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Acknowledgments

The support provided by UNEP, NBI and various partners towards the preparation of this document is gratefully acknowledged. Our special thanks go to Dr. Alex Awiti who prepared and consolidated this document and finally the financial support from the government of Sweden is highly appreciated.

Executive summary

Although communities in the Nile Basin region have always responded to climate variability by altering cropping patterns, livestock and water management practices, these largely autonomous strategies are unlikely to build resilience of livelihoods, economies and ecosystems to cope with the projected magnitude and scale of climate change in the 21st Century. Moreover, the vulnerability of the Nile Basin region is exacerbated by the interaction among 'multiple stresses' including poverty, high disease burden, conflict and a low adaptive capacity. UNEP recognizes the importance of the Nile River Basin in the context of a variable and changing climate and hence the imperative to design and pilot adaptation options at basin level.

The objective of this report was to identify and evaluate best practice adaption options in response to risk, and vulnerability to climate change induced water stress as well as in the context of stated national adaptation priorities and climate change response strategies. This report contributes to the goal of building the resilience of ecosystems and economies that are most vulnerable to climate change induced water stress in the Nile Basin. The adaptation best practice examples presented in this report provide an evidence-base upon which the project on 'Adapting to Climate Change induced Water Stress in the Nile River Basin' can increase institutional and technical capacity to further test, replicate and scale up at the Nile River Basin level. Furthermore, this report will

contribute to enhancing UNEP's capacity to share knowledge and experience for adaptation policy and planning in the Nile Basin region.

Although climate forecasting in the Nile Basin region is imperfect and complex, projections reveal increases in average annual temperature, erratic intra-annual weather patterns coupled with more frequent and more severe extreme weather events. Rainfall and river flow records during the 20th century show high levels of inter-annual and inter-decadal variability. Moreover, significant fluctuations in rainfall have occurred in the humid highlands of East Africa and Ethiopia (headwaters of the Nile) over decadal timescales with marked consequences for Nile flows.

Climate change induced water stress will affect socio-economic welfare through complex causal pathways including drought or flood induced crop failure, loss of livestock, and epidemics of infectious diseases (e.g. malaria, cholera and Rift Valley Fever). Impacts of climate change induced water stress on livelihood option at the household and community level often combine with non-climate stressors including poverty, high prevalence of HIV/AIDS, rapid population growth, low levels of education and skills, weak state capacity to provide basic services (water and sanitation, energy, healthcare, emergency response).

The national adaptation action plans and strategies reviewed in this report have detailed adaptation priorities and underline the political commitment among the Nile Basin countries to deal with the impacts of climate change. Three intuitive approaches appear to have informed the prioritization of adaptation programs of actions and strategies, namely: i) social vulnerability approach (addressing underlying social vulnerability); ii) resilience approach (managing for enhanced ecosystem resilience); and iii) targeted adaptation approach (targeting adaptation actions to specific climate change risks).

Although adaptation actions and strategies have been framed in the limited context national development priorities or perceived national risks or vulnerability, it is valuable to examine transboundary or regional implications of adaptation actions. For instance, in the context of inter-annual and inter-decadal variability of Nile flows in the headwater countries, large-scale water storage and irrigation projects have the potential to disrupt local livelihoods and national economies that rely on river water, especially Sudan and Egypt.

This report presents an analysis of existing adaptation practices with a view to identify best practices based on a set of criteria including the

potential of the adaptation actions to:

- i. Deal with current/urgent climate risks;
- ii. Focus on the most vulnerable communities and groups;
- iii. Build the resilience of ecosystems and apply ecosystem-based approaches;
- iv. Support the adaptation activities of governments and communities of vulnerable regions, including assessments of impacts and vulnerabilities, piloting adaptation, and capacity building.

The adaptation practices described in this report include community-based rangeland rehabilitation, micro-water harvesting, disaster risk management, index-based risk transfer, grazing management and virtual water. However, climate change in the Nile Basin region presents novel risks and vulnerabilities often beyond the experience local communities and governments. Such impacts are related to inter-annual or inter-decadal variability of floods and droughts.

