Adaptation to Climate Change Induced Water Stress in the Nile Basin

Summary for Decision Makers

UNEP

SWEDEN

NILE BASIN INITIATIVE
Initiative du Bassin du Nil

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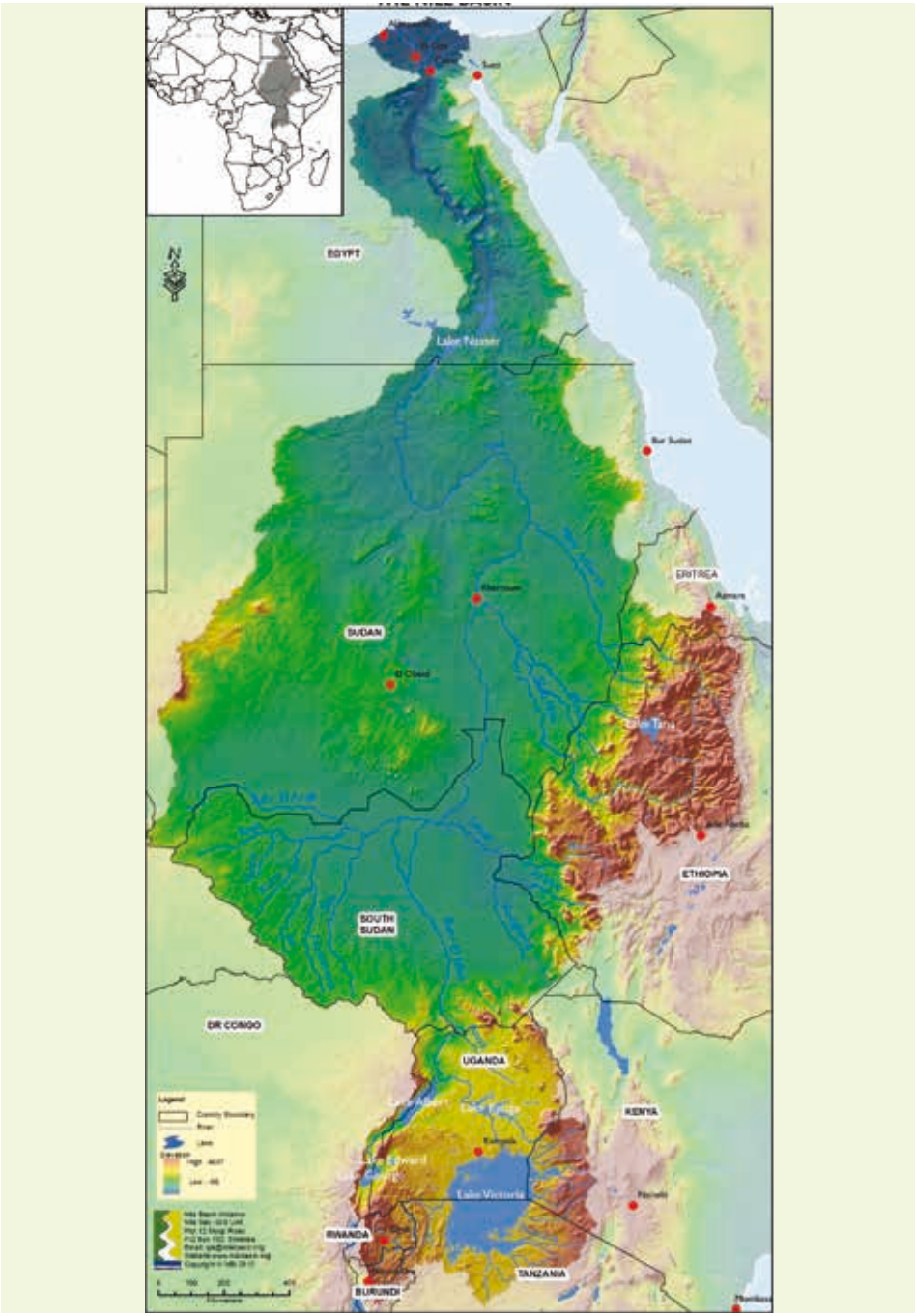
Acronyms

AU	African Union
AMCOW	Africa Ministerial Council on Water
AWW	Africa Water Week
CBO	Community Based Organization
CCA	Climate Change Adaptation
CIWA	Cooperation in International Waters
CMP	Catchment Management Plan
CMO	Community Management Officer
COMESA	Common Market for Eastern & Southern Africa
CWP	Country Water Partnerships
DGD	Directorate General Development
DEWA	Division of Early Warning & Assessments
DHI	(Formerly Danish Hydraulic Institute)
DRC	Democratic Republic of Congo
DSS	Decision Support System
DWRM	Department of Water Resource Management
EBA	Ecosystem-Based Adaptation
EAC	East African Community
ENTRO	Eastern Nile Technical Regional Office
ESMG	Environmental & Social Management Guidelines
ESP	Environment & Social Management Policy
FAO	Food & Agricultural Organisation of the United Nations
GCM	General Circulation Model
GDP	Gross Domestic Product
GIS	Geographical Information Systems
GWP	Global Water Partnership
IGAD	Inter Governmental Authority on Development
ILRI	International Livestock Research Institute
IPCCC	Inter-governmental Panel on Climate Change
IWMI	International Water Management Institute
IWRM	Integrated Water Resource Management
LVBC	Lake Victoria Basin Commission
NAP	National Adaptation Plans
Nile COM	Nile Council of Ministers
Nile TAC	Nile Technical Advisory Committee
NRM	Natural Resource Management
PPE	Perturbed Physics Ensemble
RCM	Regional Climate Model
R&D	Research & Development
SAP	Subsidiary Action Programme
SWC	Soil & Water Conservation
SIDA	Swedish International Development Agency
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

Key messages for decision makers

- Countries in the Nile River Basin need to adapt to climate change in water management without delay.
- When planning adaptation across boundaries, riparian countries should focus on preventing transboundary impacts, sharing benefits and risks in an equitable and reasonable manner and cooperating on the basis of equality and reciprocity.
- Adaptation measures should strive to be cost-effective, environmentally sustainable, culturally compatible and socially acceptable. Prioritization of measures should be based on the results of vulnerability assessments, costs and benefits assessments, as well as on development objectives, stakeholder considerations and available resources.
- Ensuring that data and information are readily available is crucial for making climate projections and identifying vulnerable groups and regions. So sharing information, including that from early warning systems, between countries and sectors is essential for effective and efficient climate change adaptation.
- The process of developing and implementing adaptation measures should build on learning-by-doing.



Source: NBI Eastern Africa report on review of national climate resilience frameworks of the Nile Basin countries, 2013

Executive summary

In the Nile Basin region, increases in population, poverty, degradation of freshwater ecosystems and competing demands for shrinking natural resources coupled with climate variability and uncertainty have resulted into widespread impacts on human livelihood and survival. Water is one of several current and future critical issues facing Africa and the Nile Basin in particular. Water supplies from rivers, lakes and rainfall are characterized by their unequal natural geographical distribution, accessibility and unsustainable use. Climate variability is likely to impose additional stress on water resources in the Nile Basin region through increased evaporation losses due to rising temperatures; increased precipitation in some areas hence extreme flooding events; and reduction in precipitation in other areas leading to severe drought and low flow conditions during dry seasons. Additional challenges include, lack of sufficient institutional capacity and networking, inadequate climate variability monitoring and response mechanisms, lack of communication between science and policy communities, and inadequate technical capacity that is needed to cope with climate change related impacts.

