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RIVER BASIN

Review of Adaptation Best Practice Examples in the Nile River Basin Region



UNEP



SWEDEN



NILE BASIN INITIATIVE
Initiative du Bassin du Nil

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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 2oC 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 Nino 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 trend since the 1960s. However, although these trends seem to be consistent over the continent, the spatial and temporal patterns of change vary across the Nile Basin region. For instance, in Ethiopia, minimum temperatures have increased slightly faster than maximum or mean temperatures (Conway et al., 2004). In eastern Africa, decreasing trends in temperature from weather stations located close to the Great Lake region have been observed (King'uyu et al., 2000). The patterns of variability in rainfall are more complex than those observed for temperature. Rainfall in the Nile Basin region exhibits significant spatial and temporal variability (Hulme et al., 2005). Rainfall and river flow records during the 20th century reveal high levels of inter-annual and inter-

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% in Africa.

2.2 Agriculture & food security

Despite the complexity and imprecision of climate change models, there is a fairly consistent pattern of direct impacts of climate change on Africa's agriculture (Lybbert and Sumner, 2010). The impacts of climate change induced water stress such as increased frequency and intensity of droughts and flooding, will affect the stability of, as well as access to, food supplies. Food insecurity and loss of livelihood would be further exacerbated by the loss of cultivated land (example). Autonomous or unplanned adaptive measures in response to agro-ecological shifts, such

as expansion of agriculture into previously forested areas, will lead to additional loss and fragmentation of valuable habitats, especially woodlands, forests and wetlands. The associated degradation of ecosystem services presents a veritable barrier to achieving sustainable economic growth in the Nile Basin countries.

Higher temperatures in arid and semi arid regions will likely depress crop yields and shorten the growing season due to longer periods of excessive heat. Egypt's major crops include wheat, maize, clover, cotton, rice, sugar cane, sorghum and soybean. For instance, Egypt's national wheat and maize production do not meet the current demand for these crops, and each year additional amounts have to be imported. Similarly, for countries like Kenya and Ethiopia, yield deficits and the need for food aid has been growing over the past decade. By the 2080s, the area of arid and semi-arid land in Africa could increase by 5-8% (60-90 million hectares). Moreover, by 2080 there will be a significant decrease in the extent of land suitable for rain-fed cereal production. Mixed rain-fed and highland perennial cropping systems in East Africa will become more marginal (Thornton et al., 2006). More frequent extreme weather events in the Nile Basin will lower long-term yields by directly damaging crops at critical developmental such as flowering, or by making the timing of critical farming operation more difficult therefore reducing the efficiency of modern farming technologies and inputs.

In scenarios with higher rainfall intensity, projected increase in risks of soil erosion will exacerbate soil nutrient depletion, damage of croplands and pastureland owing to down stream flooding. In cultivated dry lands, vegetation degeneration owing to climate change induced drought will lead to positive feedback between soil degradation low, agricultural productivity and reduced pasture rainfall, with corresponding loss of pastoral areas and farmlands (Zheng et al., 2002). However, uncertainty remains with respect to issues such as the impacts of increased temperature on the stability of carbon and soil organic matter pools. Rising soil temperatures will decrease soil moisture and exacerbate the rate of soil organic carbon mineralization and depletion of the soil organic carbon pool. Depletion of soil organic carbon pools invariably exacerbates soil physical degradation (i.e. decline in soil structure, reduction in infiltration and soil nutrient decline).

Drought is threatening about 18.6 million hectares of mechanized & non-mechanized rain fed agricultural fields

2.3 Drought

The Nile Basin is a region prone to extreme climate events such as drought and flood. Drought is one of the major environmental disasters in the Nile Basin, generally characterized by abnormal soil water deficiency. It is mainly caused by natural climatic variability, such as precipitation shortage or increased evapotranspiration. However, since these climatic factors have a large spatial and temporal variation, it is hard to monitor or predict drought events. In the past two decades, successive years of low precipitation have left large areas of the region in severe drought that resulted in crop failure, water shortage and has raised serious food security concerns for the region. Given that a 65 to 85% of rural populations in the Nile Basin is engaged in the



agricultural sector, episodic or prolonged drought invariably undermines economic growth and exacerbates poverty.