The review of best practice adaptation reveals that climate change adaptation actions in the Nile Basin countries are largely undertaken as stand-alone interventions, rather than as part of broader national development initiatives. This report suggests that priority should be given to increasing the capacity of the Nile Basin countries to adapt to climate change in ways that complement broader socio-economic and environmental/biodiversity conservation aims of national development.

Monitoring and review of adaptation actions will become, in the longer term, important components of adaptation strategies at local, national or regional level as implementation of priority adaptation actions/decisions gain traction. The adaptation programs of action reviewed here do not provide for monitoring or review. It is important that subsequent programs of action identify monitoring objectives and assign the responsibilities to appropriate institutions with a cross-sectoral mandate.

The report concludes that there are significant outstanding research challenges in understanding the processes by which adaptation is occurring at the local/national level and how and what capacities need to be leveraged to catalyze wider adoption and integration in national development. Many initiatives on adaptation to climate change reviewed here are recent and hence it is not possible to evaluate the degree to which they can reduce vulnerability or enhance resilience to climate change. Further research and monitoring will be needed to evaluate adaptation best practices suggested here to assess direct as well as knock-on effects on socio-economic and ecological dimensions.



1.0 Scope & context

Africa's vulnerability to climate change is acknowledged in the Third Assessment Report (TAR) of the IPCC. Areas of particular concern include water resources, agriculture and food security, prevalence and distribution of human diseases, plant pests (IPCC, 2001), ecosystems and biodiversity, sea level rise and inundation coastal zones and attaining the Millennium Development Goals (MDGs). There are indications, with high confidence levels, that the Nile River Basin Countries will bear the brunt of the adverse and highly uncertain impacts of climate change.

Although communities in the Nile Basin region have always responded to climate variability and change by altering cropping patterns, livestock and water management practices, these largely autonomous strategies are unlikely to enhance or maintain resilience of livelihoods, ecosystems and economies to the projected scale of climate change. Moreover, vulnerability of the Nile Basin region is exacerbated by the interaction and reinforcing feedback among 'multiple stresses' including poverty, high disease burden, conflict and a low adaptive capacity. UNEP recognizes the importance of the Nile River Basin in the context of a variable and changing climate and hence the imperative to design and pilot adaptation options at the basin level. Furthermore institutional capacity building including providing solutions for climate proofing options will be critical components of a responsive and adaptive climate change adaptation strategy.

The countries of the Nile Basin are particularly vulnerable because the mechanisms for coping and adapting to adverse effects of a variable and changing

climate are opportunistic or reactive or narrowly sector-based, and do not consider overall holistic or system level implications of adaptation actions. For instance, in semi-arid Tigray, northern Ethiopia, public and private investments in micro-scale water harvesting infrastructure has provided households with a source of supplementary irrigation. However, Ghebreyesus et al. (1999) showed that the overall incidence of malaria, especially among children, for the villages close to dams was seven-fold higher compared to control villages. Similarly, in the 1990s, Egypt responded to high Nile flows through policies that led to expansion of irrigation (Conway, 2005). In the recent decades however, this expansion has increased the exposure and sensitivity of Egypt's agricultural sector to climate induced fluctuations in Nile flows.

Analysis of time series rainfall and river flow records during the 20th century reveals high levels of inter-annual and inter-decadal variability in the Nile flows. The variability is experienced locally in the headwater (humid Ethiopian and East African highlands)

regions of the Nile and regionally through its effects on downstream in Sudan and Egypt. The effects of this variability are manifested through droughts and associated famine, floods and non-stationary levels in Lake Victoria as well as the exposure of Egypt and Sudan to inter-annual and inter-variability in the flows of the Nile River.

The health effects of a variable and changing climate are likely to be overwhelmingly negative. Changes in rainfall will affect distribution and transmission potential of vector- and water-borne pathogens (IPCC 2001). For instance, cholera – associated with both floods and droughts – may increase with climate change in the Nile River Basin region. Malaria has been identified as the disease most likely to be affected by climate change (Yanda et al., 2006). The vulnerable areas are those where transmission is currently limited mainly by temperature in highland areas (Lindsay and Martens, 1998). Malaria has already increased in previously malaria free highlands of Kenya, Ethiopia, Rwanda and Tanzania due to recent changes in temperature (Van Lieshout et al., 2004).