About 238 million people inhabit the Nile basin area and this number is expected to double by 2025 (NBI, 2012). This rapidly growing population is the main driver behind the ever-increasing demand for water and is the chief factor that is responsible for land degradation and environmental pollution. Natural resource dependency by communities, particularly in water is likely to present potentially severe problems for the region in adapting to the challenges of climate change. Unless riparian countries understand these complexities, they cannot provide evidence-based solutions to address new problems, let alone the recurrent crises (water, food, energy) that affect and are affected by the way in which scarce and vulnerable water resources are managed. This situation challenges science to provide a basis for awareness and informed decision-making by practitioners and policy-makers at all levels, from the community to the regional level, in a way that takes into account the risks involved in decision-making under increasing uncertainty.

Although climate change has a fundamental role for water management, reforms in the water sector in the Nile Basin region often have very weak links to climate. Vulnerable sectors to impacts of climate change in the Nile region were identified as agriculture, water, energy and ecosystems and the identification of needs for adaptation to climate change is likely to include

satisfying access to water[1]. Not all countries in the Nile Basin have a water policy, let-alone a comprehensive water policy. An analysis of the existing policy and legal framework in the eleven (11) riparian countries revealed that most do not have any policies or laws that deal directly and explicitly with climate change issues[2]. Only seven of the eleven Nile Basin countries have existing National Adaptation Programmes of Action (NAPAs) and National Communications (NCs) respectively and are therefore committed to having adaptation high on their agenda. Decision-makers and practitioners in the Nile Basin region urgently require tools and information at all levels, from local to national to regional to enable them to evaluate climate change impacts, design and implement appropriate adaptation measures as part of the water resources management.

This Summary for Decision Makers (SDM) is intended for use by a variety of stakeholders, including Government departments and responsible agencies

[1]GWP Eastern Africa, Report on Review of National Climate Resilience Frameworks of the Nile Basin Countries, 2013

[2]Ibid

with institutional mandates to implement actions in sectors that are vulnerable to climate impacts and enable them to make informed decisions in sector development planning and budgets. This SDM draws from the outcomes of the "Adapting to climate change induced water stress in the Nile River Basin" project, an initiative jointly implemented by UNEP and its partners notably the Nile Basin Initiative (NBI, Global Water Partnership (GWP), DHI (formerly Danish Hydrological Institute), PROTOS, International Livestock and Research Institute (ILRI) and Wollo University as well as national governments and local communities.

With support from the Swedish Government the overall project goal was *to build the resilience of ecosystems and economies that are most vulnerable to climate change induced water stress in the Nile Basin countries through building key adaptive capacity and piloting adaptation in "hotspots" with technical, policy and financial interventions*. It was operational from 2009 – 2013 focusing primarily at the transboundary level. Results and information emanating from the project are expected to support policy areas and decision makers in the Nile Basin region in addressing the myriad complexities of increasing water scarcity, deteriorating water quality, lack of access to electricity, climate change and its potential impacts (such as droughts, floods, wetland degradation) as well as uneven levels of economic development. It is hoped that the results from the project will lead to increased cooperative management of the common Nile Basin water resources.

This SDM outlines four policy areas, based on the work packages of the Nile Basin project as follows: 1. Comprehensive Assessments; 2. Policy and Capacity Building; 3. Demonstration/field sites; and 4. Communication. It highlights key areas for policy discussion and thereafter makes recommendations for policy action for each area as follows:

1. Comprehensive assessments – UNEP collaborated with the DHI in undertaking the comprehensive assessments and modelling work. An assessment methodology and climate change adaptation plans for water resources in the most vulnerable areas ("hot spots") in the Nile Basin was developed through analysis, determination of vulnerability and development of scenarios. The assessment framework developed by UNEP included themes, tools, criteria and indicators for selecting hotspots linked to scenario development. The framework sought to improve the regional knowledge and information base on adaptation strategies and transformative policies to manage these shared resources of the Nile Basin. A vulnerability assessment report, which identified adoption of climate

change adaptation methods that build resilience of vulnerable sectors and ecosystems in the region was produced. The purpose of the assessment study was to extend the knowledge and information base and aid critical thinking and decision-making. The report is part of a knowledge based policy intervention that will complement and strengthen ongoing efforts to address the challenges of managing the water resources in the Nile Basin. Several policy areas and recommendations for policy actions were identified on the basis of these interventions.

DHI also contributed to work under comprehensive assessments by identifying flood and drought prone areas, developing criteria for the identification of "hot-spots", and downscaling global climate models. DHI developed and applied a *regional scale operational framework* to assess climate change. This framework combines regional scale climate modelling with distributed hydrological modelling to assess the impacts of climate change on the water resources. The regional scale climate modelling and hydrological modelling tools will be used to assess the impacts of climate change on hydrology resources in order to evaluate adaptation measures at the regional scale. Based on these interventions, several policy areas and recommendations for policy actions were identified.

2. Policy and capacity building – Global Water Partnership (GWP) and the Nile Basin Initiative (NBI) were both responsible for building the capacities of government agencies, research institutions, Non-Governmental Organizations and other social actors that can enable them to facilitate climate resilience at local and national level. The NBI facilitated political and technical processes and provided relevant climate information, while GWP provided training, information management and dissemination through climate change adaptation portal and awareness materials. Based on these interventions, several policy areas and recommendations for policy actions were identified.

3. Demonstration/Field site - Based on information generated by the comprehensive assessment work on hotspots, Uganda and Ethiopia were selected as pilot countries where demonstrations were undertaken. UNEP collaborated with several partners to implement functional and replicable demonstration sites linked to adaptation practices in a mountain and dryland ecosystem. Results from the demonstration sites where shared

with other countries within the basin. PROTOS, a Belgian NGO collaborated with the Department of Water Affairs in Uganda to support local communities to prepare a long-term climate change and IWRM action plan to enhance their adaptive capacity to climate change and integrate improved water management in the Mpanga Catchment of the Nile Basin in Uganda. ILRI, working closely with Wollo University, implemented activities in drought-prone hotspots of the Blue Nile Basin, that sought to enhance the adaptive capacity of communities to climate-change induced water scarcity in the Kabe watershed in Amhara Region, Ethiopia. Several policy areas and recommendations for policy actions and potential upscaling were identified based on these interventions.

> Decision-makers and practitioners in the Nile Basin region urgently require tools & information at all levels, from local to national to regional to enable them to evaluate climate change impacts, design & implement appropriate adaptation measures as part of the water resources management

4. UNEP supported the preparation of communication and public awareness materials on work undertaken by the project, including sharing of outreach materials based on outcomes from Information compiled through various reports by the project.

   In terms of replicability of project results, the regional modelling framework developed by DHI has significant potential for application outside of the Nile Basin project. It can be applied in similar large or transboundary river basins and it can readily be used for small basin(s) to evaluate national or local climate impact assessments for water resources, water resource management and/or the evaluation of climate adaptation measures. GWP and NBI will use their extensive national, regional and global level networks and experience to facilitate policy and capacity support for climate change adaptation in the Nile Basin region. It is expected that the implementation of the NBI climate change strategy will pave the way for replicating results that were achieved by the project in the future.

1.0 Overview

1.1 Background

In the Nile Basin region, increases in population, poverty, degradation of freshwater ecosystems and competing demands for shrinking natural resources coupled with climate variability and uncertainty have resulted in widespread impacts on human livelihood and survival. The population in the region has increasingly become more vulnerable to extreme hydrological impacts such as increase in frequency of floods and droughts and changes in river flow associated with wide spread water resources degradation and modification of riparian ecosystems/habitats.

Water is one of several current and future critical issues facing Africa and Nile Basin in particular. Water supplies from rivers, lakes and rainfall are characterized by their unequal natural geographical distribution, accessibility and unsustainable use. The fragile upstream areas of the Nile River are characterized by widespread deforestation and wetland drainage in an attempt to expand agricultural land, urban areas and industries. Soils have been eroded, resulting in reduced crop yields hence widespread famine and poverty. Groundwater recharge has reduced and water levels have lessened, whereas river flows have become flashier. Other stresses include high sediment

loads, seawater intrusion around coastal areas and waterweed infestation.

