of adapting to these effects over different timescales.

The study findings provided a sobering warning to high-level decision-makers on the potential economic impacts of climate change. Annual losses 2.6% of GDP were predicted to occur by the 2030s. Extreme events would have an increasingly dramatic impact on infrastructure and the built environment, and other key sectors such as agriculture, industrial processing, manufacturing, tourism, infrastructure and health would also be impacted.

Box 2.6: Climate change and hydropower in central Tanzania

Central Tanzania is critical in terms of hydropower generation, contributing 50% of Tanzania's hydropower production capacity. A recent study has shown that by the year 2030, the low availability of hydropower might lead to significant additional costs for the country if it chooses to use thermal technologies, which are more expensive than hydropower. In the high-climate scenario, the expected losses would lead to a 1.7% decrease in national Gross Domestic Product (GDP) in 2030. Even in the moderate-climate scenario, it would imply a 0.7% decrease in national GDP. However, efficiency provides a no-regrets option.
The analysis showed that it is possible to compensate most of the expected shortfalls in power production by implementing energy efficiency measures such as demand reduction and/or reduction of spills at hydropower dams. To assess more accurately the impact of droughts on power generation, historical rainfall data were correlated with historical power production at Kidatu, the largest hydropower plant in the country. The analysis revealed that 1 GWh can be produced for every 2 mm of rain in the central region of Tanzania. This result was then extrapolated to all hydropower schemes in central Tanzania, which provided an understanding of the amount of hydropower available under the different climate change scenarios considered. It was estimated that although the energy reserve margin by 2030 could be as high as 26% with no climate change, it could fall to 12% under moderate climate change, or 0% in the high climate change scenario. Typically a reserve margin under 15% is considered to be a risk.

Source: ECA, 2009

Box 2.7 Climate and demographic stresses on transboundary resources in SADC

The regional climate change programme[xvi] was a programme of work with Southern African partners on the impacts of climate change, with the broad objectives of increasing regional participation in globally funded adaptation projects and improving resilience. The study objectives were to:

- better understand climate- and water-related impacts and risks associated with change in transboundary basins throughout the region
- highlight regional vulnerabilities in the ability of countries, river basins and the region to adapt to these emerging risks and potential climate change
- explore approaches to evaluating these impacts, based on the characteristics of these basins, typical availability of information and the inherent uncertainty around change.

The approach that was developed for this assessment was built around three fundamental elements: qualitative assessment, scenario analysis and representative basin case studies. Three river basins were selected (the Okavango, Zambezi and Limpopo) using the following key criteria: geographic spread (reflecting different climatic, hydrological and institutional conditions); inclusion of a diversity of 'climate and water' stories; strategic relevance and climate vulnerability from a regional perspective; and information availability.

The study identified two climate change scenarios and two development scenarios, giving a matrix of four plausible future scenarios. Themes of climate change impact on water resources were developed through the use of regional workshops to develop: i) baseline assessment of current conditions; ii) syntheses of basin development plans; and iii) identification of significant climate and water stories or scenarios.

This qualitative analysis allowed an exploration of the key challenges facing transboundary basins in SADC and presented lessons that can be carried forward for the development of national and regional climate resilience.

Tools to support water related impact assessment

A wide range of decision support and modelling tools are available to assess the impacts of climate change on water resources, and the resulting impacts on water dependent sectoral activities. These modelling tools are most often used for planning and design purposes but can be adapted to include an assessment of climate change impacts assessments. Figure 2.2 gives a schematic overview of the types of modelling tools most commonly used to assess the impacts of climate change on water resources systems and the sectoral activities they support. It should be noted that these models often require a substantial amount of input data in order to generate credible outputs. This may only be available or justified in larger river basins or where significant investment or development is planned. Participatory tools for vulnerability assessment are likely to be more appropriate at the level of rural communities. Box 2.8 gives the example of climate change impacts modelling in the Mekong basin in which a range of technical tools are used to quantitatively model the impacts of different climate and development scenarios on the availability of water and flood risk.

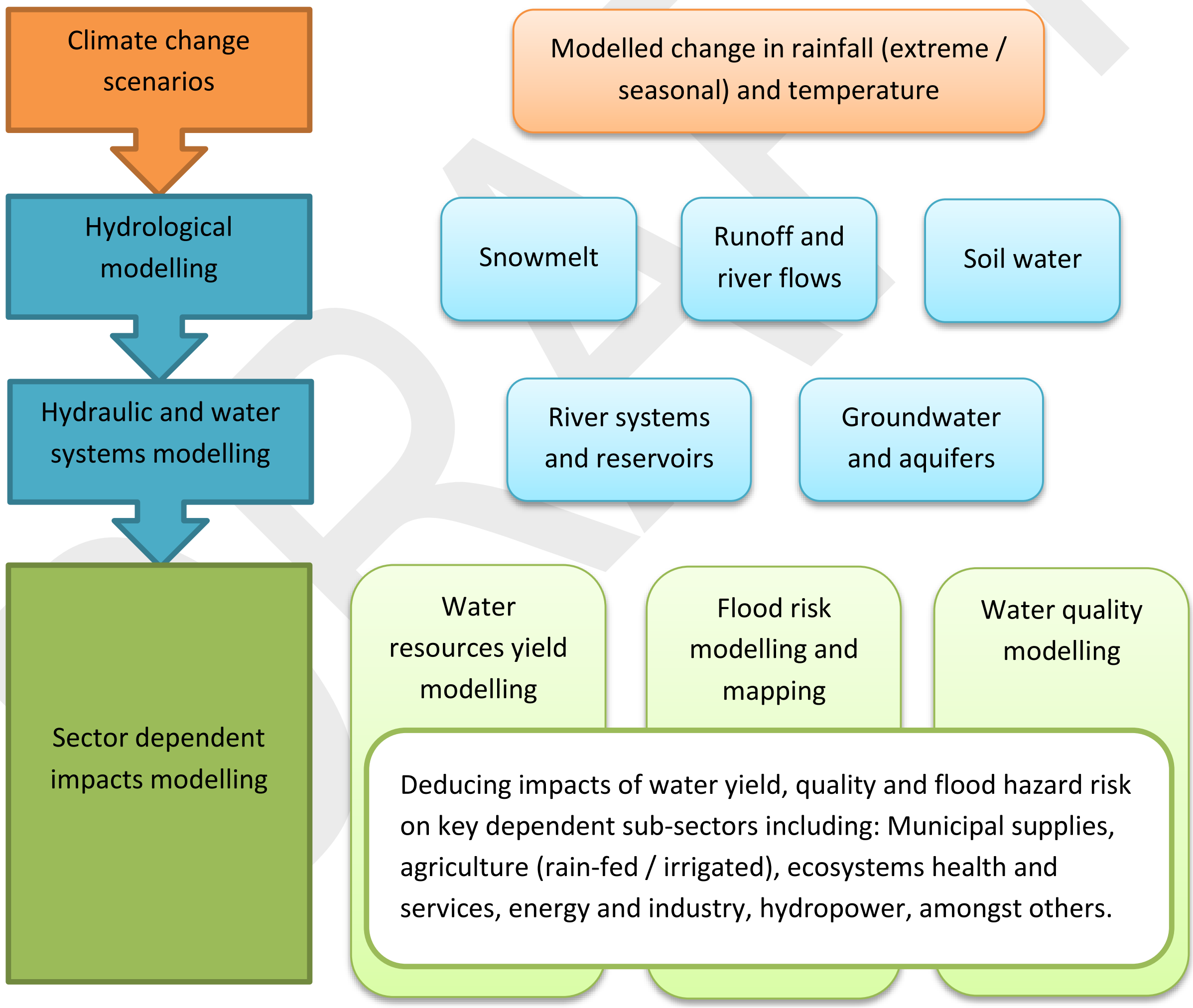


Figure 2.2 - Schematic overview of the types of models which can be used to assess the impacts of climate change on water resources systems

Where models and decision support systems already exist much of the groundwork in collecting baseline data and building and validating models will have been completed. In this case, the models can be adapted to include scenarios of future climate change and socio-economic scenarios and utilised as impact assessment tools.

A key point is to ensure that models and decision support systems are validated in the context of their representation of how biophysical systems operate at present, particularly under historic climate variability, before assessing how climate change may alter responses to the systems.

Climate change scenarios used to stress test the models should also be carefully constructed to cover the range of uncertainty in GCM model projections. In cases where there is a high degree of uncertainty in future rainfall patterns for example, it is important to have a small number of composite scenarios which span a range of possible futures. Given the uncertainties associated with GCM projections, climate change specialists are increasingly using broader sensitivity analyses to understand how systems respond to range of climate stresses. This gives a better understanding of system behaviour than the use of a narrow range of GCM projections. Once the sensitivity is well understood, the potential range of climate change projections can be mapped onto it. This process is referred to as Decision Scaling. It represents a move away from top down impact assessment approaches, placing less reliance on the highly uncertain GCM projections. Further information on the approach can be found in Garcia et al. (2014).

Box 2.8 - Mekong River Commission (MRC) Toolbox – an example of using modelling tools to understand and assess risks in the Mekong system

The MRC are responsible for managing the sustainable development of water resources for the Mekong River. The commission, combining efforts from Cambodia, Lao PDR, Thailand and Viet Nam, have been conducting research and documenting data since 1959. They have recently released the MRC toolbox, which facilitates access to and use of the data collected, as well as relevant decision support tools for to support decision making across the 4 countries.

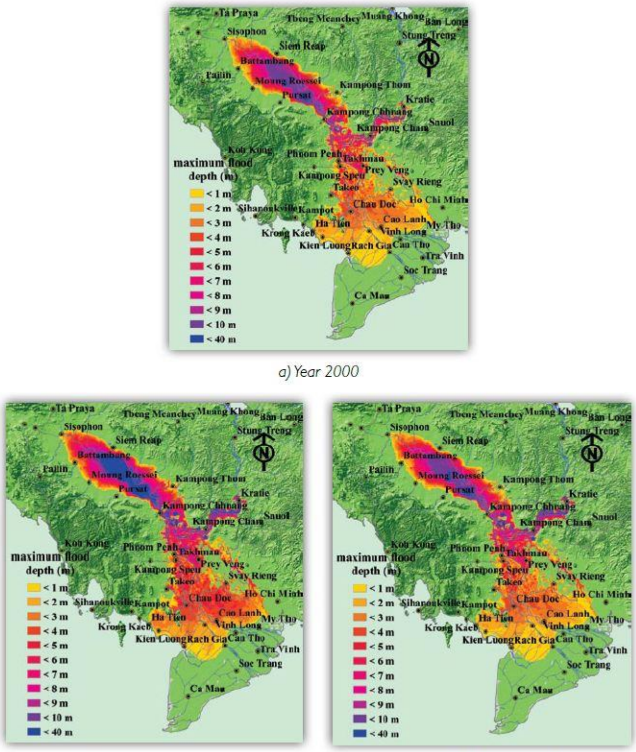
Modelling the flow of the Mekong is one example of the many studies completed by the MRC. It was conducted by producing a bespoke software model of the Mekong's hydrologic and hydraulic characteristics. The hydrological cycle was modelled by balancing the rainfall and flow. Data required included rainfall and temperature records, flow gauge measurements, digital maps (topography, vegetation, land use) and hydrographic atlases (describing the depth, geometry and morphology of the river). The hydraulic modelling was validated using historical and current data.

This model was then used to assess the impacts of climate change by varying the input data. For example, increasing rainfall and testing likelihood of flooding. Other inputs of potential interest include rainfall, evaporation, temperature and vegetation data.

Three potential future flow regimes were created, based on varied increase in hydropower generation and irrigation. These new inputs were used in the model, and for ease of description the catchment was split into 6 'sub-catchments', called hydro-geographic zones (collections of similar land-type taking into account land use, resource develpments and hydrology amongst other factors). The trend in hydrological periods (dry seasons, flooding seasons, and transition seasons) was also documented in the model. The results of these future scenarios showed significant variation in seasonal flow; including increased flow during dry seasons and delayed starts to the flood season. This study will be used to cross-check results of future risk assessments.

Further information on the Mekong River Commission is available online at http://www.mrcmekong.org/

Chu Thai HOANH1, Kittipong JIRAYOOT2, Guillaume LACOMBE1, Vithet SRINETR2, 2010. Impacts of climate change and development on Mekong flow regime. First assessment – 2009. MRC Technical Paper No. 29. Mekong River Commission, Vientiane, Lao PDR. Available online at



a) Year 2000

b) Year 2048 (Scenario A2)

c) Year 2047 (Scenario B2)

Figure 6.Estimated flooded area without climate change (a) and with climate change (b) and (c)

http://www.mrcmekong.org/assets/Publications/technical/tech-No29-impact-of-climate-change.pdf

What are viable cost-effective adaptation options to reduce the impacts of climate change or to exploit opportunities?