In recent years, Ethiopia has suffered from a number of severe droughts and associated famines. In the Amhara region for instance, of the 105 woredas forty-eight are drought prone and chronically food-insecure. In the Sudan, annual rainfall has declined from 425 mm to 360 mm. Successive drought years between 1978 and 1987 caused severe socio-economic damage, including loss of human life and resettlement of nearly 3 million people. Drought is threatening about 18.6 million hectares of mechanized and non-mechanized rain fed agricultural fields. What is at stake here is the livelihood of over 80 % of Sudanese who depend directly on agriculture as well as the nearly half of the country's GDP. The Humid agro climatic zones will shift southward, rendering areas of the North increasingly unsuitable for agriculture. Crop production is predicted to decline significantly for both sorghum and millet with attendant impacts on livelihoods and income security.

2.4 Flooding

The discharge levels from the Ethiopian Plateau (source of the Blue Nile) are highly variable and the region is highly vulnerable to the extremes of flooding. During exceptionally wet years, high discharge from the Blue Nile, Atbara and the Sobat result in large scale flooding in the floodplain areas of southeastern Sudan. In the recent years, extreme flood events have been reported in 1994, 198, 1999 and 2001. These events have led to damage of irrigation infrastructure and the spread of waterborne diseases.

In the Sudd swamps in southern Sudan local pastoralists have a long history of adapting to floods (Johnson 1988). The area of permanent swamp increased from 2800 km² to 16 600 km² and the area of seasonal swamp increased from 11 200 km² to 14 000 km² after the early 1960s (Sutcliffe & Parks 1987) in response to an almost doubling of outflows from Lake Victoria.

2.5 Sea Level rise & coastal zones

The dominant feature of the northern coastal zone is the low-lying delta of the River Nile, with its large cities, industry, flourishing agriculture and tourism. The Delta and the narrow valley of the Nile comprise 5.5% of the area of Egypt but over 95% of its people of which 25% live in the Low Elevation Coastal Zone

(LECZ) areas. Approximately 15% of Egypt's GDP is generated in these LECZ (The World Bank, 2005). In this context, the Nile Delta and Mediterranean Coast include 30-40% of Egypt's agricultural production, half of Egypt's industrial production, mainly Alexandria, Damietta and Port Said.

Given Egypt's growing population, its limited fertile land, its large area of desert, and the concentration of its economic activities in the coastal zones, the potential social and economic impact of climate change could be devastating for the country's future. In addition to the relative sea level rise (RSLR) and subsidence current trends, Egypt's Mediterranean coast and the Nile Delta are highly vulnerable to abrupt SLR due to climate change.

Rising seas would destroy parts of the protective offshore sand belt, which has already been weakened by reduced sediment flows resulting from the construction of the Aswan Dam in 1964. Without this sand belt, water quality in coastal freshwater lagoons will be altered, seawater will likely intrude fresh groundwater, and recreational tourism and beach facilities will be inundated. Furthermore, a predicted 6.1 million people will be displaced and 4,500 square kilometers of cropland will be lost.

2.6 Supply & demand of Nile waters

Trends in regional per capita water availability in Africa over the past half century indicate that water availability has declined by 75% (IPCC, 2001). In its report, the IPCC (2007b) has projected that by 2020 between 75 and 250 million people in Africa will be exposed to an increase of water stress due to climate change. By 2050, area experiencing water shortages in SSA will increase by 29%, while river flow in the Nile region will decrease by 75% by 2100 (UNEP, 2006). Egypt has an estimated annual water supply of 63.7 km³ against an estimated annual use of 61.7km³. However, this headroom could easily be wiped out by inter-decadal variability going by events in the last decade.

In addition to the negative consequence of global warming, the continuous increase in population is likely to threaten water security among the Nile Basin countries. Egypt's water resources are highly dependent on the River Nile, hence vulnerable to inter-decadal climate variability in the Equatorial Lakes and the Ethiopian Highlands. Any decrease in the total supply of water, coupled with an expected increase in consumption due to the high population growth rates, modest economic growth and the rise in the standards of living, will have drastic impacts on downstream supply.

2.7 Health

Emerging evidence of climate change effects on human health shows that climate change has altered the distribution of some infectious disease vectors. For instance, 34% of the global disability adjusted life years (DALYs) attributable to climate change occur in sub-Saharan Africa (Costello, 2009). Recent outbreaks of epidemics such as malaria, Rift Valley Fever (RVF), and cholera in the Nile Basin headwater countries (Kenya, Uganda, Tanzania, Ethiopia and Rwanda) have been strongly correlated with inter-annual rainfall variability linked to the El Niño. In central Ethiopia erratic seasonal patterns of rainfall and disease epidemics (Malaria or diarrhea or malnutrition) was associated with a 2.5-fold increase in local population mortality over a two-year period (Emmelin, 2008).