The Nile Basin region is extremely vulnerable to climate variability due to a high dependence on rain-fed and irrigation-based agriculture, natural resources for daily livelihood and limited knowledge base and transfer mechanisms. Variability in climate is likely to impose additional stress on water resources in the Nile Basin region through increased evaporation losses as a result of rising temperatures; increased precipitation in some areas leading to extreme flooding events. Reduction in precipitation of other areas is likely to lead to severe drought and low flow conditions during dry seasons. Moreover, challenges such as inadequate financial resources, lack of sufficient institutional capacity and networking, lack of region specific scientific information, inadequate climate variability monitoring and response mechanisms, lack of communication between science and policy communities, absence of knowledge base on successful mitigation and adaptation measures and inadequate technical capacity need to be urgently addressed to cope with climate change related impacts.

Decision-makers and practitioners in the Nile region need to evaluate climate change impacts, design and implement appropriate adaptation measures as part of the water resources management. This in turn requires tools and information at all levels, from local to national to regional, to support their decisions. There was a perception that tools and information for the Nile Basin at the regional scale, were missing. Within transboundary basins like the Nile, it is critical that the implementation of climate adaptation measures addresses the basin as a whole and that different alternative be evaluated both to avoid regrettable outcomes and to exploit joint benefits.

The Nile Basin region is extremely vulnerable to climate variability due to a high dependence on rain-fed & irrigation-based agriculture, natural resources for daily livelihood & limited knowledge base & transfer mechanisms

1.2 Statement of the issue

Research and science have revealed that the speed and scope of climate change is likely to have serious implications for regional security in the Nile Basin and Africa as a whole. Consequently, insecurity coupled with climate change will present very real developmental challenges. Natural resource dependency by communities, particularly on water is likely to present potentially severe problems for the

region in adapting to the challenges of a changing climate. It is noteworthy that livelihoods will be affected by climate change especially for communities in rural areas and hence the challenges posed by climate change are also likely to result in environmentally induced migration. There is need therefore for policy considerations within the basin countries that will take migration issues into account, as this is likely to be one of the most profound expressions of adaptation or failure to adapt.

Unless riparian countries understand these challenges and complexities, they cannot provide evidence-based solutions to address the new problems that arise, let alone the recurrent crises (e.g., of water, food, energy) that affect, and are affected by the way in which scarce and vulnerable water resources are managed. This gap challenges science to provide the basis for awareness and informed decision-making by practitioners and policy-makers at all levels, from the community to the regional, in a way that accounts for the risks involved in decision-making under increasing uncertainty.

This Summary for Decision Makers (SDM) is intended for use by Government departments, responsible agencies and actors with institutional mandates in climate-sensitive sectors that implement actions at all levels to enable them make informed decisions in sector development planning and budgets. The SDM is also relevant for other organizations such as research institutions with the capacity to analyze the technical (and policy) issues and propose if and

how they fit with existing knowledge, data and approaches at country level; civil society, donor organizations and media, can become important driving forces for change if well informed. It is also relevant for UN agencies, CGIAR and bilateral programs at country level because they have deeper capacity and parallel interventions that might benefit from knowledge exchange with the project.

Decision-makers and practitioners in the Nile Basin region require tools and information at all levels, from local to national to regional to evaluate climate change impacts, design and implement appropriate adaptation measures as part of water resources management. However, there is a clear lack of such tools and information at the regional scale. Hence the urgent need to support decision-makers and practitioners in water resource managements in the Nile Basin region to enable them to make informed decisions by providing them with tools and information concerning climate change adaptation in the Basin.

1.3 UNEP-NBI engagement in climate change adaptation issues

This project was an initiative jointly implemented by UNEP and its partners notably the NBI, GWP, DHI, PROTOS, ILRI and Wollo University as well as national governments. With financial support from the Swedish Government the overall project goal was *to build the resilience of ecosystems and economies that are most vulnerable to climate change induced water stress in the Nile Basin countries through building key adaptive capacity and piloting adaptation in "hotspots" with technical, policy and financial interventions*. It was operational from 2009 – 2013 focusing primarily at the transboundary level.

The results and information from the Nile Basin project are expected to support policy and decision makers in the Nile Basin region to address the increasing water scarcity, deteriorating water quality, lack of access to electricity, climate change and its potential impacts (such as droughts, floods, wetland degradation) as well as uneven levels of economic development. It is hoped that the results from the project will lead to increased cooperative management of the common Nile Basin water resources. Such cooperation can lead to a vast range of benefits including increased hydropower and food production, better access to water for domestic use, improved management of watersheds and reduced environmental degradation, reduced pollution and more control over damage from floods and droughts. The project approach encouraged the adoption of climate change adaptation options that build resilience of vulnerable sectors and ecosystems in the region.

This SDM is based on the interventions of the findings of this project. The subsequent sections present a brief overview of the key results of the thematic areas of the project followed by recommendations for policy options. It seeks to support policy and decision makers to make use of the results and information from the project based on work undertaken in climate science and practice (demonstration sites) to inform their decisions on water resource management at the regional, national and local levels, with particular emphasis on the challenges that rapid human-made developments and environmental change pose to the sustainable management of the Nile River Basin.

1.4 Overview of some pre-existing climate related policies in Nile Basin countries

Even though climate change has a fundamental role for water management, reforms in the water sector in the Nile Basin region often have very weak links to climate. The most vulnerable sectors to impacts of climate change in the Nile region have been identified as agriculture, water, energy and ecosystems and the identification of needs for adaptation to climate change is likely to include satisfying access to water. While access to water is generally considered fundamental to development processes, the water sector itself seldom recognizes the importance of considering adaptation to climate change in water policies, plans or programmes. Not all countries in the Nile Basin have a water policy, let-alone a comprehensive water policy. An analysis of the existing policy and legal frameworks in the eleven riparian countries revealed that most do not have any policies or laws that deal directly and explicitly with climate change issues. Although some national policies have attempted to address climate change related issues, currently most countries are addressing aspects of climate change through a number of sectoral policies (e.g., environment, agriculture, water, etc), even though climate change may not be the focus of such policies and plans.

Only seven of the eleven Nile Basin countries have existing National Adaptation Programmes of Action (NAPAs) and National Communications respectively and therefore are committed to having adaptation high on the agenda. Furthermore, adaptation with regards to water resources has been identified as a priority. In the respective NAPAs and National Communications there is recognition that social and economic development are strongly linked to climate change and adaptation in particular. Therefore this project is expected to contribute to poverty reduction in the basin countries as defined in their respective national poverty reduction strategies and national development plans.

2.0 Comprehensive assessments

The project developed an assessment methodology and climate change adaptation plans for water resources in the most vulnerable areas ("hot spots") in the Nile Basin through analysis, determination of vulnerability and development of scenarios. UNEP and DHI (formerly Danish Hydrologic Institute) collaborated closely in undertaking the comprehensive assessments and modelling work.

2.1 UNEP

As part of its work under comprehensive assessments, UNEP sought to improve the regional knowledge and information base on which adaptation strategies and transformative policies will be based with regard to managing transboundary water as a shared resource in the Nile Basin. UNEP developed an assessment framework that includes themes, tools, criteria and indicators for selecting hotspots linked to scenario development. A vulnerability assessment report was produced, which identified the adoption of climate change adaptation options that build resilience of vulnerable sectors and ecosystems in the region. The purpose of the assessment study was to extend the knowledge and information base to aid critical thinking and decision-making. The report

that was generated is part of a knowledge based policy intervention which aims to complement and strengthen ongoing efforts to address the challenges of managing the water resources in the Nile Basin.