Work to assess vulnerability, impacts and adaptive capacity identify opportunities for adaptation. However, the NAP process seeks to enhance the coherence of adaptation and development planning, rather than duplicating efforts already undertaken or underway. A start point for identifying adaptation options is therefore to systematically work through existing water-related strategies, programmes and plans to identify already identified options.

Reviewing existing strategies, programmes and plans

At the national level, the following provide a useful starting point:

- **National Adaptation Programmes of Action (NAPAs)** identify priority climate change adaptation activities in response to the immediate needs of a country with consideration to its vulnerability. While progress has been made to address immediate and urgent climate change impacts through the National Adaptation Programmes of Action (NAPA) process, not all NAPAs have been implemented in full and many include no/low regret options that are equally as valid as short-term measures as well as in medium- and long-term adaptation plans. More than a third of the overall projects submitted to UNFCCC (by 50 countries) were water related projects and most were categorised as high priority (priority 1 or 2). The portfolio of projects cuts across many sectors and sub-sectors including health, food security, energy, disaster management and early warning, infrastructure, water resources, ecosystems, and education and capacity development. Water security is therefore a high priority as an adaptation issue, and plays an important role to build resilience by linking both adaptation and development.

- **National Communications** are produced for the United Nations Framework Convention on Climate Change (UNFCCC). They contain information on greenhouse gas emissions, vulnerability and adaptation to climate change, and climate-related policies and measures[10].
- **IWRM and Water Use Efficiency Plans** …. A short term target was agreed following the World Summit for Sustainable Development in Johannesburg to develop integrated water resources management and water efficiency plans. Many countries have progressed towards this and the plans provide a source of no/low regret adaptation options.
- **National strategies and plans** - To get the best understanding of the national and where possible local contexts, any other programmes and strategies of relevance to the country or sub-region interests should also be identified and their priorities understood.
- **Sub-sector strategies and local development plans** – These strategies and plans can highlight needs and opportunities for targeted interventions such as pilot projects for reforming management practices or introducing new technologies. Lessons from these types of initiatives can be taken to national level for replication or upscaling.

Using screening approaches to identify adaptation options

In this section, climate risk screening is presented as an approach to bring stakeholders together and rapidly assess existing planning and decision making processes to identify climate risks and adaptation options which can be integrated within these processes. It provides a useful entry point to kick start the process of engaging stakeholders in the NAP process.

Identifying entry points for climate risk screening

Climate risk screening is a process by which an analytical framework is applied to activities, projects, plans or policies which assists in identifying risks and opportunities to integrate adaptation into existing decision making processes.

The first stage in risk screening is to bring together the relevant stakeholder group in order to identify those planning and decision making activities which should be screened for climate change risks. In the context of water this may involve a wide range of stakeholders from basin authorities, ministries of water, energy, environment and agriculture, water service providers, irrigation and hydropower operators. Specialisms may include policy advisors, project preparation, regulation and permitting, scientific and research amongst others.

The make-up of the stakeholder group will vary depending on the water related goals and priorities within the country.

Having engaged the relevant stakeholder group, the next step is to identify the planning and decision making activities which should be screened for climate change risks. Some potential water

[10] http://unfccc.int/national_reports/items/1408.php

related activities which may be screened to identify options to integrate climate change adaptation include:

- High level **policies and strategies** for water resources management and basin planning
- **Operational protocols** for water systems such as water supply, reservoirs and other raw water systems, irrigation systems
- **Investment and development plans** for infrastructure investments
- **Existing and planned assets** such as dams and reservoirs, water supply systems, irrigation systems, intakes, drainage systems
- **Regulation and legislation** such as taxes, subsidies, incentives, industry regulations, environmental and land use planning regulations
- **Financing and budget preparation processes** such as annual budget preparation, conditionality for financing infrastructure investments

The key consideration in this steps is to understand the processes by which decisions relating to water management are taken. These are the processes which can provide the entry points for integrating climate change adaptation into the standard practices of development planning.

Table 2.6 provides further examples of water related decision making processes which could be screened, broken down by sub-sectors of water use. These are indicative rather than comprehensive and should be validated through the stakeholder engagement process.

Table 2.6 - Examples of activities, projects, plans and policies which may be screened to identify opportunities to integrate climate change adaptation into decision making

Water sub-sector	Examples of activities, projects, plans and policies which may be screened
Water resources planning and management	• Existing assets and major infrastructure • Basin development plans • Water allocation and operational protocols • Environmental impact assessment (also applies to all other sub-sectors)
Transboundary water management	• Existing assets and major infrastructure • Basin development plans and strategies, for example for floods or droughts • Water allocation and operational protocols • Transboundary water agreements
Water supply and sanitation	• Community level water supply systems • Existing water supply assets and major infrastructure • Water infrastructure development plans (reservoirs, intakes, pipelines, distribution networks) • Water system operational procedures • Water system contingency planning
Agricultural water management	• Community level agricultural livelihoods and small scale irrigation systems • Land use management programmes • Agricultural incentives and subsidies • Existing irrigation assets and major infrastructure • Irrigation development plans (reservoirs, intakes, pipelines, distribution networks) • Irrigation system operational procedures • Irrigation contingency planning
Water and energy	• Risks to existing and planned hydropower installations • Risks to thermal generation plants (for example flooding or cooling water availability) • Hydropower operation and management protocols • Energy infrastructure and transmission

Water for the environment	• Ecosystem management plans and processes • Ecosystem restoration programmes • Green or natural infrastructure plans
Flood and natural disaster risk	• Contingency and emergency planning • Spatial planning regulations • Land zoning and management practices • Livelihood activities and small scale agriculture • Critical infrastructure (for example: transport, healthcare, energy, WSS) • Key economic contributors (for example mining, industry, agriculture

Screening decision making for climate risks

Climate change risk screening may use a simple framework which examines existing climate risks to a decision making activity, considers how these may change in future and then identifies options which could reduce the most severe risks by adjusting the decision making process. Figure 2.3 conceptualises this process.

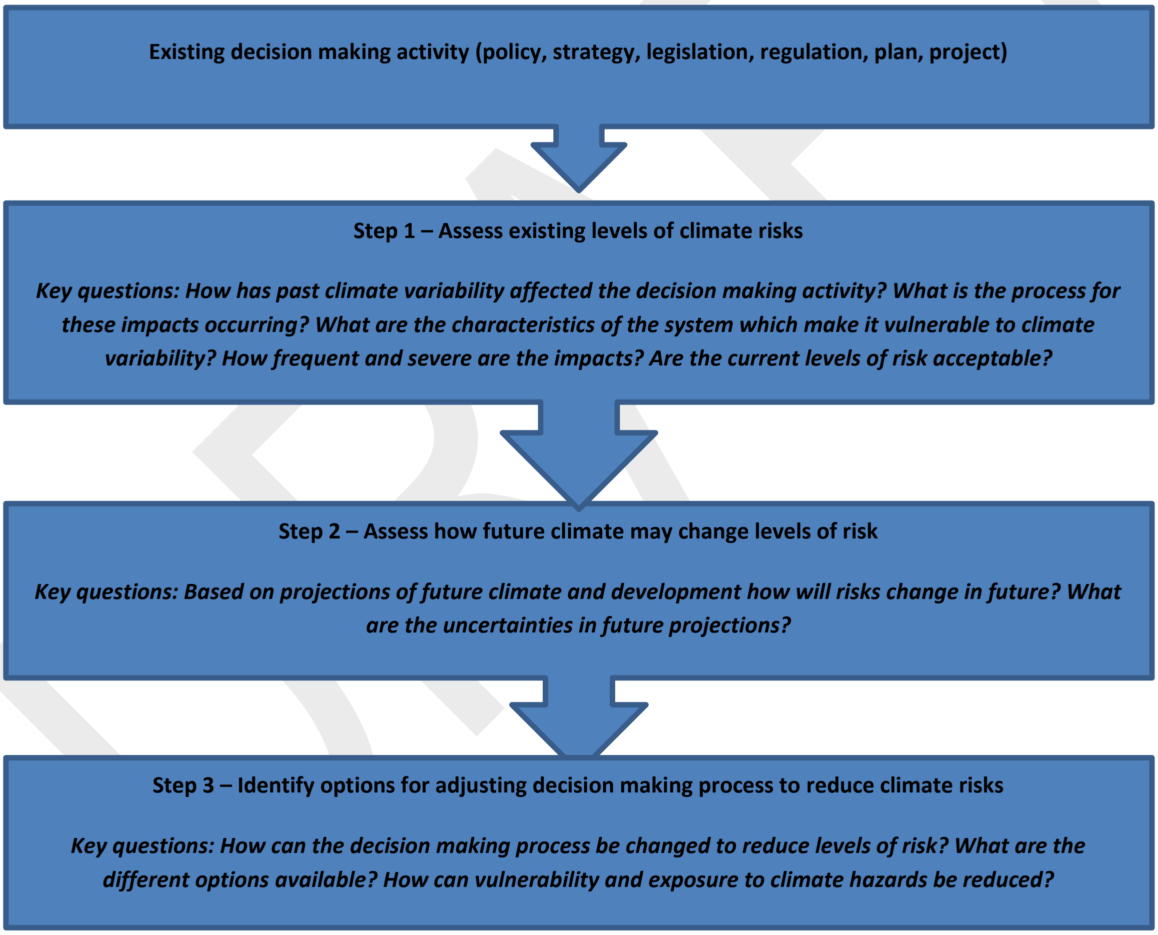


Figure 2.3 – Conceptual climate risk screening process

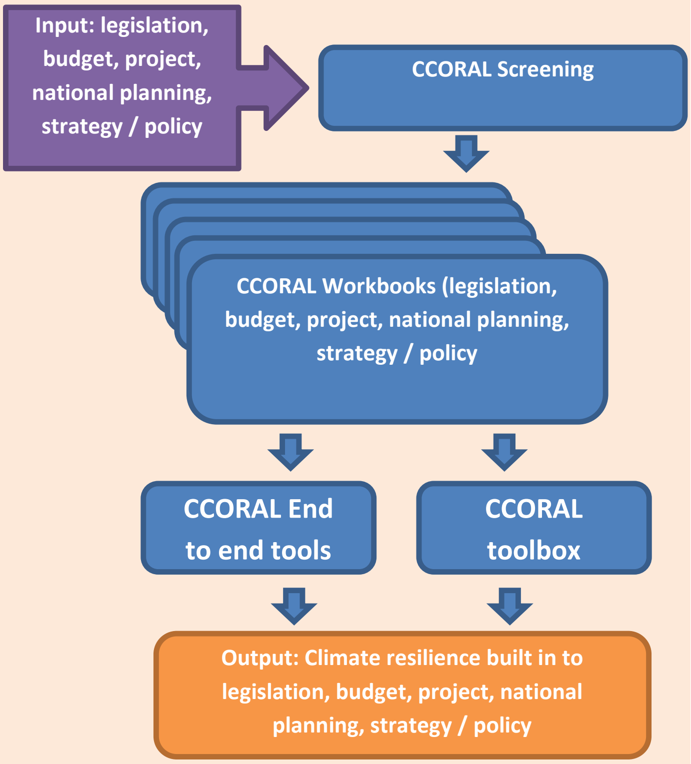
The NAP process does not specify risk screening, nor does it recommend a particular tool for screening climate risks. Therefore this guidance provides an overview of risk screening and presents an example of a tool which can be applied. It is recommended that the risk screening approach and tools are developed to be appropriate to each country's requirements under the NAP process. This might involve developing new screening tools or adapting existing tools.

Box 2.9 provides the example of the Caribbean Climate Online Risk and Adaptation tool (CCORAL) developed specifically to address the needs of government planners for a wide variety of decision making activities across all sectors. This type of screening approach can be readily applied to water related decision making and could be adapted by NAP teams to support this step in the NAP process.

Box 2.9 - The Caribbean Climate Online Risk and Adaptation tool (CCORAL)

CCORAL has been developed by the Caribbean Community Climate Change Centre (CCCCC) and was launched in July 2013. CCORAL provides an online platform which can be used to screen policies, legislation, plans, programmes, projects and budgets to identify climate risks and options which can build resilience, supporting sustainable development in the Caribbean.