The threat of food security owing to climate change is grave for Africa. Although agricultural yields and per capita food production have been steadily declining the demand for food and forage is predicted to double in the next three decades (Davidson et al., 2003). For instance, Yield decreases in millet and sorghum are predicted to decline in the Sudan due to increasing variability and decreases in annual precipitation. It is also predicted that

Sudan's humid agro-climatic zones are likely to shift southward (Government of Sudan, 2007). Similarly, in Uganda, it is predicted that an average temperature increase of 2°C would drastically reduce the area suitable for production of Robusta coffee, a major export crop (Simonett, 1989). Moreover, increasing variability in rainfall in the growing season (shifts in start of rainy season, length and amount of rain) is disrupting subsistence agricultural production and food security.

Warming temperatures are projected to cause frequent and extreme weather events, such as heavy rainstorms, flooding, and El Niño events (IPCC, 2001). Extreme rainfall and subsequent flooding damage will also have serious effects on agriculture including the land degradation (erosion of topsoil and leaching of nutrients from the soil). The edaphic and topographic characteristics of some parts of the Nile Basin make them vulnerable to flooding. For example the flood plains of rivers Nyando, Sondu and Nzoia are prone to flooding. Similarly, the Khartoum plains, the flood plains of Atbara and the main Nile in the Sudan are susceptible to flooding. The impacts of flooding include loss of human life, crops, livestock, increased risk of disease transmission (Rift Valley Fever, malaria, cholera) and damage to physical infrastructure, especially roads.

The coastal zone of the Nile Delta in Egypt is vulnerable to the impacts of climate change, not only because of the impact of sea level rise, but also because of the impacts on fresh water resources, agricultural resources (land and irrigation



infrastructure), tourism and the human settlements in the major cities. For instance, sea level rise between 0.5 and 1 meter would cost Egypt's economy \$35 billion. More importantly, the impacts of climate change will add to the many economic and social challenges already confronting countries of the Nile Basin.

These examples serve to illustrate that adaptation measures must be evaluated across different spatial scales and sectors by local communities, national governments and at the Nile Basin region level. It is therefore imperative to formulate policies, design development and investment options that enhance adaptation to current impacts while building resilience to adverse and uncertain future impacts of climate change.

The objective of this report was to identify and evaluate best practice adaptation options in response

to risk, and vulnerability to climate change induced water stress as well as in the context of stated national adaptation priorities and climate change response strategies. This report contributes to the goal of building the resilience of livelihoods, economies and ecosystems that are most vulnerable to climate change induced water stress in the Nile River Basin. More specifically, the adaptation best practice examples presented in this report are intended to provide a practice evidence-base on which the project on 'Adapting to Climate Change induced Water Stress in the Nile River Basin' can increase institutional and technical capacity to further test, replicate and scale up at the Nile River Basin level. Furthermore, this report contributes towards enhancing UNEP's core capacity to assemble, evaluate and share knowledge and experience and practices for adaptation policy and planning.

2.0 Review of priority risks & vulnerability to the impacts of climate change induced water stress in the Nile River Basin

2.1 Introduction

Although forecasting climate is vital, it is imperfect and complex. Nevertheless, projections for Africa reveal increases in average annual temperature, erratic intra-annual weather patterns coupled with more frequent and more severe extreme weather events. African societies, economies and ecosystems are therefore the most vulnerable and yet possess the least capacity (technical, financial and institutional) to adapt; a situation aggravated by the lack of climate change scenarios using regional climate models or empirical downscaling.

The Third Assessment Report (TAR) observed that temperatures have shown an increased warming

decadal variability. Moreover, significant fluctuations in rainfall have occurred in the humid headwaters of the Nile in (East Africa and Ethiopia) over decadal timescales with marked consequences for Nile flows (Conway, 2005).

For the countries of the Nile Basin region whose economies and public health status are highly dependent on a benign climate, higher spatial and temporal resolution in forecasting, especially for extreme weather (droughts, floods or high temperature) is an existential imperative. In the 2010 World Development Report, the World Bank (2009) focuses on developing countries and estimates that without offsetting innovations, climate change will ultimately cause a decrease in annual GDP of 4%

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