As part of the analysis, 'hot spots' were identified as pilot areas where adaptation methods can commence. The report provides useful information on the history of the River Nile and it reviews the environmental characteristics of the basin including land use and vegetation dynamics, hydrology and the water availability and demand. It also discusses various climate scenarios based on the interactions between these issues and the probable impacts in the identified vulnerable hotspots.

The report proposes options and strategies for adaptation to climate change in the basin as provided below.

2.1.1 Land cover types

Changes in land cover have impacts on the water balance of the catchment and have been associated with increasing soil erosion and possible changes in surface hydrology and drainage, disturbances to the aquatic biodiversity and increased sedimentation. These can have long term negative impacts on food security, biodiversity, water supply and may even lead to migration. For instance, it is estimated that deforestation has contributed to increased sediment influx from the five rivers that flow into Lake Victoria and from the Kagera River costing farmers more than US$ 40 million worth of lost soil per annum (NEMA-K, 2011).

Recommendations for policy action

- *Employ sustainable land management strategies to reduce land degradation especially in arable land:* Strategies could include using apposite soil and water management strategies, protection of forests and other critical ecosystems and conservation agriculture, among others. Conservation agriculture is gaining credence as a means of dealing with climate change, reducing soil erosion and increasing agricultural yields.
- *Support the strengthening of the legal, policy and institutional frameworks for the management of environment in general and the land resource in particular:* Although many of the countries have institutions and laws governing environment and land management, there still exist in some cases a number of legal vacuums especially surrounding the issue of land use.
- *Develop a comprehensive regional biodiversity policy to maintain the rich biodiversity of the Nile Basin:* Such a policy would promote the protection of endangered species, while supporting the sustainable use of others.

2.1.2 Water resources, availability & sectoral use of water

The quantity of internal renewable water available varies considerably ranging from 36 000 m3/capita/year for the DRC to 25 m3/capita/year for Egypt in 2004 (UNEP in print). The actual number of people without access to a clean water source in the Nile countries by 2009 was about 16 million or 39 per cent (World Bank 2011). But this figure masks national disparities - 62 per cent of Ethiopians do not have access to clean water as compared with only 1 per cent of Egyptians (World Bank, 2011). Surface and groundwater sources contribute varyingly to water use in the basin and are interlinked through the hydrological cycle. Surface waters are more important to the downstream countries due to adequate precipitation. Groundwater assumes greater importance upstream and especially in the Nile Delta and Nile Valley areas where it is used in conjunction with surface water.

Agriculture accounts for at least 80 per cent of all water consumption for the countries in the Nile Basin (FAO, 2011b). Upstream agriculture is mainly subsistence and dependent on rainwater. The overdependence on the rain leaves the countries extremely vulnerable to the vagaries of climate. This has in the past led to massive agricultural losses and food insecurity and is now eliciting a move towards urgent investment in water storage capacity to counteract the uncertainty caused by the climate. All countries in the Nile Basin boost their agricultural production through irrigation, to some extent and the opportunities for expansion are immense.

Electricity is an essential ingredient for economic production, investment, development, and for human wellbeing. The hydroelectricity power potential in the region is more than 20 GW. However, the current installed generating capacity is only about 26 per cent of the potential capacity (NBI, 2012). Sustained investments are required to meet the region's power demand (NBI, 2012). One drawback of hydropower is that it exposes the region to climate change and the ecological state of the watersheds.

Recommendations for policy action

- *There is need for greater hydrological research and monitoring:* such research will fill the knowledge gaps and adequately inform the management and utilization of the water resource especially groundwater where there is dearth of information. The transboundary nature of the aquifers requires thorough study and cooperation among countries and necessitates well-equipped adaptive capacity to manage. Furthermore the inter-linkages between surface and groundwater needs to be further understood in order to aid sound management of the resource.

- *Expand the concurrent use of ground and surface water across the basin:* This information is especially useful in the downstream countries following the example in the Nile Delta and Nile Valley region. This action will reduce the over-dependence on surface water thus aiding climate change adaptation and mitigation.
- *Integrate IWRM (Integrated Water Resources Management) principles into all areas of policy planning and design:* This process will enable water management issues to be mainstreamed into activities that concern watershed management, population and economic development at all governance levels in the basin.
- *Diversify the energy sources in the region:* this can be done by developing other clean and renewable sources of energy available in the region The need to diversify the region's energy resources since hydropower has limited ability to meet the energy needs. Exploiting geothermal, solar and wind options will help to fill the unmet needs for energy and present real opportunities to reduce the current human pressure on forests for wood fuel.

> Climate change is likely to amplify the frequency & magnitude of extreme events such as severe droughts & floods

2.1.3 The threat of climate change

Although there is a lot of uncertainty regarding climate change, it is generally agreed that it is one of the most significant issues of our time and is likely to have insidious impacts on lives, livelihoods and ecosystems; and it is presupposed that many of these impacts will continue or even escalate into the future unless addressed. Climate change is likely to amplify the frequency and magnitude of extreme events such as severe droughts and floods. Droughts have significant implications on the land use patterns affecting both the environment and livelihood of the people. For instance they have had severe impacts on tourism decimating large numbers of wildlife and other fauna and affecting the flora that tourists travel to see. At a household level, the dearth of water means an even higher burden on those who have to walk further pay more to access the resource. Floods, on the other hand, also have serious social and environmental impacts such as loss of public infrastructure, property and lives; food insecurity; and disruption of livelihoods.

Recommendations for policy action

- *Mainstream climate change into the regional and national development*

plans or other framework that embraces socio-economic and political considerations: This is because the impacts of climate change are far-reaching affecting all aspects of economy, social and the environment. Most especially, the issue of water resources management needs to be incorporated into these development plans.

- *Develop and improve existing climate tools for climate change data analysis so as to enhance the provision of credible information:* Reinforcing and sustaining climate observation networks is essential if the full potential of climate information is to be realized for individual sectors. For instance climate change impacts on water issues at the river basin level have not been adequately dealt with in water resources analyses, management and policy formulation. Addressing these would improve the understanding of issues related to water resources and identify gaps in the information gained so far, which would be required for developing adaptations and sustainable utilization of water resources in the 11 countries in the NRB.

2.2 DHI (Formerly Danish Hydraulic Institute)

DHI developed and applied a regional scale operational framework to assess climate change. This framework consists of combining regional scale climate modelling with distributed hydrological modelling to assess the impacts of climate change on the water resources and provide the capability to evaluate adaptation measures at the regional scale. The regional scale climate modelling and hydrological modelling tools will be used to assess the impacts of climate change on hydrology resources in order to provide capabilities of evaluating adaptation measures at the regional scale. The framework proposes the following options and strategies as provided below:

> Reinforcing & sustaining climate observation networks is essential if the full potential of climate information is to be realized for individual sectors

2.2.1 Regional changes in temperature

Although not directly related to the water balance and water resources over the basin, all the RCM projections showed consistent increase in temperature both for the near future (2020-2050) and the far future (2070-2100). There are however strong variations in space and time for the near future, which is consistent with previous studies The temperature projections for 2020-2050

show the largest increases over Egypt and the northern part of Sudan and during the hottest months. This can be expected to affect both the agricultural and domestic water demand in this region; over and above the increases in demand projected from population growth. The projected changes for the period 2070-2100 show even larger increases in the range of 4-6 degrees over the summer months. While these changes are quite large they are nevertheless consistent with results from IPCC 4th assessment, which show increases of 3.5 degrees or more during summer. Such large increases in temperature will certainly increase water demand in major population centres both for food production and for domestic water supply. Temperature rises may both reduce the productivity of major crops and increase their crop water requirements (Eid et al., 2006).