It uses a series of checklists and worksheets to guide non-climate change specialists through the process of identifying how climate variability and change may affect the decision making activity. A toolbox then helps the user identify resources which may help them identify adaptation options. The CCORAL tool is web-based so can be continually supported and improved as required by users.



CCORAL is available at the following website http://ccoral.caribbeanclimate.bz/about

Categorising adaptation options

Adaptation options transcend water dependent sectors, spatial scales and levels of decision making. Action is required in all water-dependent sectors, at all scales from transboundary to national and local, and from policy and legislation down to project scale decision making. A pragmatic categorisation of intervention or decision making levels would be:

- **Policy and strategy formulation** – the inclusion of climate change considerations in policy and strategy formulation
- **Legislation and regulation** – ensuring regulatory frameworks and economic incentives support adaptation and drive top down change through appropriate legislation
- **Data and information** – the underpinning evidence base which supports decision making for adaptation
- **Organisation and management** – options to enhance the resilience of operational activities
- **Project preparation and investment planning** – options which can enhance the resilience of investment planning activities and project preparation

The following tables present a range of options which support climate change adaptation. These have been drawn from a range of literature and can be used as a start point to consider which of these types of option are most relevant at a national level and how they could be adapted to meet local circumstances.

In addition to the following tables, the Global Water Partnership Toolbox provides a useful source of resources to help identify options to improve water management, see Box 2.10. This will support climate change adaptation by reducing vulnerability and enhancing adaptive capacity of water systems. Reviewing the Toolbox tools and case studies will provide a basis for the development of locally relevant adaptation options.

Box 2.10- The Global Water Partnership (GWP) Integrated Water Resource Management Toolbox

The IWRM ToolBox is a free and open database with a library of background papers, policy briefs, technical briefs and perspective papers as well as huge sections of case studies and references. The Toolbox also contains a wealth of tools for water management which support climate change adaptation and should be a primary resource for those involved in the NAP process when identifying adaptation options.

The GWP Toolbox is available at the following website http://www.gwp.org/en/ToolBox/

Table A.1: Adaptation options for policy and strategy formulation

Policy and strategy guide the direction of decision making at all levels and set the enabling environment for legal and regulatory reform for planning and decision making across all levels. Ensuring climate change and integrated water resource management is articulated in policy and strategies at all levels will support the consideration of these issues in plans, projects and organisational management. This requires building the capacity of policymakers in order to raise the profile and understanding of climate change risks and empowering stakeholders to contribute to policy and strategy direction.

Water sub-sector	Adaptation options for policy and strategy formulation
Water resources planning and management	• Ensuring the formulation of national water policies and strategies incorporate climate change considerations, are based on the principles of integrated water resources management, and promote the efficiency and effectiveness of water use • Integrating water resources management issues into sectoral policies dependent on water, and ensuring coordination of policy objectives • Ensuring water resources are adequately addressed in broader national climate change policies • Building the capacity of policymakers to understand climate change risks relevant to their areas of work
Transboundary water management	• Developing climate resilient pathways for shared basin development, and continuing to strengthen regional water management institutions
Water supply and sanitation	• Ensuring national policies for water supply and sanitation promote integrated water resources management and the long term sustainability of supplies by considering climate change and disaster risk
Agricultural water management	• Ensuring policies promote resilient and sustainable agriculture and the cross sectoral integration of water management in agriculture planning • Ensuring policies support innovation and research in agricultural development to promote efficiency of water use under a changing climate
Water and energy	• Ensuring energy policies incorporate climate change risks and require the cross sectoral integration of water management into energy planning • Ensuring energy policies promote water efficient technology for energy generation to offset future climate change impacts on water availability for hydropower and thermal cooling
Water for the environment	• Ensuring policies on environmental management consider the water requirements for ecosystems services and promote the protection ecosystems against competing demands and future climate changes
Flood and natural disaster risk	• Ensuring policies for disaster risk management incorporate the potential changes in risk as a result of future climate and socio-economic changes • Ensuring policies on flood risk management are integrated with spatial planning systems and enforcement is strengthened.

Table A.2: Adaptation options for legislation and regulation

Legislation and regulation including economic incentives provide the governance tools by which water and other natural resources can be managed, particularly in the context of managing private sector water users. A strong legal and regulatory environment underpins effective water management, allowing some measure of control over water use and waste and pollutant discharge. It is a prerequisite for adaptation to climate change and is therefore a low regret strategy to build adaptive capacity. Building the capacity to understand and enforce regulations is a key step to enable the process, requiring sustained stakeholder engagement and the provision of resources to support implementation and enforcement.

Water sub-sector	Adaptation options for legislation and regulation
Water resources planning and management	• Developing climate change legislation to drive forward national action on climate change across all sectors, including water. • Reviewing water laws and regulations to determine whether these support long term sustainable development of water resources and adaptation to a changing climate and amending to enhance the resilience of water management • Ensuring legislation and regulation on land management and spatial planning control support sustainable water resources management and use • Requiring the use of climate change risk screening as part of project development for significant water infrastructure projects, as part of funding conditionality • Amending infrastructure design codes to include climate change risks to long lived infrastructure • Strengthening the enabling environment for regulation through empowerment of regulatory bodies for water management, allowing for greater enforcement of existing regulations through enforcement and compliance monitoring and the use of incentives and sanctions
Transboundary water management	• Developing legislative instruments for transboundary water management which acknowledge climate variability and change
Water supply and sanitation	• Ensuring legislation and regulation applied to water service providers considers long term future planning and climate change scenarios, in order to manage climate change risks to water supplies
Agricultural water management	• Strengthening regulation of irrigation water use and water quality to support irrigation efficiency, technology uptake and benefits to other users • Integrate irrigation regulation with other agricultural and land management legislation and regulation
Water and energy	• Integrating energy regulation with water resources regulation for cross sectoral management • Requiring the use of climate change impact assessment in planning regulations for hydropower and other water intensive energy generation projects
Water for the environment	• Strengthening and enforcing environmental protection legislation including setting incentives which encourage environmental stewardship
Flood and natural disaster risk	• Ensuring flood risk is considered within spatial planning legislation and regulation, including potential long term changes in flood risk which may affect long lived infrastructure, this could include avoiding flood prone areas for critical water supply infrastructure and designing infrastructure to minimise residual risks

Table A.3: Adaptation options for data and information management

Data and information management provides the evidence which underpins decision making. The collection, management, analysis and use of data on water and climate improves the resilience of water systems and facilitating adaptation to climate change. The collection of basic water availability, water use and the impacts of natural hazards is fundamental to evidence based decision making and planning for water. Developing scenarios of future changes, such as demand for water, pollution pressures and the impacts of climate change are important in supporting long term planning. Developing technical capacity and providing resources for applied research into risk assessment and management for water is crucial to inform adaptation to climate change. Demand for policy and planning relevant information from government and agencies involved in water management should ideally drive the provision of applied research.

Water sub-sector	Adaptation options for data and information management
Water resources planning and management	• Basin planning studies which include future climate change and development scenarios in order to understand and manage future risks and opportunities • Assessments of the impact of climate change on water resources using modelling and decision support tools to quantify changes in water availability, allocation and quality • Collection and sharing of water resources data and information across users (municipal, agriculture, energy, industry) to allow integrated planning of basin resources in the context of changing extremes in climate
Transboundary water management	• Developing and implementing data sharing protocols across borders for hydro-meteorological and water system information in order to share the benefits of cooperative water development to offset the impacts of a changing climate • Regional communities of practice to share best practice in water management such as data collection, modelling and mapping and scenario development • Transboundary basin planning studies which include future climate change and development scenarios in order to understand and manage future risks and opportunities
Water supply and sanitation	• Enhanced supply system data collection and reporting to provide the information needed to target investment towards improving services and increasing overall resilience to droughts and other climate extremes • Water demand and supply scenarios which include the changes in demographics, economics and climate to understand and address the risks of future water shortages
Agricultural water management	• Seasonal forecasting and dissemination to allow irrigation managers and farmers to adapt to changing climate and increased future climate variability as well as enhancing efficiency of water use • Recording and disseminating local knowledge and good practice in agricultural water management to support the transfer of knowledge and appropriate technology leading to a more efficient water use
Water and energy	• Collecting and analysing information on hydropower system performance though historical climate extremes such as floods and droughts. This can be used to generate lessons on managing future climate risks and enhancing the overall resilience of systems to extreme events • Energy sector climate risk assessments which provide information on water requirements for energy provision (thermal and hydropower) and understand risks to energy generation posed by climate extremes and competition across multiple uses of water
Water for the environment	• Collection of data on ecosystems services provided by water (for example wetlands, rivers, upland watersheds) such as livelihood services, flood management, biodiversity, tourism, water quality management. This can be used to inform the improved management of water and maintenance of ecosystems services in the context of climate change and development
Flood and natural disaster risk	• Collecting data on natural disaster characteristics such as droughts and flooding and their impacts to underpin estimates of future natural disaster risks under climate change and the options to manage disaster risks • Development of scenarios of future flood risk based on changes in climate and river basin development in order to provide the information needed to manage flood risks in the context of an uncertain future climate • Development of flood modelling capability and national standards of flood risk for planning to improve understanding and management of flooding • Development of flood zone modelling and mapping to inform spatial planning policies and regulations, reducing the risk of future flooding in all future climate scenarios

Table A.4: Adaptation options for organisation and management

Organisation and management refers to the institutional arrangements for managing water resources and the operation procedures and practices for water management. These aspects are crucial for climate resilience as they are the front line of managing current climate variability and competing demands for water resources. Flexible operational practices which can successfully manage variable water availability and natural hazards to minimise negative impacts and maximise equitable benefits increase the adaptive capacity of water management to future change. This requires robust and effective water management institutions with clear and agreed operational guidelines which are periodically reviewed as circumstances change.

Water sub-sector	Adaptation options for organisation and management
Water resources planning and management	• Managing climate variability and maximising operational efficiency using effective water allocation protocols across users, including drought management practices and procedures • Periodic review and adjustment of operating protocols in order to ensure they are able to adapt to changing development and climate pressures, and maximise benefits across users
Transboundary water management	• Integration of operational procedures across transboundary basins in order to maximise the efficiency of water allocation at basin scale and share benefits
Water supply and sanitation	• Developing effective drought management protocols to minimise the negative impacts of drought on users, this can include the development of operational rules and implementing tiered restrictions • Maximising efficiency in operations such as treatment, distribution and wastewater treatment through real time management, leakage reduction and investment in technology • Improving sanitation to realise health and ecosystem benefits, making more water available for use and offsetting climate change impacts on supplies
Agricultural water management	• Developing effective drought management protocols to minimise the negative impacts of drought on users, this can include the development of operational rules and implementing tiered restrictions • Developing risk sharing mechanisms such as insurance to offset risks posed by natural variability and enhance resilience to long term change • Managing the release of pollutants and nutrients into watercourses to preserve ecosystems services and downstream uses
Water and energy	• Developing flexible hydropower operation rules to maximise benefits and manage droughts / floods
Water for the environment	• Developing allocation protocols which include environmental flows to preserve ecosystems services and critical habitats, maintaining resilience of ecosystems to climate change • Developing aquatic ecosystems management processes to maintain ecosystems services, allowing for the impacts of floods and droughts and balancing human development pressures
Flood and natural disaster risk	• Developing flood forecasting and warning systems to increase resilience to current and future variability • Enforcement of spatial planning with respect to natural hazards management and development control within hazard prone areas • Developing insurance and risk sharing products to manage the residual risks of flooding on populations, especially vulnerable populations

Table A.5: Adaptation options for project preparation and investment planning

Project preparation and planning investment strategies provides a useful entry point to adapt to climate change. This is the point at which critical decisions regarding the long term development of water resources, and the selection and specification of individual infrastructure assets are made. Water infrastructure projects can often have long lasting fixed capital investments for which the risks of climate variability and long term change should be considered. Adjusting decision making processes to include climate change risks and developing the capacity of planners to understand climate change are important to ensure project preparation and investment planning support climate resilience.