Emerging evidence of climate change effects on human health shows that climate change has altered the distribution of some infectious disease vectors

However, despite a heightened awareness of the Nile Basin region's vulnerability to climate change (Olago, 2007; Yanda 2006; IPCC), there is a paucity of published empirical evidence on the effects of climate on population health in region. A majority of reviews and reports, including IPCC assessment reports, document generalized predictions about the potential continent-wide effects of climate change with very few examples of locally documented population studies in which climate change and health interact. Although ecologically sensitive diseases such as malaria are highly susceptible to climate change, wider health issues relate to the interaction between rain-fed agriculture and child nutrition and disease impacts of floods.

2.7.1 Cholera

Cholera epidemics have been observed in areas surrounding the Great Lakes in the Great Rift Valley region. It is likely that warming in these African lakes may cause conditions that increase the risk of cholera transmission. A significant association between bathing, drinking water from Lake Victoria and the risk of infection with cholera has been found in east African lakes (Shapiro et al., 1999). Communities around the Lake Victoria Basin are vulnerable to climate-induced cholera, which is exacerbated by poverty and weak public health infrastructure (Olago

et al, 2007; Yanda et al., 2006). The countries most affected by the 1998 epidemic were DR Congo, Kenya, Uganda and Tanzania (Yanda et al., 2006).

Cholera epidemics are associated with the anomalously warm and wet El Niño years, such as in 1982 and 1997. Olago et al. (2007) have argued that daily maximum temperature recorded in Lake Victoria Basin in 1982/83 and 1997/98 may have triggered cholera epidemics. The temperature trigger hypothesis is validated by climate data for the periods 1983 and 1998 when above normal precipitation, high daily maximum temperatures and widespread flooding were recorded. Cholera epidemics are also associated with positive temperature anomalies in inland lake waters (Colwell, 1996).

2.7.2 Rift Valley Fever

Rift Valley fever (RVF) is a viral zoonosis that primarily affects cattle, goats, sheep and wildlife but can also infect humans. Among animals, the RVF virus is spread primarily by the bite of infected mosquitoes, mainly the *Aedes* species, which can acquire the virus from feeding on infected animals. Extensive research on mosquito vectors of Rift Valley Fever in Kenya (mainly *Aedes* and *Culex* species) clearly has linked the risk of outbreaks with flooding (Linthicum, 1990).

In 1997/98 and 2007 major outbreaks of RVF occurred in Kenya and Tanzania. Specifically hard hit by the outbreak were the pastoral communities. The IPCC (2001) concluded that increased precipitation because of climate change would increase the risk of infections of this kind to livestock and people. In this region, livestock is critical to pastoral livelihoods, with livestock trade representing over 90% of pastoralists' incomes (Rich and Wanyoike, 2010). Following the 1997/8 El Niño in East Africa, a Rift Valley Fever outbreak in Somalia and northern Kenya killed up to 80% of livestock (WHO, 1998).

Following the 2007 RVF outbreak, the economic and social impacts, caused by morbidity and mortality of livestock and disruption of livelihoods and economies through the disruption on the meat industry were considerable. Jost et al. (2010) have quantified the multi-dimensional socio-economic impacts of the 2007 RVF outbreak in Kenya based on a rapid assessment of livestock value chains. Besides immediate negative impacts of RVF on livelihoods of pastoralists (e.g. food security and income), Jost et al. (2010) also found significant losses among other downstream actors in the value chain, including livestock traders, slaughter-houses, casual laborers, and butchers, as well as other, non-agricultural sectors. Moreover, Jost et al. (2010)



argue that the although downstream impacts often surpass the impacts of RVF at household level, public policy tends to focus primarily on losses incurred by herders and fail to respond to collateral impacts.

2.7.3 Malaria

The public health burden of Malaria is expected to increase significantly in the East African Highlands in response to climate change due to the role of temperature and rainfall in the population dynamics of its mosquito vector (Pascual et al., 2006). Temperature is known to influence the mosquito life cycle and in particular the development rate of larvae and adult survival.

Pascual et al. (2006) have shown that a mere 0.5°C temperature increase can translate into a 30–100% increase in mosquito abundance. Githeko and Ndegwa (2001) observed that malaria related hospitalization in the highlands of Kenya were associated with rainfall and higher than normal maximum temperatures in the preceding three to four months. Similarly, using data collected from 50 sites in Ethiopia between 1980 and 1990, Abeku et al. (2003) found that malaria epidemics were associated with elevated minimum temperatures in the months prior to the epidemic.