2.2.2 Regional changes in climate & water resources – White Nile

For the White Nile, the changes over the Equatorial Lakes are the most important. The RCM projections for the near future show a significant decrease of precipitation over Lake Victoria from April-November, including both months. The RCM projections that were used exhibited a strong positive bias over the lake and closer examination showed that precipitation was in the "short" rainy season. On the one hand, this effect is local to the lake but on the other hand the rainfall directly over the lake is large fraction of the total rainfall. The exact cause of this is not yet fully understood. Previous work using a different description of processes for Lake Victoria also showed a significant drying during the northern hemisphere summer (JJAS). No clear consensus

was found regarding changes over Lake Victoria for the "short" rainy season, but increases are projected north of the Lake are found in December-January. An examination of the spatial patterns showed an increase in precipitation over central Africa, which appeared to lead to increases in precipitation over the northern part of the White Nile during August and September. Rainfall projections for 2070-2100 also showed reductions in rainfall over Lake Victoria from April- November but these were not as large. In general, changes in rainfall seen over the Equatorial Lake region are smaller in magnitude and less consistent.

Changes in precipitation were directly reflected in the projected flows Malakal, which integrated the contributions from all parts of the White Nile. These included changes in the Equatorial Lakes basin to the south, the Bahr El-Ghazal basin to the west, the Sobat to the east and the Bahr-Jebel basin including the Sudd. For the near future, consistent reductions are likely to be found but the magnitude will vary strongly amongst the RCM ensemble members. There does not appear to be any clear consensus as the direction and magnitude of the change in the flows.

The large uncertainty in both the direction and magnitude of flows has important implications for the adaptation strategies to be adopted. The 2020-2050 period, i.e. 10-40 years from now, corresponds to the typical planning horizons for many infrastructure projects. Any planned adaptation measures need to be able to respond to the reductions in flow and increased water stress. However any such measures must be robust in the sense that the magnitude of these reductions is highly uncertain. The reduction in rainfall may have important consequences for rain-fed agriculture but these are expected to be critical only in the areas that are already marginal. The consequences of the 2070-2100 projections are more difficult to assess as large changes in the flows, both increasing and decreasing and the need for robust adaptation strategies.

2.2.3 Regional changes in climate & water resources – Blue Nile

The Blue Nile and Atbara both represent a significant part of the water resource in the Nile. They account for more than 70% of the main Nile peak flows and are therefore critical to the water resources downstream. The RCM projections for 2020-2050 show both increases and decreases in the region during the wet season, June to September. The reductions appeared in the western most parts of these two catchments, while the increases appeared in the south and east and suggested a general increase at the end of the wet season. No clear patterns emerged for the other seasons. By contrast, the 2070-2100

projections showed a consistent increase in the eastern most parts of the Blue Nile and Atbara catchments for most of the year including the rainy season.

These projections of rainfall changes are also clearly reflected in the resulting river flows for Blue Nile at Khartoum. There is a general tendency toward increased flows in October-November for the 2020-2050 projections but with both increases and decreases simulated in the foregoing months. For 2070-2100 the flow projections are consistently larger and for some ensemble members very large but there is a very wide range of flows. This is consistent with previous studies (e.g. Elshamey et al., 2009) that indicate that the Blue Nile is extremely sensitive to small changes in rainfall and PET. As small changes in either rainfall or PET are amplified in the flows and the hydrological models developed for this region are based on a limited amount of data made available, with low spatial and temporal resolution, these projections should be viewed as uncertain and applied with caution. Climate adaptation measures in this region will have to consider both increases and decreases in the high flow range and potential flooding.

2.2.4 Regional changes in climate & water resources – Main Nile

Generally the rainfall in the main part of the Nile is very low but the RCM projections indicated some small reductions in the slightly less arid Delta area. The main influences on the water resources in part of the Nile are expected to be the changes in climate and the extraction of water for irrigation, and industrial and domestic water supply. Because of the low rainfall, the impacts of climate change in the high flows are caused by changes in flow from the Blue Nile and to a lesser extent the Atbara. The low flows, outside the peak flow season, are likely to be influenced by changes in the White Nile flows but this does not appear to be the case.

The Gaafra station represents flows between the Aswan Dam and the coast. The simulations using the 2020-2050 water demand projections show significant reductions over the entire flow range with the exception of April-June. The changes in 2070-2100 only amplify these reductions. Reductions in the peak flows (August-September) range from 6-16 %. Reductions in the low flows (Jan-Feb) range from 7-15%. Comparison with the range of flow simulations from the RCM climate projections show that flow changes for the 2020-2050 period are likely to be dominated by the increase in water demands and increasing water stress. It should be noted that the water demand scenarios estimated here are conservative. Firstly, the changes are made for a 2005 baseline estimate, so withdrawals in 1960-1990 are likely to be less and the changes to 2020-2050 larger. Also the increases in temperature and

water stress are likely to further increase water demand. Finally, while the data especially for the irrigation demands are taken from some of the most recent and comprehensive assessments (FAO, 2011a) these remain highly uncertain.

Even for the RCM projections with the largest increases in flow, the magnitude of the water demands will still exceed these increases in some months. It should be noted that while the climate projection show a range with both increasing and decreasing flows, the demands will only continue to increase. Furthermore, these figures represent changes in the mean flow. Vulnerability to water stress in dry years or a sequence of dry years will be even larger.

For the far future general increases in flow are projected but there is a large range of variation among the projections, and therefore no clear-cut conclusions can be made. Estimates of projected population for Egypt for 2050 can be found that range from 115 to 179 million which indicate how uncertain the future water demands may be and will certainly increase water stress in all sectors including food production. Agriculture consumes about 85% of the water resource and contributes 20% of GDP in Egypt.

Recommendations for policy actions

- *Incorporate regional hydrological model and regional climate information into the Nile Decision Support System (DSS)*: DHI/UKMET developed a regional framework for assessing climate change and adaptation, which was applied to flow and climate changes in the near (2020-2049) and far future (2070-2099). In order to receive the full benefits of the framework,

the regional hydrological model and regional climate information should be incorporated into the Nile Decision Support System (DSS). This approach provide a common and transparent mechanism to evaluate alternative measures for water resources management and climate adaptation. Incorporating the regional model and information into the Nile DSS will strengthen the sustainability of the project outcomes. Further training related to both RCM modelling and hydrological modelling would also strengthen this process.

- *Application of the tools:* The training provided to NBI staff led to the identification of an extensive list of potential applications of the information and framework by participants. These efforts should continue well beyond the project and also ensure that the information is embedded in the NBI and Nile Basin countries. The regional hydrological modelling tool should be applied to evaluate alternative measures for water resource management and climate adaptation. The models could be more fully exploited by refining them using local knowledge and data to support decision-making at the national or local level.
- *Need for improved quality and quantity of underlying data:* to better understand and quantify the impacts of climate change and climate change adaptation, the quality and quantity of the data should be improved. This is critical for ensuring the reliability of water resources modelling. Many past studies have demonstrated that modelling current and future changes in river runoff for the Nile presents a number of challenges such as the large size of the basin, the complexity of the hydrology. These challenges could be addressed by ensuring more frequent, higher resolution and high quality hydro-climatic data. Satellite remote sensing offers some interesting prospects for addressing data scarcity but cannot completely replace in-situ data and work best when used together with in-situ data.
- *Sharing of observation data:* Efforts to maintain, optimize and extend observation networks in the region are also required. These observation data however have limited value at the regional scale if they are not shared for mutual benefit.
- *Need for improved availability and consistent socio-economic data:* This will allow socio-economic evaluations to be incorporated into water resources analyses and in the assessment of potential climate adaptation measures.

2.2.5 Development of criteria for identification of "hot-spots" using indicator mapping

The concept of "hot spots", in terms of climate and water resources, and in

particular their scale was deemed to be extremely important. "Hot spots" were initially thought of as local areas with significant water resources, climate or other issues. However, it became increasingly clear that the so-called "hot spots" were much larger regions. Based on this understanding, Egypt, the Blue Nile, Sudan and Lake Victoria were identified as some of the hot spots. In this regard, the DHI study examined the impacts of climate change and water demand scenarios at the regional scale and investigated particular aspects of the focus areas in the Equatorial Lakes basin, the Ethiopian Highlands (Blue Nile and Atbara basins) and the Egypt and Sudan water demand region.