Water sub-sector	Adaptation options for project preparation and investment planning
Water resources planning and management	• Considering climate change projections when preparing large multi-purpose infrastructure projects. This might include sensitivity testing of the impacts of river flow changes on future performance, and the identification of efficiency measures to offset this risk • Investigating both supply side (surface, groundwater) as well as demand side options (such as efficiency increases, leakage reduction, demand management) when carrying out long term water resources planning
Transboundary water management	• Considering climate change when planning major infrastructure in transboundary basins, this might include developing scenarios of climate change and development by riparian states on the performance of infrastructure.
Water supply and sanitation	• Assessing climate change risk to water supplies as part of strategic planning of water supplies, this could include projecting long term trends in supply and demand which includes climate change and considering the most appropriate investment programming to manage future uncertainty • Assessing the climate change impacts on a range of different potential water supply infrastructure options such as different mixtures of groundwater, surface water and water re-use, in order to identify infrastructure which is robust to climate change • Including assessments of the impacts of droughts and simple climate change scenarios when undertaking small rural water and sanitation projects • Investing in technology which maximises the efficiency of water supply systems
Agricultural water management	• Scenario planning of the performance of major irrigation plans under climate change, including sensitivity testing of yield projections to understand the level of risk posed by climate variability and change • Investing in technology to improve water efficiency such as drip irrigation and other technologies
Water and energy	• Considering climate change projections when preparing hydropower projects. This might include sensitivity testing of the impacts of river flow changes on future performance, and the identification of efficiency measures to offset this risk • Assessing the climate change impacts on planned energy infrastructure, such as the availability of water for thermal power station cooling, to understand the potential future risks and identify measures to reduce consumptive use as far as practicable or use alternative energy sources
Water for the environment	• Assessing risks to the long term sustainability of ecosystems management practices such as grazing patterns, forestry management and fisheries.
Flood and natural disaster risk	• Ensuring all types of infrastructure are resilient to natural disasters and are located as far as reasonably possible outside hazardous areas such as floodplains and areas at risk of landslide for example • Including climate change risks in design of flood protection works, this may require designing to allow flexibility for raising defences in future, or including an additional safety margin to offset future uncertainty • Investing in flood embankments, flood storage areas, natural infrastructure and other flood protection measures, as well as flood risk management such as monitoring and early warning systems

B.3 Reviewing and appraising adaptation options

Overview

Selecting priority adaptation options is set within a context of their contribution to short- and long-term sustainable socioeconomic development, their costs, effectiveness and efficiency. Categorizing adaptation options in terms of no/low regrets, climate sensitive and climate risky can be one way of undertaking this process. It will also be important take lessons learned from the piloting of various adaptation initiatives and projects into account (e.g. through the NAPA process or similar), in order to ensure that the conditions for success are in place.

Key questions for the water sector to address

Aligning with the Technical Guidelines for the NAP process, key question for water planners and managers to address in Element B.3 will include:

- What are the costs and benefits of water sector adaptation options?
- How best can the water sector adaptation options be implemented, and what are the conditions for success?
- Is it possible to identify co-benefits between the water sector adaptation options and development?

Suggested further reading

The European Union MEDIATION project has developed a toolbox for climate change adaptation planning containing range of highly relevant tools. This includes a section of tools on decision making for adaptation which covers both traditional decision making approaches as well as specialist approaches including robust decision making and real options analysis

Available at: http://www.mediation-project.eu/

The United Nations Framework Convention on Climate Change (UNFCCC) guidance on assessing costs and benefits for adaptation provides a useful introduction to options appraisal in the context of climate change adaptation. It also presents case studies on the application of various techniques

UNFCCC. 2011. Assessing the Costs and Benefits of Adaptation Options: An Overview of Approaches. The Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change. Available at: http://unfccc.int/files/adaptation/nairobi_work_programme/knowledge_resources_and_publications/application/pdf/2011_nwp_costs_benefits_adaptation.pdf

What are the costs and benefits of water sector adaptation options?

The overall goal of ranking and prioritisation is to identify the most important, yet feasible, decisions or measures to be taken that fit with the national vision on adaptation and the national goals for environmental, social and economic development. A wide range of analysis techniques are available to help prioritise options for implementation. Each has its own strengths and weaknesses and the selection of the most appropriate technique needs to be considered on a fit for purpose basis. The Technical Guidelines for the NAP process provides an overview of the main tools and includes some useful references on these tools.

It is important to acknowledge that these are not decision making tools themselves, only that they help inform the decision making process itself. Figure 3.1 provides a broad framework for the selection of the more common decision-aiding tools used in the water sector. The characteristics of the adaptation options and the main considerations to be taken into account when prioritising these can help to determine which approach is most appropriate.

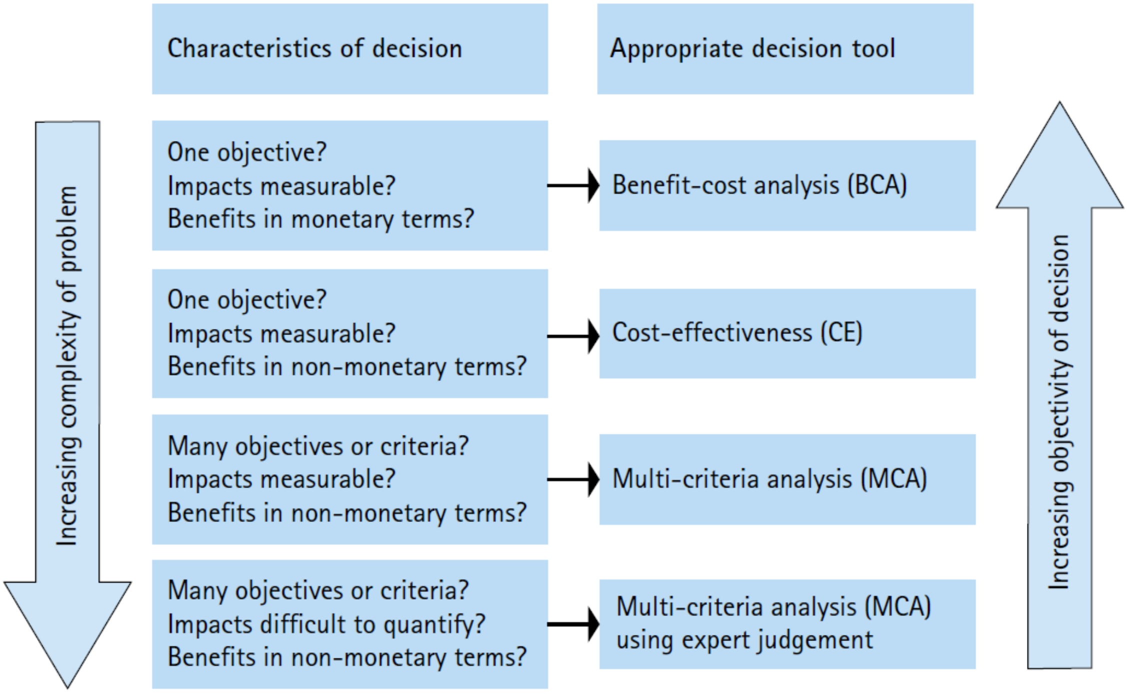


Figure 3.1 – Summary of selection criteria for decision making tools (Based on UNFCCC 2014)

Although these standard decision making techniques are well proven for prioritisation, the uncertainty in future climate change and development pathways can limit the effectiveness of these tools. Climate change uncertainty should be explicitly included in these decision making techniques, using sensitivity analyses to understand how varying future climate conditions affects the results of prioritisation. This will help to identify those options which are robust to a range of future conditions. Sensitivity analysis is also useful to understand which assumptions are the most sensitive to change, and can involve 'switching values' to understand how changing assumptions can lead to changing decisions on the priority of options.

While these decision making tools attempt to give an objective analytical framework for decision making the realities and practicalities of decision making should always be borne in mind. Ways of ensuring solutions work on paper and succeed in practice include (based on GWP, 2006a):

- Making sure that the formulation team includes people with a broad range of practical experience.
- Ensuring adequate stakeholder consultation and input.
- Striving for transparent decision-making processes.
- Being aware of and linking into existing policy formulation and budgeting processes.
- Keeping in mind the diverse, complex, and not always logical influences on human decision-making and behaviour.

Alternative decision making approaches

In addition to the widely used decision making techniques discussed above, a growing range of specialised techniques are being utilised for adaptation planning. These include Robust Decision Making, Real Options Analysis, Portfolio Analysis, Analytic Hierarchy Process, Social Network Analysis and Adaptation Turning Points (Watkiss and Hunt, 2013). These techniques can be used to assist in the identification of adaptation options, their prioritisation and the packaging of options into coherent strategies. A detailed discussion of specialised decision making approaches is beyond the scope of this supplement, Box 3.1 provides further information on these techniques.

Box 3.1 – Further resources on specialised prioritisation techniques for climate change adaptation

European Union (EU) MEDIATION project Summary of Methods and Case Study Examples from the MEDIATION Project

The MEDIATION project guides researchers, policy advisors and experts to suitable climate change adaptation methods and tools for a wide range of questions and from various disciplines and perspectives.

The MEDIATION Adaptation Platform contains a Toolbox of methods for decision making as well as a large number of other tools and techniques of relevance to climate change adaptation planning such as impacts assessment and scenario analysis. The Toolbox is available online at *http://www.mediation-project.eu/platform/*

Beyond Downscaling: A Bottom-Up Approach to Climate Adaptation for Water Resources Management.

Chapter four of this publication provides a useful overview of a range of approaches for identifying and evaluating adaptation strategies for water management. These include; No-regret / low-regret, Precautionary principle/safety margins, Sensitivity analysis, Benefit-cost analysis, Stochastic optimization, Adaptive management, Real options, and Robust decision-making. In addition the document gives valuable insights into the key considerations for adapting water management to an uncertain climate, and outlines tools which can help implement these principles.

García, L.E., J.H. Matthews, D.J. Rodriguez, M. Wijnen, K.N. Di Francesco, P. Ray. 2014. Beyond Downscaling: A Bottom-Up Approach to Climate Adaptation for Water Resources Management. AGWA Report 01. Washington, DC: World Bank Group. Available at: http://alliance4water.org/Beyond/beyond.html

Applying these specialist approaches requires an in depth knowledge and may require substantial analytical work and supporting data. Seeking specialist support to identify the most appropriate approaches, and adapting these to national circumstances and institutional processes will be required if they are to be successfully adopted. Table 3.1 provides a summary of standard and specialised decision making approaches.

Table 3.1 - Summary of traditional and specialised decision making techniques (reproduced from Swart and Singh, 2013)

	Brief description	Usefulness and limitations in climate adaptation context
Social benefit - cost (BCA)	Evaluates all relevant costs and benefits to society of all options and estimates the net benefits/costs in monetary terms. BCA aims to directly compare costs and benefits allowing comparisons within and across sectors.	Most useful when: • climate risk probabilities are known; • climate sensitivity is likely to be small compared to total costs/benefits; • good-quality data exist for major cost/benefit components.
Social cost-effectiveness analysis (CEA)	Compares relative costs of different options and can assess alternative ways of producing same or similar outputs, identifying least-cost outcomes using cost curves. Used extensively in climate change mitigation.	Most useful when: • as for BCA, but also applicable to non-monetary metrics (e.g. health); • agreement exists on sectoral social objective (e.g. acceptable risks of flooding.
Multi-criteria analysis (MCA)	Allows consideration of quantitative and qualitative data using multiple indicators for integrating broad objectives (and related decision criteria) in a quantitative analysis. It provides systematic methods for comparing these criteria, some of which are expressed in monetary terms, some in other units.	Most useful when: • there are broad objectives and qualitative data (including non-monetary metrics); • there is opportunity/need for stakeholder input towards agreement.
Real options analysis (ROA)	Extends principles of BCA to allow economic analysis of learning, delay and future option values providing context for decisions under uncertainty. Can also provide an economic analysis of benefits of flexibility and value of information on climate risks and actions.	Most useful for: • large, irreversible capital-intensive investment, with potential for learning (especially in case of long decision/construction lifetime); • climate risk probabilities are known or the range is within bounds.
Portfolio analysis (PA)	Allows an explicit trade-off to be made between the return (measured, e.g., in net benefit terms from the BCA) and the uncertainty of that return (measured by the variance) of alternative combinations (portfolios) of adaptation options under alternative climate change projections.	Most useful when: • a number of adaptation actions are likely to be complementary in reducing climate risks.
Robust decision making (RDM)	Aims to assess robust rather than optimal decisions and stress testing options against large numbers of future scenarios. Can work with climate uncertainty or in formal approach full-system uncertainty. Can trade off economic efficiency against other criteria.	Most useful when: • there is deep uncertainty; • scenarios for alternative climate, socioeconomic and vulnerability futures can be constructed and data for their characterisation are available.
Economic iterative risk management (adaptive management	Iterative risk management (adaptive management) is an established approach that uses a monitoring, research, evaluation and learning process (cycle) to improve future management strategies extended to capture economic appraisal using conventional or alternative decision tools.	Most useful when: • climate risk probabilities are not well established or do not exist; • there are threshold levels for risks (benefits expressed in quantitative or economic terms).