Land cover affects mosquito habitat by changing local temperature and humidity. In Uganda for example, temperatures were significantly higher in communities bordering cultivated swamps compared with natural ones, and average minimum temperatures were associated with the number of *Anopheles gambiae* mosquitoes per house (Lindblade et al., 2000).

The development time of malaria parasites inside a mosquito, extrinsic incubation period (EIP), has been shown to shorten at higher temperatures so mosquitoes become infectious sooner (Patz and Olson, 2006; Gilles, 1999). The biological amplification of temperature effects on mosquito populations is critical to advancing risk assessment of the impacts of climate change on malaria.

Several studies of long-term trends in malaria incidence and climate in the East African highlands have not found a link to temperature trends, emphasizing instead the importance of other key determinants of malaria risk such land use change, poverty and inconsistent vector or disease-control programs (Hay et al., 2002; Shanks et al., 2002). Hence, studies that link malaria and warming in the East African Highlands (e.g. Githeko and Ndegwa, 2001; Abeku et al., 2003) are therefore controversial in part due to varying quality of time series disease data, and in part due to the difficulty in adequately controlling for demographic and biological (drug resistance) data (Patz et al., 2005).

The public health burden of Malaria is expected to increase significantly in the East African Highlands in response to climate change due to the role of temperature & rainfall in the population dynamics of its mosquito vector

2.8 Rural livelihoods

The impact of climate change on subsistence-based rural livelihood in the Nile Basin is seldom addressed. Case studies are few and rarely available in the public domain. Specific impacts of climate change on subsistence livelihoods must be examined within the context of whole sets of confounding impacts at regional to local scales (Adger et al., 2003). Subsistence rural livelihoods in the Nile Basin are complex and involve multiple interdependent strategies. Many smallholder livelihood strategies will include elements of crop production, livestock keeping, harvesting of natural resource products (fishing, forest and wildlife products) and non-agricultural strategies such off-farm unskilled labor, remittances.

With a large proportion of rural subsistence-based (most of whom depend on agriculture, livestock, fisheries) population in the Nile Basin, there is special

concern over the overall impacts of climate change on rural livelihood strategies. Climate change is expected to generate the following aggregate effects among rural households communities across the Nile Basin:

1. Increased likelihood of crop failure;
2. Increased risk of livestock mortality;
3. Increased likelihood of forced sale of productive assets and indebtedness (land and livestock) at disadvantageous prices;
4. Out-migration of able bodied adults in search of off-farm employment, leading to shortage of household farm labor;
5. Dependency on food relief and remittances;
6. Unsustainable exploitation of natural resources as a means of income and consumption smoothing (e.g. upland deforestation, destruction wetlands) hence increasing the risk of land degradation and downstream flooding as well as change in disease vector ecology;
7. Poor nutrition, low income and poverty could lead to poor outcomes on human development indicators such as health and education leading to intergenerational poverty.

Climate change induced water stress will affect human nutrition through complex causal pathways including drought or flood induced crop failure, loss of livestock, and epidemics of infectious diseases (e.g. malaria, RVF). The effects of drought on health in the Nile Basin region include under nutrition and malnutrition. Invariably, drought reduces dietary diversity and constrains overall food consumption, leading to micronutrient deficiencies, malnutrition and mortality, especially among children aged less than 5 years.

Impacts of climate change on livelihood option at the household and community level often combine with non-climate stressors including poverty, high prevalence of HIV/AIDS,



Climate change induced water stress will affect human nutrition through complex causal pathways including drought or flood induced crop failure, loss of livestock, and epidemics of infectious diseases

rapid population growth, low levels of education and skills, weak state capacity to provide basic services (water and sanitation, energy, healthcare, emergency response). Poverty constrains the capacity of agricultural and pastoral communities in the Nile Basin to manage climate risks. At the same time, climate related risks and uncertainties are key factors that reinforce a vicious poverty trap among poor households.

In the Nile Basin region, poverty, more than any other factor, determines vulnerability to climate change and constrains adaptive capacity. The poor depend inordinately on climate-sensitive resources (soils, vegetation and water) for sustenance and economic development (Millennium Ecosystem Assessment, 2005). Moreover, the poor have few fungible assets, including little or no savings and limited or total lack of access to credit. Poverty also tends to trap households/communities in livelihoods options even when these are no longer effective,

hence limiting access to new information, innovation or opportunities to develop new skills. Finally, people living in poverty are often forced to occupy the least productive or most disaster-prone lands, such as flood plains, slums, eroding hillsides, and low lying and unprotected coastal areas. Under these already difficult conditions, even modest changes of climate hazards will quickly push households and communities beyond their abilities to cope.