> Need for improved availability and consistent socio-economic data: This will allow socio-economic evaluations to be incorporated into water resources analyses and in the assessment of potential climate adaptation measures

Recommendations for policy actions

- *Additional research to inform decision/policy making:* Further work is required to quantify future water demands across the region and in particular to develop quantitative estimates of their uncertainty. Uncertainty is an inevitable part of decision-making for both climate change and hydrological change and needs to be embraced as part of the process. Decision-making for water resources management under uncertainty is not new, however climate change contributes additional aspects of uncertainty for practitioners. While the climate research community will continue to improve climate modelling and reduce uncertainty, it cannot be eliminated. Knowledge of the uncertainties is in fact useful information for decision-makers. In some cases the projections made here give a clear indication of the direction of change but not the magnitude but this is useful information.

2.2.6 Downscaling of global models

DHI performed a new set of regional climate model (RCM) simulations for the Nile River Basin that was based on the generation of the UK Met Office GCM-based perturbed physics ensembles (PPE). This was the first application of such an approach over the Nile and presented results for both 2020-2050 and 2070-2100 projection horizons. While General Circulation Models (GCM's) provide physically based projections of how climate may change, their

resolution is typically a few hundred kilometres. Higher resolution modelling is better able to capture the local detail and forcing, which can be important for water resource impact assessment at the regional or national level. This can be achieved by using higher resolution regional climate model driven by GCM models at their lateral boundaries (dynamical downscaling).

In this study the RCM projections were developed from a subset of 5 of the most recent Hadley Centre's perturbed physics GCM ensemble. This subset was selected in order to capture the spread or range of outcomes produced by the full 17 member ensemble, while excluding those unable to represent the African climate realistically; using a recently developed systematic methodology (McSweeney et al., 2012). This was achieved by evaluating the models against observations of the annual cycles of temperature and precipitation and the spatial patterns of precipitation and 850 hPa winds.

An ensemble based approach is recommended for two reasons. Both previous studies and the IPCC 4th assessment have shown that projections for precipitation over the Nile are highly variable. Given the sensitivity and vulnerability of the Nile to climate changes it is important that climate changes assessments do not rely on a single model. Secondly, this is a first step towards quantification of the uncertainties, which is fundamental to decision-making but often not addressed. This study is one of the first applications of the PPE approach outside of Europe.

Regional model simulations were then derived by dynamically downscaling from this 5-member ensemble using the PRECIS RCM. RCM simulations were run using the A1B SRES scenario. Comparison of these RCM results show that this ensemble appears to correctly capture the annual cycle of temperature, both for Africa as a whole and for the sub-regions. The RCM ensemble appears to slightly over-estimate the precipitation but captures the annual cycle for most of the regions. Interestingly, the RCM ensemble shows a significant improvement over the GCM ensemble in many parts of Africa.

Recommendations for policy actions

- *Robust approach to climate change adaptation:* For example, the far future (2070-2099) projections indicate both increases and decreases in flow are possible. A robust or no-regret approach to climate adaptation must be taken that considers both possibilities and also the impact of other drivers like increasing water demand or crop and land use changes.

3.0 Policy & capacity building

Both GWP and NBI sought to build the capacities of government agencies, research institutions, NGOs and other social actors on climate resilience at local and national level, taking in account the opportunity offered by a basin-wide approach, which reduces the acute local vulnerability common in adverse climate situations.

3.1 Nile Basin Initiative (NBI)

The NBI facilitated political and technical processes for the Nile Basin Project and assisted other project parners to access relevant climate information at the national level.

3.1.1 Institutional & policy support to Nile Basin countries

The 3rd Nile Basin Discourse Forum (NBDF) was held in Kigali, Rwanda and it included the Nile-COM, Nile-TAC and hundreds of other key stakeholders in the region. The theme of the meeting, *"Climate Change and its Implications for Sustainable Development and Cooperation in the Nile Basin"* was intentionally selected to build awareness and resilience toward climate change consequences in the Nile Basin. Outcomes from the meeting indicated significant complementarities between the the objectives of the joint Nile Basin project and the 3rd NBDF.

NBI participated in the 6th World Water Forum in Marseille, France in March 2012, where it was represented at a High Level Delegation composed on four Ministers, three TAC Chairs, three Head of Centers, and one communication specialist. Participation in this forum provided NBI with high visibility to share its achievements on the project.

3.1.2 Awareness creation

Several awareness raising activities were held, indluding workshops and meetings (e.g., induction and awareness workshop for fifty governance and national experts, basin-wide governance awareness and publicity forum for key stakeholders to disseminate the project's communication materials/ products). Participation in the regional and national Nile Day Celebrations on 'Water Energy, Food: Importance of Nile Day' held in Jinja, Uganda helped raise awareness on climate change adaptation.

Climate change adaptation issues were addressed in several NBI publications, including the Nile Basin Sustainability Framework document that consolidated the achievements of the past years of cooperation; the State of the Basin (SoB) report, which is intended to increase understanding and appreciation amongst policy makers and basin communities on the health of the water systems in the Nile Basin; the NBI Atlas; including other publicity materials, which were used to raise awareness for Nile-TAC/Senior Management and key stakeholders during the 4th Africa Water Week (AWW) and the Africa Ministerial Council on Water (AMCOW) Meeting held in Cairo.

The Nile News, a quarterly bulletin that is prepared and disseminated to a wide-base of key stakeholders in the Nile Basin, included updates on the Nile Basin project and at least one article dealing with different dimensions on climate change awareness, adaptation, and / or mitigation in the region.

3.1.3 Facilitation of data collection & information sharing in the Nile Basin region

The collection of data relevant to water management and climate change adaptation and mitigation in the Nile Basin was accessed from member states and shared with project partners. The data included time-series data (meteorology and hydrology); temporal and special coverage features and technical reports and relevant studies, which led to the development of a downscaling module of regional climate change (Circulation Model).

3.1.4 Additional climate change adaptation measures

NBI developed a new 5-year program entitled "Nile Climate Resilient Growth

Program" which commenced in January 2013, and is financed by CIWA/NBTF (Cooperation in International Waters in Africa). This project will be implemented in two phases. NBI will continue to factor in suitable measures that are capable of ameliorating the impacts of climate change (projects proofing at the SAPs level) in the design of all its regional development projects. NBI is in the process of finalizing its Climate Change Strategy to support environmental management functions at Nile-Secretariat as well as stakeholder participation in climate change adaptation.

Recommendations for policy action

- NBI is pursuing efforts towards sustainable infrastructure in the Nile region aimed at water, food and energy security.
- NBI's draft climate change strategy is scheduled for approval by the Nile-COM (the highest governance structure) at its next session.

3.2 Global Water Partnership (GWP)

GWP was specifically responsible for trainings, information management and dissemination through climate change adaptation portal and awareness materials.

3.2.1 Trainings, preparation & dissemination of information & knowledge/awareness materials

A high-level workshop was convened for decision makers from Government Departments from all Nile member states who met for the first time in five years. Participants included representatives from government ministries; lead members of Nile TAC, Regional Climate Research Institutions; Swedish Development Cooperation; UNFCCC Country Focal points to deliberate on vulnerability facing their countries and propose measures different parties should make to enhance basin wide resilience to adverse climate change impacts.