The following sections provide an overview of standard decision making approaches including multi-criteria analysis, benefit cost analysis (BCA) and cost effectiveness analysis (CEA) before moving on to discuss the issues associated with addressing climate change uncertainty in prioritisation through no and low regrets options and adaptive and flexible decision making.

Multi-criteria analysis

In the case of natural resources such as water, calculating the monetary benefits of many adaptation options can be challenging – for example for options such as policy and legislative reform, watershed protection and ecosystems protection. Multi-criteria analysis (MCA) has therefore gained some traction in the sector as it can more readily take into account associated criteria for environmental, social and economic development.

Box 3.2 identifies the types of criteria which should be considered when prioritising adaptation options, based on the Technical Guidelines. One way to apply the above criteria would be to utilize stakeholder input and create a decision matrix using scores (e.g. 1=low to 3=high) for each option or strategy against the listed criteria. A simple averaging of the scores for each criterion could indicate which adaptation strategies should be implemented or prioritized. Table 3.2 gives an indicative example of this type of scoring system for the a hypothetical set of interventions aimed at increasing water security.

Box 3.2 Selection criteria for a Multi-criteria analysis (MCA)

As reflected in the Technical Guidelines, the selection of the most appropriate or relevant adaptation strategies would include considerations of a set of criteria that is in line with national goals for sustainable development. The process would need to take into account where climate impacts are likely to be most severe and who or which systems are most vulnerable. The criteria used at the national level may include:

- Timing/urgency for action: those actions for which further delay could increase vulnerability or lead to increased costs at a later stage;
- Cost: general cost of proposed strategies, including human and other resources, and where relevant, economic costs and benefits;
- Co-benefits: whether the strategies would have negative or positive impacts on other sectors or systems, including on vulnerable populations or the environment/ecosystems, or synergies with other multilateral environmental agreements;
- Efficacy: the extent to which the measure is able to effectively reduce the risk; 'No regrets'. 'No regrets' solutions are those that will have a positive impact even if climate change impacts do not occur. Such measures are especially useful when the type or degree of climate change impact is still linked to a high degree of uncertainty;
- Flexibility or robustness: measures that allow for adjustment or change in the future if climate change impacts are different from what had been expected;
- Overall contribution of the measures to poverty reduction, which will help to enhance adaptive capacity;
- Contribution to sustainable development and strategic relevance to national development goals;
- Social and political acceptance;
- Economic, social, technological and environmental feasibility.

Multi-criteria analysis (MCA) aims to aggregate measurements of benefits and costs that cannot readily be measured on the same scale; this requires the subjective weighting of the importance of the benefits and costs to allow their comparison on a common, usually arbitrary, scale. Assumptions on the relative importance of each criterion and assigning weightings themselves can be difficult. Engaging with stakeholders to discuss and agree weightings is one means of satisfying different interests across different stakeholders.

MCA has the advantage of being a participatory process in which different stakeholders may provide different responses allowing the level of consensus and agreement to be assessed. Even if a formal scoring system is not adopted, the use of criteria can form a discussion structure to raise some of the issues for and against different options. In the context of water related adaptation options, this participatory process is a useful way of managing the diverse range of stakeholders involved.

MCA has been used successfully for climate change adaptation planning in the National Adaptation Programme of Action (NAPA) process. Box 3.3 provides a grounded example of the use of MCA in the development of the Bhutan NAPA.

Table 3.2- Indicative MCA scoring table for a hypothetical example of interventions for water security

Criteria	Score = 1	Score = 2	Score = 3	Option 1 Reservoir	Option 2 Rain water harvesting	Option 3 Leakage reduction
Cost	>$10 million	>$1 million	<$1 million	2	2	2
Effectiveness of performance	Uncertain	Acceptable	Well proven	3	1	3
Risk of climate change impacts	High	Uncertain	Low	1	1	3
Total score				6	4	8

Box 3.3 - Case study of MCA application for prioritising the National Adaptation Programme of Action (NAPA) options in Bhutan

MCA was applied to determine the prioritisation of adaptation options in the development of Bhutan's NAPA. The MCA was carried out through participation of representatives from the most climate-sensitive sectors, including agriculture, biodiversity and forestry, natural disaster and infrastructure, health and water resources. This ensured that weightings assigned to options were a fair reflection of the views of a broad range of stakeholders.

Initially 17 adaptation options were identified, which were then screened to obtain a total of 9 using simple criteria designed to rapidly sift options. These criteria were:

- Climate change risks and the level or degree of adverse effects
- Demonstrated fiscal responsibility (or cost effectiveness)
- Level of risk associated with choosing not to adapt
- Complements country goals, such as overcoming poverty, enhancing adaptive capacity or other environmental agreements.

The remaining nine options were subjected to an MCA for prioritisation, whereby the stakeholder group assigned scores of 1–5 on each of the following criteria for each option. The first three criteria represent benefits and the fourth represents costs:

- Human life and health saved/protected by the intervention.
- Arable land with associated water supply (for agriculture/livestock) and productive forest (for forestry/forest products collection) saved by the intervention.
- Essential infrastructure saved by the intervention (e.g. existing and projected hydropower plants, communication systems, industrial complexes, cultural and religious sites and main tourist attractions).
- Estimated project cost.

The results for this scoring were then weighted according to an agreed importance of each criterion as determined by the stakeholder group to give a total score for each option. Finally, the scores were adjusted on the basis of whether the option was local, regional or national. to rank the options in order of priority. These priorities were used to make the case for funding the two highest priority options; namely, a disaster management strategy and artificial lowering of Thorthomi Glacier Lake.

In this MCA, the costs of implementation had a relatively low weight (0.2) compared to the benefits (0.8), indicating that achieving beneficial outcomes had a greater value than the costs incurred in doing so.

Benefit cost analysis (BCA) and cost effectiveness analysis (CEA)

The most widely used single-criterion method is benefit-cost analysis (BCA) of individual projects in which a threshold value of the result (e.g. size of net present value, benefit–cost ratio or economic rate of return) is prioritise projects. However, BCA does not address the relative distribution of benefits and costs among different stakeholders and the choice of discount rate to deal with future costs and benefits is challenging. Ensuring that social and economic costs and returns are included in the BCA and agreeing on their monetisation can be difficult but should be attempted. This is especially true in the area of natural resources management where externalities of development are far-reaching (AMCOW, 2012).

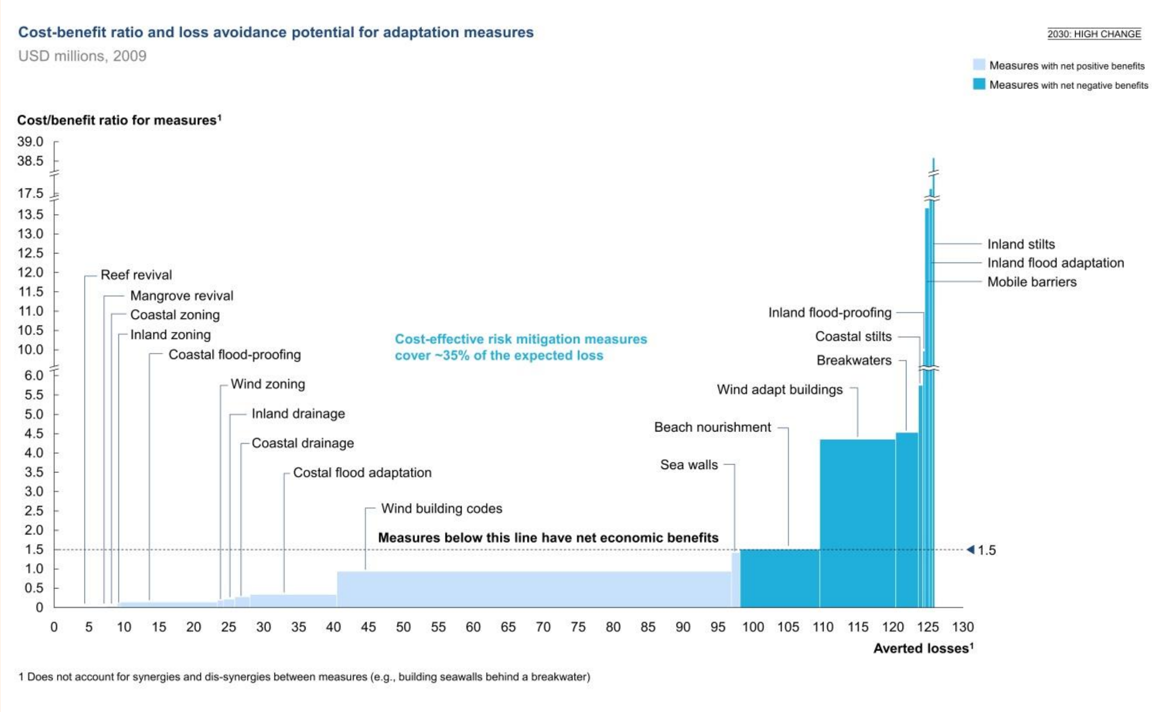
Another single-criterion method is the cost-effectiveness analysis (CEA) of a range of alternative ways of attaining the desired outcome. This is relevant where a country faces one or a small number of risks from climate change and is able to identify and cost the different ways of dealing with each of these risks. CEA is applicable where it is difficult to quantify benefits. The projects can be arranged on an ascending curve according to their cost per unit of 'benefit'. This is the basis of the adaptation cost curve by the Economics of Climate Adaptation (ECA) Working Group and has been applied by the Caribbean Catastrophe Risk Insurance Facility to prioritise adaptation options (see Box 3.4). Countries could investigate this approach as an alternative to MCA where it is possible, or desirable to monetise benefits and costs.

Box 3.4 The Caribbean Catastrophe Risk Insurance Facility (CCRIF) results of the Economics of Climate Adaptation (ECA) Study

A component of the ECA study carried out by CCRIF provided a high level estimate of the cost effectiveness of adaptation options for eight pilot countries Anguilla, Cayman Islands, Antigua and Barbuda, Dominica, Barbados, Jamaica, Bermuda and St. Lucia.

This is a methodology for the identification, assessment and ranking of projects for the reduction of climate risk. It can apply to situations where there is a specific overriding climate-related risk that can be addressed by a number of different policy responses. These responses may be alternative or cumulative in nature. The cost curve plots the quantitative impact of the various options on the problem (x axis) against their cost-effectiveness or cost per unit of benefit (y axis).

In the figure below, risk reduction options are presented for Barbados to reduce the negative impacts of climate change in 2030 under a high climate change scenario. The approach to assess the climate risks uses projections of future climate hazards (such as hurricanes) into the future as well as an assessment of the value of assets exposed to these hazards and the vulnerability of the assets (a measure of how much damage a hazard could inflict on an asset). Different adaptation options are then applied and their benefit-cost ratio together with the reduction in impact are assessed. The options are then ranked on a curve to indicate their cost-effectiveness. In the case of Barbados, the analysis indicates that reef revival, mangrove revival and coastal zoning can together avert ~$10 million in losses for a much lower cost making them attractive options. On the other hand mobile barriers, coastal stilts and breakwaters are more costly than the losses they would avert making them less attractive.



Although this assessment provides adaptation options for 2030, it would also be interesting to see a cost curve for the current climate risks. This would help identify those measures which are currently attractive and compare these with future adaptation options to identify changes in cost benefit ratio in the future. This could be used to make the case for actions to be undertaken regardless of climate change projections.

Source: CCRIF, 2010, Enhancing the Climate Risk and Adaptation Fact Base for the Caribbean: An informational brochure highlighting the preliminary results of the Economics of Climate Adaptation (ECA) Study available from www.ccrif.org
The study was implemented by CCRIF and regional partners including Caribbean Community Climate Change Centre and UN Economic Commission for Latin America and the Caribbean, with analytical support provided by McKinsey & Company and by Swiss Re, who developed the loss assessment model. It is based on the ECA framework developed by the ECA Working Group.

How best can the adaptation options be implemented, and what are the conditions for success?

There is a need for adaptation options which increase resilience towards current levels of climate variability while supporting adaptation to longer term changes in climate. The implications for water resources management are twofold:

- **Firstly, getting the fundamentals right**. General improvement in water resources management will help manage climate risks now and in the future through better information, policy, regulation, allocation and cooperation. This reduces the vulnerability to current climate variability and paves the way for more proactive climate change adaptation. These types of no and low regret options should be prioritised as effective measures to reduce vulnerability to climate change.
- **Secondly, facing the climate change challenge**. Water resources management must be adapted to consider potential climate and development change in the future to make sure it is sustainable. Substantial investments in infrastructure are required now which will have lasting effects and could

be placed at risk by climate change. Planning under this uncertainty requires a flexible an adaptable future sequencing and planning of investment decisions to manage exposure to future risks.

Prioritising no and low regrets adaptation options

The concept of no regret and low regret actions addresses the link between resilience to current and future climate risks, these are further discussed in Box 3.5. The concept is based on the premise that actions should be prioritised which manage current risks and also perform well under a range of future uncertainty. This requires a consideration of both current conditions being experienced as well as the potential future scenarios and how they would impact on the options. Ideally, no and low regret options should be prioritised as they bring benefits under existing and future conditions.

Box 3.5 – No and Low Regret Options for adapting to climate change.

No regret adaptation options are not affected by uncertainties related to future climate change because they help address problems associated with current climate variability, while at the same time, build adaptive capacity for future climate change. Investment decisions for such interventions can be taken without assessing project risks due to uncertainty on future climate. An example of a no regret intervention would be enhancing provision and dissemination of climate information as well as access to early warning systems by local communities living in flood and/or drought prone areas.

Low-regret adaptation options are those where moderate levels of investment increase the capacity to cope with future climate risks. Typically, these involve over-specifying components in new building or refurbishment projects. For instance, installing larger diameter drains at the time of construction or refurbishment is likely to be a relatively low-cost option compared to having to increase specification at a later date due to increases in rainfall intensity(World Bank, 2012).

***Source**: World Bank, 2012, Mainstreaming Adaptation to Climate Change in Agriculture and Natural Resources Management Projects. Adaptation Guidance Notes available online at http://go.worldbank.org/T3FMU3FDX0*

No and low regret options typically aim to reduce the vulnerability of systems to climate variability and to increase the capacity of the systems to adapt to a changing climate in future. It should be noted that in practice very few options are truly 'no regret' as all investments will have some opportunity cost associated with them (Wilby & Vaughn, 2011). Some indicative water related adaptation option examples are provided in Table 3.3 below.

Table 3.3 Examples of water related no/low regrets investments at different levels (AMCOW, 2012)

Planning level	Example no/low regret option
Regional level	• Data sharing • Developing decision support systems for water management • Disaster risk reduction through management of residual risks such as disaster risk insurance.
National-level	• Carrying out comprehensive climate risk assessments to inform strategic planning centrally or by sector • Building links between research organisations and policymakers for land and water management • Review of planning regulations and systems through a 'climate risk lens' to understand how guidance or regulation could accommodate climate change and climate risks

Sub-national and local levels	• Review of climate risks posed to sub-national infrastructural systems (water supply, transport, power) • Municipal flood-risk management strategy development. • Drought management planning at basin level • Land and water management demonstration projects to improve livelihoods and generate lessons • Income diversification and micro-finance to improve resilience of communities • Review of the distribution of climate risks across communities focusing on vulnerable sections of the community

Flexible and adaptive planning for water infrastructure

Climate change and future development pathways are both highly uncertain and adaptation implementation in the water sector needs to retain flexibility to respond to this future uncertainty, particularly if maladaptation is to be avoided. An iterative approach to implementation can help to ensure that decisions are not 'locked in' to a particular course of action over long time periods.

Adaptation pathways can help decision-makers to consider ways to build in flexibility through adapting incrementally over time. The aim is to develop an adaptation plan that reduces risk progressively, while avoiding foreclosing options prematurely or taking action that could mean wasted investments or unnecessary cost. Mapping out alternative pathways which can benefit from waiting and learning before making potentially inflexible and costly choices is a useful approach, see Box 3.6 for an example of the sequencing of investments in the context of coastal flood risk management.

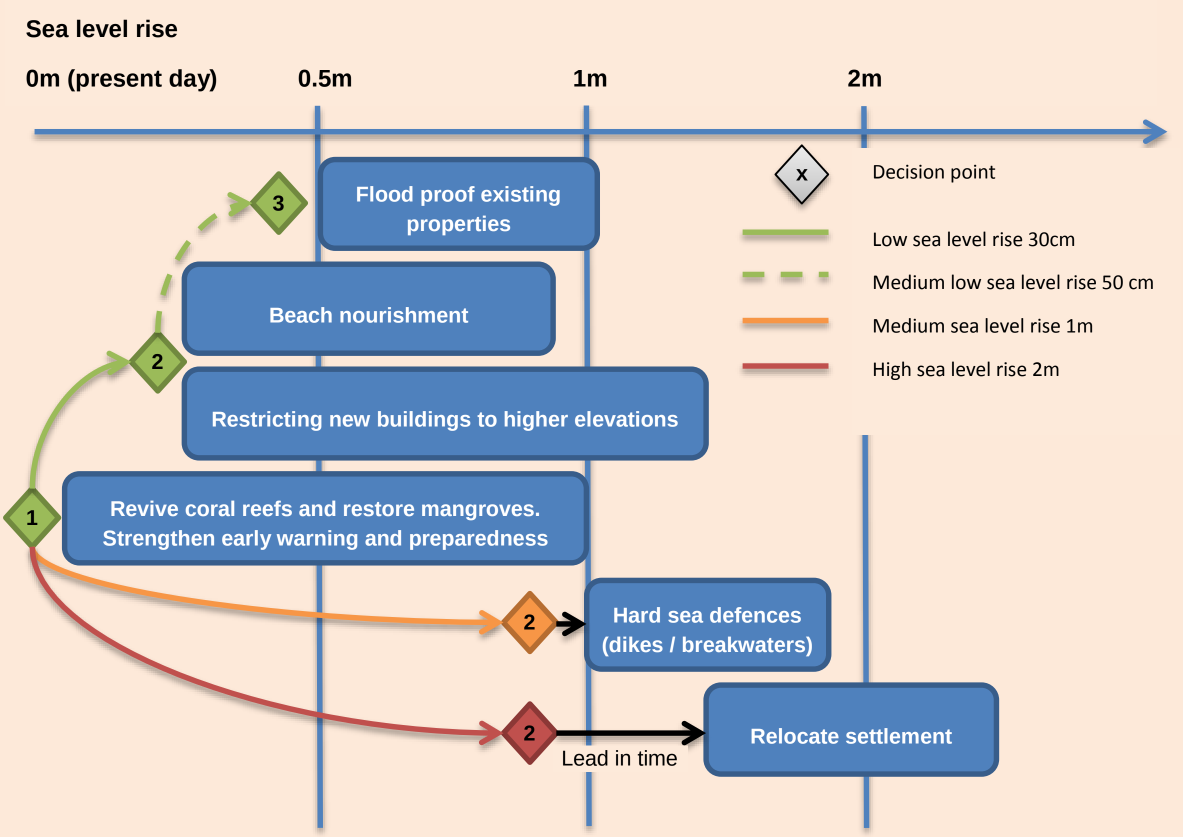
Box 3.6 – Flexible planning for climate change adaptation: a hypothetical example of coastal flood risk planning.

For this settlement, sea levels are expected to rise by between 30 cm and 1 m by 2100, but in a worst-case scenario, could rise by more than 2m. Local consultations lead to the development of a number of potential options, which are effective over different ranges of sea level rise (as shown by the positions of the blue boxes below). From here, it is possible to design packages of measures that perform best for different future scenarios. For example, if sea levels were known to follow a medium-low scenario (green dashed line), then the optimal package would include reviving coral reefs and restoring mangroves; strengthening early warning and preparedness; beach nourishment; and flood-proofing new and existing properties. In the high scenario (red solid line), the best strategy would be to begin a gradual relocation of the settlement to higher land.

A challenge for the advisers is that it is difficult to switch between these 'optimal' packages as more is learnt without incurring significant costs. For example, while it would be easy to scale up from a low to a medium-low scenario by flood-proofing properties, moving from this to a high scenario plan would mean abandoning those properties. Similarly, taking the worst-case scenario only would not be appropriate due to its high social and cultural impact.

The adaptation pathways diagram, shown below, can help an adviser to consider ways to build in flexibility through adapting incrementally over time. The aim is to develop an adaptation plan that reduces risk progressively, while avoiding foreclosing options prematurely or taking action that could mean wasted investments or unnecessary cost.

The four pathways mapped out below each involve waiting and learning before making the inflexible and costly choice between flood-proofing existing properties, building hard sea defences and relocating the settlement. But there is a cost to this delay as the settlement faces a growing danger from storm surges. To reduce this risk, the plan proposes to implement a number of low-regret measures, including reviving coral reefs, restoring mangroves, and strengthening early warning systems and preparedness. But new properties continue to be built and this will lock in increasing vulnerability – to rectify this, the plan recommends a temporary restriction on development in the flood-prone area.



From this plan it will be possible to define appropriate decision points where the decision must be made to switch to a set pathway (decisions at these points are numbered from 1 to 3). The decision point will depend on (a) the sea level rise at which an intervention becomes effective; (b) the rate of sea level rise; and (c) the lead time of the intervention. The plan requires regular monitoring and review to reassess the pathways and decision points.
This case study has been reproduced from a UK Department for International Development Topic Guide on Adaptation (Ranger, 2013)
***Source**: Ranger, N. Topic Guide. Adaptation: Decision making under uncertainty. Evidence on Demand, UK (2013) 86 pp. The original topic guide from which this case study has been reproduced is available from the Evidence on Demand website at http://www.evidenceondemand.info*

Long lived infrastructure assets present a particular cause for concern as they require substantial capital investment, will likely be operated for many decades, and may have high degrees of inflexibility once implemented. As a general approach, adaptation strategies for water system infrastructure may require actions such as:

- **Designing adaptable infrastructure**. Water infrastructure often has a long life span and will be used in climate and societal conditions which could be very different to the present day. Infrastructure which can be upsized or adjusted with minimum cost and disruption is better placed to cope with future uncertainty. This might include designing water treatment works which can be upsized in the future if demand increases more than is expected.

- **Building in safety factors to infrastructure to accommodate uncertainty in future climate**. For example, increasing the capacity of a proposed storage may be used to offset the uncertainty in future rainfall patterns. The cost of doing this during the construction phase may be much lower than attempting to add capacity at a later date or construct additional sources. However, this is only applicable where the additional upfront costs are low relative to the risk offset.

- **Utilising a range of options to achieve an outcome**. In the context of water this could include diversifying and/or conjunctive use of water sources such as groundwater, surface water, desalination, rainwater harvesting, water recycling and water efficiency measures. This spreads risk of climate change impacts across a range of measures rather than relying on a single solution. It should be noted that climate change is only one of many considerations in developing such options. For example desalination is resilient to drought but is energy intensive to operate from a cost and climate change mitigation viewpoint.

- **Supporting infrastructure with non-structural measures**. Non-structural measures are inherently more adaptable than fixed infrastructure assets for example, water tariffs can be reformed on a periodic basis and used to influence consumer demand behaviour. Investments in information, planning and policy can provide greater confidence in the planning and design of infrastructure assets.

There is a wide range of background information available on adaptive decision making and a concise introduction is provided by Ranger (2013).

Is it possible to identify co-benefits between the adaptation options and development?

Water, climate and development are inextricably linked and there are clear co-benefits between water adaptation options and development. Enhancing water security through climate resilient development will be central to achieving the post-2015 development goals (SDGs), and this is increasingly recognised within the emerging SDG goals themselves.

Effective and efficient water management delivers benefits across a wide range of sectors and functions which depend on water, including ecosystems services. Enhancing resilience of water supports disaster risk reduction, reducing the impacts of floods and droughts on society and economy, now and in the future. Improving the efficiency of water management can reduce energy requirements, and also contribute to climate change mitigation objectives. Options which support resilience as well as mitigating climate change are referred to as climate compatible development options (CDKN, 2010).

This section highlights some of important co-benefits delivered by water related adaptation. Identifying options with co-benefits and including these benefits in prioritisation will be important to maximise the value of adaptation interventions in the NAP process. Stakeholders should work across sectors to identify and buy into adaptation options which bring co-benefits to develop a broad base of support for their implementation.

Examples of co-benefits are given for wastewater treatment and sustainable land management in Table 3.4. Identifying the specific co-benefits associated with adaptation options under the NAP process will be important in determining the high priority options which deliver wide benefits.