Presentations were made at the Nile Technical Advisory Committee (Nile-TAC) & Nile Council of Ministers (Nile-COM) meetings in Kigali, Rwanda in July 2012 to sensitize decision makers. The presentations focused on the achievements and challenges of transboundary cooperation in a changing climate. The aim was to ensure the Nile-TAC were fully conversant with NAPAs, including the climate debate in their countries, and the cross-border implications and opportunities that had not been significantly brought to the fore at the national level. Engagement with parliaments was based on the realization that effective reforms will mainly be assured by appropriate

legal framework(s) and parliamentary oversight on programs and budgets. In the same month, a presentation was made at the Nile Parliamentarians Conference (in Kigali, Rwanda) highlighting the role of parliamentarians, as both the people's representatives and highest law making body, in the climate change adaptation discourse.

3.2.2 Review of national climate resilience frameworks of the Nile Basin countries

GWP has established country teams through the Country Water Partnerships (CWPs) in the Nile Basin. CWPs are multi-stakeholder platforms that bring together government departments, research institutions, non-state actors and technical agencies capable of understanding implications of climate change across different sectors. GWP facilitated the assessment of the national climate resilience frameworks in the Nile Basin using the CWPs. Each CWP prepared a country report that summarized key social, policy, environmental and technical issues on the specific country's situation, challenges and initiatives undertaken to ensure climate resilience. The purpose of the reports was to assess the current situation on the impacts of climate change, the mitigation and adaption measures in place, including the legal, policy and institutional framework so as to determine the basin's climate change resilience status. Key organizations consulted included the Ministries of Water, Ministries of Environment, UNFCCC Focal Institutions, Ministries of Agriculture, Ministries of Energy, Ministries of Health and other institutions.

3.2.3 Preparation & dissemination of information

GWP developed a series entitled 'Colors of the Nile' that appears in five different colors to signify different important messages. In addition, othet sensitization interventions on climate change adaption issues were undertaken through e-communications and print media outlets

Recommendations for policy actions

- *The need for flexible climate change adaptation measures:* such measure include the impacts of climate change in the Nile region, which are mainly felt through their effect on water availability for various sectors and users. The degree of impacts varies from place to place depending on the strengths and weaknesses of natural and human systems. Therefore, climate change adaptation measures need to be flexible in responding to such differences.
- *Promote a nexus approach:* the most vulnerable sectors to impacts of climate change in the Nile region were identified as agriculture, water, energy and ecosystems. These resources are naturally integrated, and adaptation strategies need to reflect the food-energy-water/environment nexus.
- *Link local adaptation measures to regional/transboundary level:* existing national climate change adaptation measures/strategies, in most cases, do not clearly consider the regional and transboundary aspect of addressing the challenge. Thus, countries need to be supported to consider regional and transboundary cooperation as an important strategy for water security and climate resilience. Moreover, implementation of adaptation measures at local and country levels need to be linked with measures at regional/ transboundary level.
- *Establish national frameworks for climate-resilient development:* countries of the Nile Basin are at different levels in establishing national frameworks for climate-resilient development. Therefore, support is required to bring all countries at similar levels to enhance regional/transboundary cooperation for water security and climate resilience in the Nile Basin.

Link local adaptation measures to regional/ transboundary level: existing national climate change adaptation measures/strategies, in most cases, do not clearly consider the regional and transboundary aspect of addressing the challenge

- *Support for broader capacity building interventions:* climate change is impacting all sectors and stakeholders, and all of them do have role in building water secured and climate resilient development. Therefore, capacity building programs need to target key sectors and stakeholders beyond the water and climate sectors such as ministries of planning and finance, parliamentarians, local government, NGOs/CBOs and private sector. Similarly, awareness raising programs should target in reaching the broader society.
- *Establish broad based partnerships:* establishing and/or strengthening partnerships at various levels (regional/transboundary, country, local) is key for enhancing cooperation and collaborative action by stakeholders, countries, and key actors.
- *Promote more coordinated and collaborative actions:* Generally the results of the program are more of supporting countries and regional institutions to take more coordinated and collaborative actions. Support should continue to make sure that the results of the program are taken up and implemented at different levels (community, country, transboundary).

4.0 Country interventions

Functional and replicable demonstration sites were implemented to demonstrate adaptation work at a site level within the Nile River Basin and share findings of the overall project at local basis and region-wide. The two demonstration sites linked to (national) community adaptation practices at the sub basin level (mountain ecosystem and a drought prone area) were identified. UNEP partnered with a non-governmental organization, PROTOS in Uganda and another with ILRI in Ethiopia. Activities implemented in Uganda focused on a mountain ecosystem within the basin in Mpanga Catchment at the foot of Ruwenzori Mountain, while activities in Ethiopia focused on a dryland ecosystem in the Amhara region in Northern Ethiopia.

4.1 Uganda country implementation

PROTOS, a Belgian NGO worked very closely with the Department of Water Affairs in Uganda to implement activities within a mountain ecosystem. In this sub-project, PROTOS supported local communities to prepare a long-term climate change and IWRM action plan to enhance their adaptive

capacity to climate change and integrate improved water management in the Mpanga Catchment of the Nile Basin in Uganda. After the assessments were completed, wide scale sensitization efforts were carried out at various levels (villages, schools, Government structures, Regional and National platforms). Different planning mechanisms were tested and implemented leading to several proposals for pilot activities. The pilots were implemented in different districts surrounding Fort Portal and the Rwenzori mountains using government structures such as district departments and municipal councils, with supervision and technical backstopping from PROTOS and contracted partners.

4.1.1 Development of a long term strategy & climate change action Plan to enhance adaptive capacities of communities to climate change

A long term strategy and climate change action plan was developed to enhance the adaptative capacities of communities to a changing climate. A two day induction meeting was held in Kampala with representatives of NGOs (the IWRM environment and climate change Working Group) to present the project. The meeting was attended by 35 people from different organisations and Government institutions. Several sensitization and capacity building intervetions on climate change adaptation were undertaken, including sensitization of over 2000 pupils in 20 schools and sensitization of over 6570 people on the importance of improved water management. Key stakeholders were also sensitized on climate change adaptation and their capacity was built. A training a toolkit on climate change adaptation was developed and twenty-six representatives of key stakeholders (including local government) were trained on climate change adaptation tools. Twenty zones were selected from which six hundred community members were trained on how to map out climate change risk areas. Several committees (Local Environment Committees and the Mpanga Catchment Management Committee) were established. Local environment committes were trained on climate change issues, while the Community Management Officer was charged with drafting, approval and implementation of the action plan in the long term. A Technical Team that actively participated in critical program steps was formed, leading to high stakeholder input and participation in the drafting of the management plan and in identification of pilot actvities.

4.1.2 Execution of pilot projects

A baseline assessment was conducted, which identified priority areas for implementation of project activities. Relevant pilot projects were pre-selected, leading to the development of participatory action plans. The plans

were approved by the Community Management Officer, while the District Implementation Committees were tasked with monitoring the pilot projects. Three pilot projects – wild coffee in Kyenjojo, waste traps in Fort Portal and planting of additional tree seedlings – were identified and implemented. In an effort to diversify the landuse and restore local ecosystem, seven thousand indigenous trees were planted at the source area by fifty households. Fort Portal town piloted a waste selection (glass separation) intervention that sought to improve the efficiency of the existing composting plant. Additionally, after the sensitization and catchment planning campaigns, over twenty-five thousand tree seedlings (of about 12000 fruit trees) were distributed to households.

4.1.3 Platform for information sharing on adaptive mechanisms on climate change

Several communication avenues were established to raise awareness on climate change. These included a video documentary and a web application to map available data in the catchment.

Recommendations for policy actions

- PROTOS is still implementing the IWRM program in collaboration with the Department of Water Resource Management (DWRM) with funding from the Belgian Directorate General for Development with emphasis on

access to drinking water and sanitation. Within the context of this long term cooperation between PROTOS and the DWRM, the outcomes of the UNEP supported pilot will be further monitored, while seeking opportunities to further roll out the proposed climate change adaptation actions within the catchment.