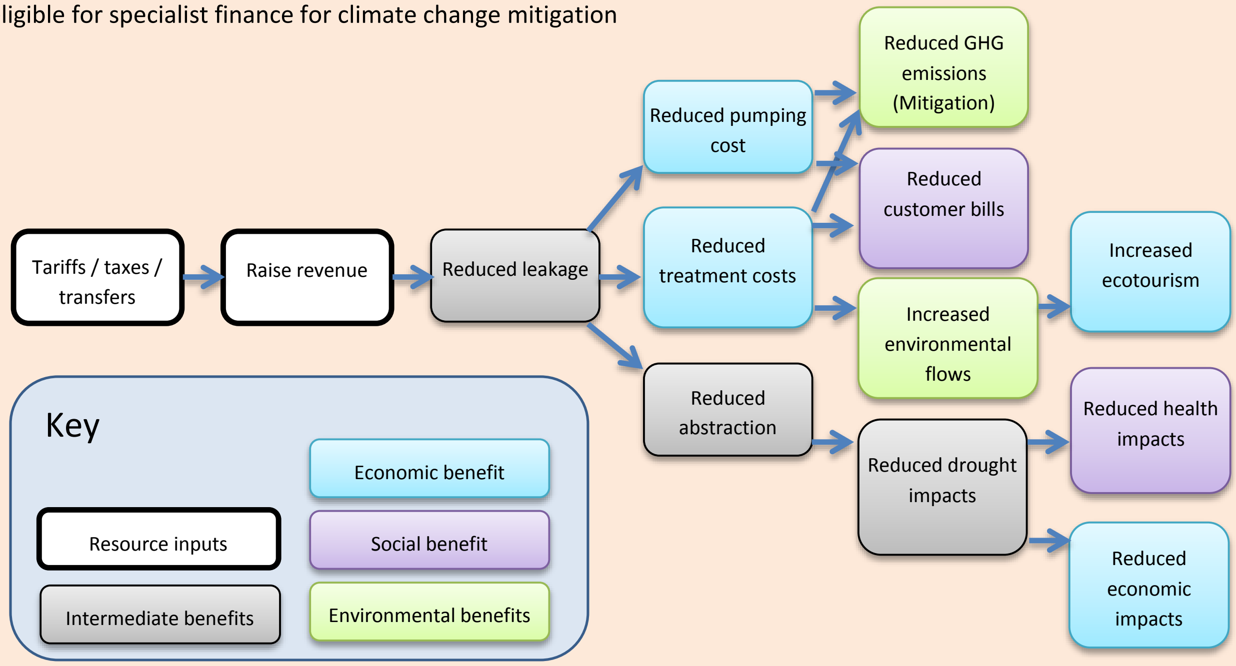
Table 3.4 - Examples of co-benefits for two water management activities

Example water management activity	Co-benefits with other stakeholders
Water Resources Management	• Allocates water efficiently and effectively between competing sectors and users, providing a consistent environment for decision making • Assesses water availability • Can be used to maintain ecosystems flow requirements • Manages risks of drought and flood events
Wastewater treatment	• Maintains water quality for other users (surface and groundwater) • Maintains ecosystems services • Preserves water quality for freshwater fisheries • Reduces human environmental and food health risks
Sustainable land management	• Reduces soil erosion and consequent reduction in agricultural production • Reduces soil erosion and subsequent deposition of silt and turbidity in the marine environment, maintaining fisheries and tourism activities • Reduces runoff and flood risk downstream • Increases stability of land, reducing landslide risks • Maintains ecosystems services with associated societal and economic benefits • Preserves environmental quality required for tourism • Reduces polluted runoff and associated human environmental health risks

Box 3.8 presents an example of how the activity of reducing leakage in water supply systems brings benefits to a range of stakeholders. In this case the cross sectoral benefits of leakage reduction can be clearly conceptualised, the challenge remains to ensure the incentives for sharing cross sectoral costs and benefits for this intervention are equitable.

Box 3.8 – Co-benefits in water management: The example of reducing leakage in municipal water supply

Integrating water management across sectors and seeking improvements in efficiency through management tools or infrastructure improvement can yield benefits to a number of different users. In this hypothetical example, reduction in leakage brings a cascade of wider benefits including reduced greenhouse gas emissions which may be eligible for specialist finance for climate change mitigation



B.4 Compiling and communicating national adaptation plans

Overview

An important step in the NAP process is the distillation of the knowledge and adaptation options from the water sector assessments into national and other adaptation plans. Subject to a country's approach, the national adaptation plans will likely focus on issues of national strategic importance and cross-cutting issues that contribute to broad national development. A collection of priorities for the water sector, and its various sub-sectors, is therefore a critical component of NAP process as they underpin programmes among broader development objectives such as health, food security, water security, climate resilient infrastructure development, and others. The water sector should be engaged in the process of developing adaptation plans at a national level.

Key questions to be addressed for the water sector include:

Aligning with the Technical Guidelines for the NAP process, key question for water planners and managers to address in Element B.4 will include:

- How will priority water sector adaptation options be aggregated into national adaptation plans?
- How will inputs of relevant water sector stakeholders be incorporated into producing the national plans?
- How can the national adaptation plans and related outputs best be communicated and disseminated at the national level?

Suggested further reading

The Organisation for Economic Co-operation and Development (OECD) has compiled a comprehensive report comparing the range of different policies and strategies used by member countries to implement climate change adaptation. It provides a useful introduction to the range of potential policy and strategy options which are available to mainstream climate change adaptation into planning processes.

OECD. 2013. Water and Climate Change Adaptation: Policies to Navigate Uncharted Water, OECD Studies on Water, OECD Publishing. Available at: http://dx.doi.org/10.1787/9789264200449-en

The World Bank sourcebook on tools for institutional, political, and social analysis of policy reform is targeted at practitioners and provides an overview of numerous analytical techniques, including stakeholder analysis and organisational mapping which can support the development of adaptation plans. Chapter 7 of the sourcebook provides an overview of the tools and their application at different levels of planning.

Holland, J. 2007. Tools for Institutional, Political, and Social Analysis of Policy Reform: A Sourcebook for Development Practitioners. World Bank, Washington D.C., USA. Available at: http://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/TIPs_Sourcebook_English.pdf.

How will priority water sector adaptation options be integrated into adaptation planning processes?

Water sector engagement in the NAP process is one of many sectors for the coordinating agencies of the NAP process to consider. A wide range of adaptation actions concern water and many of the adaptation priorities for water will involve water dependent and water related sectors. Therefore there is a crucial task in ensuring water dependent sectors are engaged in the process to take ownership of relevant water related adaptation priorities. For example, this might include working with ministries of agriculture to integrate adaptation priorities related to water efficiency or pollution control into national NAP planning.

Figure 4.1 from the Technical Guidelines illustrates the potential flow of responsibilities in NAP planning. In the context of water, adaptation priorities will be identified at both the national multi-sectoral level and the individual sector level. The flow clearly identifies the integration of sectoral priorities into a national plan. This will be the critical stage to ensure a coherent suite of adaptation options have been identified for water and are owned by relevant stakeholders for implementation following NAP endorsement.

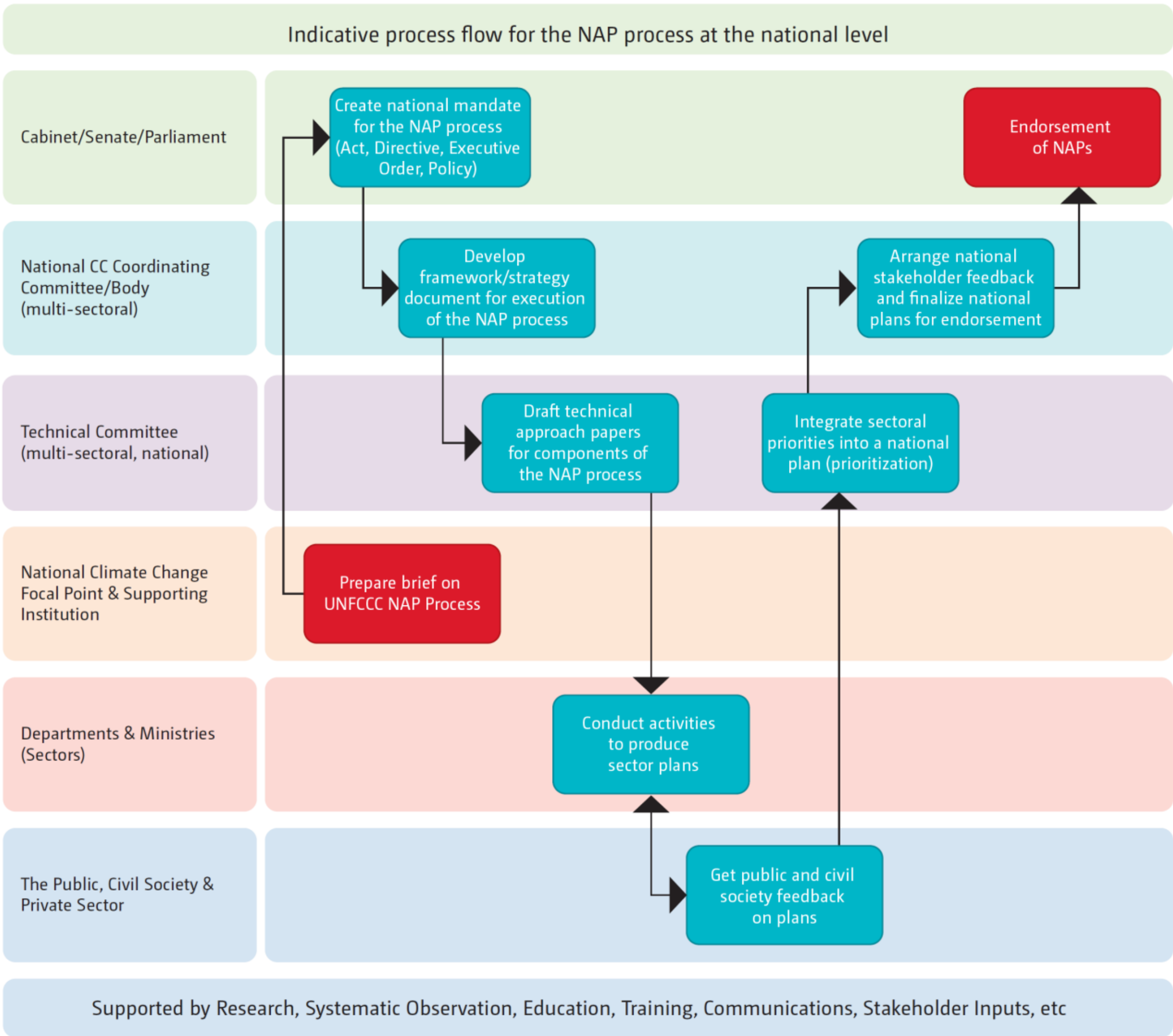


Figure 4.1 - Possible flow of responsibilities for a national adaptation plan process until the endorsement stage (reproduced from the Technical Guidelines)

How will inputs of relevant water sector stakeholders be incorporated in the NAP process?

Subject to a country's approach, sectoral adaptation planning will focus on issues of national strategic importance and cross-cutting issues that contribute to broad national development, and include a collection of priorities for the sector and it's sub-sectors. A significant number of activities at the sector/sub-sector level are likely to be in the form of sectoral policies, programmes and plans are likely to be designed to achieve major development dividends and to move towards adaptations of systems and operations that will be heavily affected by climate change. In many cases these will support broader water security and climate resilience, including health, food security, infrastructure development, and others.

In this context the input of water stakeholders are required to achieve two outcomes:

- Water sector stakeholders should work with water related sectors to integrated adaptation options related to water management into sectoral or thematic components of NAP plans. This will support the ownership of water related options by the sectoral agencies most appropriate for their implementation
- Water sector stakeholders should coordinate adaptation options related to water management, ensuring they present a coherent portfolio for managing cross-sectoral water risks. This will involve working with the national NAP coordination unit, to ensure the synergies between water related options are fully explored to maximise potential co-benefits across sectors

The detailed role which the water sector takes will depend on the national arrangements for coordinating and leading the NAP process. It is important that the water institutions and agencies engage with the NAP Coordination Unit, become conversant with the national NAP process, and remain flexible and responsive to support the overall NAP process.

How can sector adaptation plans and related outputs best be communicated and disseminated at the national level?

The NAP process as a whole will have an associated communications strategy through which the overall outcomes of the process can be shared and communicated more widely. The role of the water sector is to support this process and to provide additional information and/or communication materials as requested by the NAP coordination unit. This involves preparing tailored communications for water related aspects of the NAP plans and strategies, convening meetings and workshops to raise awareness and to obtain buy-in amongst water sector stakeholders, and supporting the provision of capacity development activities to facilitate implementation of NAP plans and strategies. The support role played by water sector stakeholders will be required throughout the NAP process, including during subsequent implementation, monitoring, evaluation and review phases.

B.5 Integrating adaptation options into national and sub-national development and sectoral planning

Overview

The NAP process seeks to integrate climate change adaptation into national and subnational development calls for an understanding of the relevant planning cycles and the adaptation options that are relevant for those cycles. As the NAP process is closely linked to national or subnational development planning, the integration process should be an integral part of the NAP process. Continuous stakeholder interaction will give planners an appreciation of the underlying analysis and help to find appropriate entry points for integration.

Key questions for the water sector to address

Aligning with the Technical Guidelines for the NAP process, key question for water planners and managers to address in Element B.5 will include:

- How can adaptation in the water sector best be integrated into ongoing development planning processes?
- What kind of opportunities can be generated through the integration?
- How can the process of integration be facilitated?

Suggested further reading

This Stockholm Environment Institute report describes the entry points at different planning levels for the integration of adaptation options.

Lebel, L., Li, L., Krittasudthacheewa, C. et al. 2012. Mainstreaming Climate Change Adaptation into Development Planning. Adaptation Knowledge Platform, Bangkok, Thailand and Stockholm Environment Institute, Stockholm, Sweden. Available at: http://www.climateadapt.asia/upload/publications/files/4f66f3868a813Mainstreaming_climate_change-v6_for_Web.pdf

The Organisation for Economic Co-operation and Development (OECD) has produced a policy guidance document that is the benchmark for confronting the challenge of integrating adaptation within core development activities.

OECD. 2009. Integrating Climate Change Adaptation into Development Co-operation: Policy Guidance. OECD Publishing, Paris, France. Available at: www.sourceoecd.org/development/9789264054769

How can adaptation in the water sector best be integrated into the on-going development planning process?

Preparing for the integration of climate change into development planning at the national and/or sectoral level requires the identification of appropriate entry points within the sectoral planning processes. The integration needs to consider influencing future planning processes, in particular with regard to the development or modification of policy measures and budget allocations, as well as entry points within existing strategies programmes and plans.

Integrating climate change into development planning either at the national or sectoral level is a multi-year, multi-stakeholder effort that entails water sector stakeholders to work with central government actors (head of state's office, finance and planning bodies, political parties and parliament, national statistics office and judicial system), other line ministries (sector and sub-national bodies (environment, agriculture, etc.), non-governmental actors (civil society, academia, business and industry, general public and communities, and the media) and other development partners and actors. Entry points for integration can be many, and Box 5.1 illustrates potential entry points for water related adaptation priorities.

Box 5.1 Potential entry points for water related adaptation priorities

Examples of development planning processes for integrating water-related adaptation priorities could include the following:

National strategies and plans

- National Development Strategy or Plan (NDS)
- Poverty Reduction Strategy (PRS)
- National Sustainable Development Strategies (NSDS)
- National Disaster Risk Reduction (DRR) strategies
- National Emergency Management and Disaster Response Preparedness Plans
- Water/food/energy security strategies
- Green growth / Low carbon / Climate Compatible strategies and plans

Thematic and sectoral plans

- Health Sector plans – e.g. rainwater harvesting, safeguarding water sources, sanitation and hygiene aspects
- Infrastructure – e.g. water system infrastructure, multi-purpose use, and operations and management
- Integrated Water Resource Management and Water Use Efficiency plans –e.g. watershed management, water master plans, improved assessment of water resources, water demand management, water re-use, and enhanced water allocation mechanisms
- Agriculture– e.g. including land-use planning, soil-water conservation, water saving technologies, water re-use, and improved irrigation efficiencies
- Energy – e.g. improved operation of reservoirs, reduced reservoir sedimentation, conjunctive use of resources, and efficient use of hydropower
- Environment – e.g. enhanced ecosystems services, managed watersheds, and environmental flows
- Disaster risk reduction – e.g. flood and drought risk management including preparedness, emergency response and recovery aspects.

Integration with national development strategies and budgetary processes

When new national development strategies are produced, adaptation in the water sector should feature as a cross-cutting theme. Government spending patterns are generally slow to change, and changes between sectors are generally more difficult to achieve than changes within sectors. The main tool for change is the

National Development Strategy, or similar, which is typically produced in the first year of a new government and updated every three to five years. One of the main tasks is to ensure that water sector adaptation to climate change is included in the National Development Strategy.

In the short term, any on-going National Development Strategy formulation or-reformulation should seek to include water security, climate resilience and adaptation as a cross-cutting theme. Few national development strategies currently include water security or climate resilience as a significant cross-cutting theme and if there is any on-going work to prepare a National Development Strategy, it is an urgent priority to ensure that it includes water security and climate change. If this does not happen, the chance may be lost for another three to five years. Box 5.2 presents an example of how an analysis of the institutional setting, entry points for integration, and challenges that needed to be overcome can help to inform entry points.

In general, Cabinet provides the leadership for National Development Strategy but most national strategies also include wide public consultation to provide validation and public support and ownership. Water and adaptation may not currently be a top priority but dissemination of information and insights by lead water institutions and agencies is ones means to increase public awareness and to act as leverage to influence politicians and priorities.

Box 5.2 Integrating Water Security and Climate Resilient Development into Development Plans

In Burundi, a Country Report on Integrating Water Security and Climate Resilient Development into development planning was prepared in 2014. This included an analysis of the institutional setting, entry points for integration, and challenges that needed to be overcome. Some of the findings and recommendations included:

- Multi-sectoral involvement and coordination at national level, cascading into local-level planning processes, had the potential to bring tangible benefits for the nation
- To enable a cooperative institutional framework, the report recommended a *Water and Climate Change Office* under the 2nd Vice-President to speed up the process of integrating issues of water security and climate resilience in the national planning
- Synergies between plans and programmes need to be strengthened to achieve pro-poor, environment-friendly and climate-resilient development
- To help address water and climate change issues in national-level planning processes establishing domestic environmental and climate financing mechanisms were to be established
- Proposed entry points for integration included: benefitting from new institutional structures for the implementation of the National Water Strategy; strengthening EIA guidance and procedures to ensure climate resilience is taken into account; building climate resilience into basin master plans; and consideration of changing climate in project design standards (e.g. design of roads, drainage system etc.)

The national budget is the main tool for promoting increased investment in water sector adaptation. The budget process covers both recurrent and development spending. Whilst the National Development Strategy provides guidance over broad directions, the national budget process is where the hard decisions over resource allocation take place. The water sector ministries and agencies should clearly communicate and maximise their opportunity to claim climate resilience benefits in promoting the water sector with central planning agencies. The Budget Strategy Paper and Medium Term Budget/Expenditure Frameworks (MTBF or MTEF) are the starting point for influencing annual budgets.

Most countries now have a budget cycle that starts with some form of strategic guidance. This generally starts with some form of Budget Strategy Paper (BSP) that gives general principles and generally coupled with a MTBF or MTEF to give multi-year (3 or 5 year) indications of sectoral ceilings. Influencing the BSP and MTBF/MTEF and where possible explicitly highlighting how water sector and sub-sector proposals will promote broader goals such as water security and climate resilient development should be emphasised. It is also important that the recurrent cost implications of water sector adaptation projects are logged and accounted for in budget proposals. Supplementary budgets may also offer opportunities to influence sectoral allocations. In many cases, the funding from supplementary budgets is allocated to those projects that can disburse rapidly within the year and it is useful to have a stock of rapid spending opportunities ready to propose for the supplementary budget.

Integration into sectoral and thematic strategies

In developing NAPs, the route to implementation should be considered early in the process to facilitate the detailed planning for implementation of priority options. Implementation of adaptation activities will vary in form and character across scales, and depending on the circumstances. However, in general, these are likely to relate to policies, projects and programmes linked to the attainment of national water, food, and energy security, health agendas, safeguarding environmental and ecosystem services, and national security. Box 5.3 provides an example of the integration of water resources management into national thematic strategies on poverty reduction, the environment and climate change.

Box 5.3 Underpinning Economic Development and Poverty Reduction Strategies

The 2011 Rwandan National Strategy for Climate Change & Low Carbon Development aims to guide the process of mainstreaming climate resilience into key sectors of the economy. To this end, climate resilience has been integrated into the national planning documents, for example the National Policy for Water Resource Management (2011); Economic Development Poverty Reduction Strategy II (2013-2018) and the Strategic Plan for the Environment and Natural Resources Sector Strategy (2014-2018).

A National Policy on Water Resources Management (NPWRM) was prepared in 2011. A 5-year Strategic Action Plan for its implementation is also in place, under the lead of MINIRENA, the Ministry responsible for Natural Resources, and its technical arms the Rwanda National Resources Agency (RNRA) and Rwanda Environmental Management Agency (REMA).

The water sector and sub-sector objectives are designed to underpin Rwanda’s Vision 2020 and the Economic Development Poverty Reduction Strategy (EDPRS II) and other high-level national policies. The country’s water policy focus includes strategies and plans to enhance climate resilience through measures to promote water conservation, to implement a sound water allocation system, to enhance the institutional framework, to establish and improve monitoring systems, to better understand climate risks, and to build institutional capacity to manage climate risks. Transboundary waters are also recognized as an important component of sustainable water resources management. As such, it is notable that most of the actions identified in the draft 2012 Strategic Plan for Water Resources Management (SP-WRM) constitute no/low regrets options, alongside infrastructure options to increase storage and control of water resources as part of the overall mix.

What kind of opportunities can be generated through the integration?

The NAP process provides opportunities to develop an integrated approach to climate change adaptation and development and to also to integrate adaptation planning and practices across sectors. Given the cross-cutting nature of water, the need to influence fragmented development efforts is critical. Coherent and well planned cross-sectoral and regional planning will enable the effective management of necessary trade-offs so as to prioritize interventions and the allocation of resources.

Key opportunities generated through the integration of water sector adaptation within the national NAP process include:

- **Enhanced cross-sectoral exchange**. Effective coordination and clarity on roles and responsibilities among central economic planning and financing ministries, the water sector and other sectoral ministries and departments, and between various governance levels is essential to achieving effective planning and implementation of adaptation actions. The organisation of regular meetings of inter-ministerial and other working groups helps to facilitate coordination.

- **Influencing others**. Integrating adaptation into policy and planning instruments is not to be restricted to the water sector alone. It should extend to all water-dependent economic sectors and a key role of water sector actors is to raise awareness of issues, to provide guidance and advice, and to influence change among sectors and sub-setors that may be less well informed or lack capacity to respond.

- **Engaging with non-government actors and the private sector**. Involvement of stakeholders, including both government and non-government stakeholders, is key to ensuring effective adaptation planning processes. Building partnerships and engaging stakeholders is the best way to support more resilient development and to avoid conflicts and inequalities.

- **Shared learning and approaches**. Promoting open dialogues and encouraging participatory assessments and projects helps to build local ownership and builds local institutional capacity. Participatory approaches to learning and action are effective in empowering and enhancing local adaptive capacity, which is a key ingredient for continuing efforts to increase climate resilience.

How can the process of integration be facilitated?

Once adaptation options have been identified and prioritised for implementation they will require integrating into existing plans and work programmes to provide a modality for implementation. Options which are clearly part of a coherent sector strategy or expenditure framework will be more likely to gain support from development partners as well as leveraging domestic sources of finance. The integration of adaptation options into organisations development planning processes will require a consideration of the following principal actions:

- **Ensure high level political support** for integrating options into relevant planning bodies and detailed planning processes. This provides a driver for planning authorities to carry through investments to the implementation phase

- **Understand the planning process** and find entry points to influence it at whichever planning level the adaptation option is most relevant.

- **Identify 'windows of opportunity'** for detailed planning and implementation of options within existing plans and strategies (e.g. alongside the planned upgrading of existing infrastructure) or integrating longer-term adaptation options in strategies under review (e.g. strategic water resources planning)
- **Maintaining support** to planners through partnerships and capacity building to catalyse integration and capitalise on new skills and partnerships

Concluding remarks

[To be inserted]

End Notes

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