- For a pilot project of one year, it is advisable to integrate pilot activities into an already existing program due to the short timeframe.

4.2 Ethiopia country implementation

ILRI implemented a sub-project in drought-prone hotspots of the Blue Nile Basin, Ethiopia. The project sought to enhance the communities' adaptive capacity to climate-change induced water scarcity in the Kabe watershed in Amhara Region. Key partners included – UNEP, ILRI, and Wollo University (WU). UNEP was responsible for project oversight and linkages to other related activities in the region. ILRI provided technical support and linked Wollo University to other local institutions. WU was the project lead in the implementation of the project at the landscape scales in collaboration with ILRI, which in turn sub contacted SARC (ARARI) for action research and Woreilu Wereda Office of Agriculture for community mobilization

4.2.1 Understanding effective use of land & water management iInterventions

A range of approaches (consultation meetings, workshops and surveys) were used to identify constraints, the project site and partner institutions at the local, regional and national levels. A baseline assessment was conducted to identify potential climate change adaption interventions. The Kabe watershed was selected because water scarcity is apparent, climate variability is evident and upstream-downstream relationships are strong. The assessment provided a basis for understanding the existing opportunities and barriers to the adoption of effective water management, including the type of incentive mechanisms required to facilitate collective action.

Interventions to adapt climate change/variability included technologies/ practices such as improved crop varieties, home-garden activities, livestock (breeds and feed), water (water harvesting and springs development), Soil and Water Conservation (physical and biological), forestry/agroforestry. Capacity building and knowledge sharing events included trainings, workshops, meetings, field-days/visits, blogs, and wiki. Others included digital stories, mapping and baseline studies.

Home-garden root crops, vegetables (carrots, potatoes, shallots, cabbages) and fruit trees (apple, plum) benefited both male and female households. There were good achievements in livestock (breeds and feed) whereby local ewes mated with improved rams produced more than 80 lambs. Improved sheep weighed on average 3.8 kg at birth (local breeds averaged about 1.9 kg) and sold on average for $80 ($38 for local sheep breeds). There were notable results in water harvesting and springs development, with 213 farm households benefiting from two improved springs. In addition, three hand-dug wells were constructed and a water-harvesting dam. Hand dug wells can irrigate 0.13 -0.5 ha of land. Soil and Water Conservation (SWC) (physical and biological) included coverage of physical SWC- 247 ha, Biological SWC measures- 215 ha and survival (%) of trees and grasses -47.56%. With regard to grazing land management, grass biomass harvested after blocking from grazing 82 ha of grazing lands was 2.8 t ha-1 on dry weight basis.

Recommendations for policy action

- The barley variety, Estaysh, the wheat variety, Dinknesh and the field pea variety, Addi received the highest score by farmers mainly in relation to their yield advantage and disease resistance. Therefore, there is a need to multiply and scale up these varieties. This approach can help to reach more farmers and capacitate communities to improve food security and adapt the effect of climate change.
- The soil in the upstream part of the watershed is highly depleted and requires nutrient addition from organic and inorganic fertilizer sources. It was evidenced from a location specific on-farm fertilizer trial (LOSOFT) at the watershed that the soil was responsive to DAP and urea fertilizer application. The plots provided with DAP and urea fertilizers provided more wheat and barley grain and biomass yield than the traditional (without fertilizer application) farmers' crop production system. However, farmers strictly questioned the escalating price of fertilizer for its wider utilization. Therefore, continuous awareness creation on the use of recommended fertilizer rates and creating various income generating options are very critical.
- The local sheep at the watershed are characterized by their low reproduction performance and low body condition although they have their own important qualities. On the other hand, the introduced Awassi crossbred showed reasonable birth weight as compared to the local sheep. Farmers can achieve earlier weaning weight and benefit more from the Awassi cross-bred sheep if they able to feed the locally available fodder trees

as well as improved forages. Appropriate feeding regime especially for pregnant ewes should be also promoted in order to achieve better pre- and post-weaning weights.

- Tree planting with water harvesting structure such as eyebrow basins could increase the survival rate and growth performance of tree species. Tree planting should be also combined with stone fenced structures in high altitude and wind prone areas to protect the seedlings from frost and wilting and enhance growth performance. Based on three-month data, Acacia saligna and Acacia decurrens demonstrated the best survival and growth performance.
- Additional research is needed to more fully understand the long-term impact of the various project interventions. For example, there is a need to understand the impact of SWC interventions on hydrological processes (discharge rate of water before and after interventions); effect of sheep crossbreeding and improved crop varieties on erosion of locally available genetic resources; and effect of eucalyptus species on local water resources.

4.2.2 Knowledge base forums at local level to share best practices

A strong partnership was established, which created additional demands for research and development. Baseline information on socio-economic, resource maps, etc. was used to build the capacity of farmers and extension workers through training and site visits. Potential crops, livestock, water and other Natural Resource Management (NRM) technologies and practices were identified, introduced and evaluated, which ultimately strengthened the capacity of communities to adapt to climate change/variability. Examples of improved crop varieties that were introduced include wheat (Dinkinesh), barley (Estayish) and field pea (Adi) varieties with a grain and biomass yield gain of 1.9 and 4.1; 3 and 3.6; and 2.3 and 1.8 t ha-1 over the grain and biomass yield of the local varieties, respectively.

Recommendations for policy action

- The early success stories of the project indicate that similar activities should be scaled up within and beyond the watershed. The pilot project should be either extended or a new project developed to generate more robust evidence for the benefits of some climate change adaption interventions that require more time and follow up such as evaluation of the performance of improved sheep (ram) and crop varieties, NPK fertilizer, fruit trees, SWC measures and afforestation programmes.

5.0 Communication & awareness

UNEP prepared project promotional and public awareness materials and shared communication and outreach materials based on outcomes from the project. Some of the reports that were prepared include: (i) stock-taking of existing activities related to climate change adaptation in the basin, key players (research, policy etc.) and existing projects at regional, national & local level; (ii) a collection of good practices at regional, national and local levels across the basin on adaptation; (iii) capacity needs assessment at basin, sub basin and national level; and (iv) a mapping of the institutional landscape and a strategy for policy and institutional support.

6.0 Sustainability & replicability of project

The technical results of the project can be sustained through the use of analytic tools such as the Nile Basin DSS, which undertakes monitoring of river basin processes (e.g. evapotranspiration, enhancing basins monitoring

infrastructure). Technical results can be disseminated for use by a variety of stakeholders through information and knowledge product dissemination platforms such as the Nile-IS, ENTRO web-portal, and the Nile Basin Development Forums (NBDF) including newsletters, ad hoc technical briefs, and the State of the Basin Report that is produced every two years in support of science-policy dialogue.

6.1 Comprehensive assessments

The regional framework developed by DHI has significant potential for application outside of the Nile Basin project. It can be applied in similar large or transboundary river basins and can readily be used in smaller basin(s) to evaluate national or local climate impact assessments for water resources, water resource management and/or the evaluation of climate adaptation measures and options.

6.2 Policy & capacity building

NBI and GWP used their extensive national, regional and global level networks and experience to facilitate policy and capacity support for climate change adaptation in the Nile Basin region. The NBI climate change strategy will pave the way for replicating the results achieved by the Nile Basin project in the future. The results of the Nile Basin project have reinforced NBI efforts to integrate climate change adaptation into the development agenda across all sectors, and to use climate compatible development strategies that promote economic growth while reducing risks to the environment.

6.3 Country interventions

Results from the Mpanga Catchment in Uganda are replicable because project activities were aligned to the new Ugandan Policy on Catchment Based IWRM. Whereas, results from the the Blue Nile basin in Ethiopia can be easily replicated in similar drought prone areas because of the practical and sustainable approaches that were used.

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