Under the uncertainty of climate change, poor people are risk-averse (Rosenzweig and Wolpin, 1993). Smallholder farm households may not adopt technology or practices that could increase productivity, precisely because such innovations may require some upfront investment that may escalate their vulnerability by eroding the very assets they need to survive a crisis (Dercon, 1996). Lack of credit restricts access to agricultural inputs such as improved seeds, fertilizers as well as information and technologies.

3.0 Comparative analysis & synthesis of national adaptation & action programs & national communication on climate change

3.1 Introduction

Within the Nile Basin region, an optimal response to climate change requires designing adaptation mechanisms to enhance the ability to cope with and build resilience to anticipated impacts. Uganda, Tanzania, DR Congo, Ethiopia, Sudan, Rwanda and Burundi have prepared National Adaptation Programs of Action (NAPA) detailing priorities, projects and policies intended to reduce national vulnerability and build adaptive capacity to the impacts of climate change. Kenya and Egypt have detailed similar aims in their national climate change response strategy national communications respectively.

The NAPA documents analyzed respond primarily to national and socio-economic conditions of the respective country, with particular emphasis on challenges perceived as most urgent in that country. Egypt's National Communication recognizes that climate change will cause a reduction in Nile flows, and that population growth will lead invariably to increased demand for water. The primary objective of the national adaptation actions and strategies was to identify short, medium and long-term actions and to address the impacts climate change and variability within the context of economic development priorities.

3.2 Motivating & facilitating factors for NAPA development

More recently, the 2007 Bali Action Plan identified adaptation as one of the key building blocks necessary for a strengthened future response to climate change. Other adaptation-related activities include the Nairobi Program of Work on impacts, vulnerability and adaptation to climate change, development and transfer of technologies, research and systematic observation.

Article 3 of the UN Framework Convention on Climate Change encourages governments to adapt to climate change. Similarly, the Delhi Ministerial Declaration on Climate Change and Sustainable Development, issued at the Eighth Conference of the Parties of the Framework Convention on Climate Change in 2002, stated that adaptation "is of high priority for all countries" and that "adaptation requires urgent attention and action on the part of all countries". Adaptation has been identified as a high priority in the Least-Developed Countries (LDCs), which are considered highly vulnerable to climate change. Hence, planning for adaptation in the LDCs has been facilitated through development of National Adaptation Programs of Action (NAPA).

Equally essential, albeit poorly understood, are key facilitating national imperatives without which it is unlikely that the international motivations outlined above would have any support at the national planning level. The national adaptation processes prioritized the adaptation actions needs in the context of vulnerability of key sectors of their respective ecological and socio-economic circumstances. Adaptation is therefore not just an international obligation because the countries of the Nile Basin region recognize that:

1. Climate change presents a major challenge for development and poverty eradication. The economies depend on weather-sensitive resources, such as agriculture and millions of poor people in these countries are vulnerable to extreme weather events and climate change impacts on ecosystems, water and agriculture and human health.
2. The development goal of utmost priority in all the Nile Basin countries is eradication of poverty through increased agricultural production. Hence, the countries of the Nile Basin region recognize that climate change presents a major obstacle to the prospects of lifting the most vulnerable out of poverty.

3.3 Identification of vulnerable sectors

Across the Nile Basin countries, priority setting for adaption actions at the national level enlisted

strong stakeholder participation through a variety of consultation forums. Participatory vulnerability assessment methods were applied to collate local experiences and perceptions of climate change vulnerability and vulnerability. Initial scoping studies involved review of existing data and national studies on vulnerability, especially in the water, agriculture and public health sectors. The participatory workshops and expert consultations informed the basis and process for proposing and prioritizing national adaptation programs of action.

Table 3.1 shows the vulnerable sectors prioritized by the Nile Basin countries. As shown in Table 1, some countries focused on a small number of key sectors while others opted for inclusion of a broader range of issues. Some of the prioritized sectors are more country-specific than others, reflecting unique national circumstances, local geographical conditions and national development priorities. For instance, Ethiopia based its prioritization on: i) the poverty reduction potential; ii) complementarities of national and sectoral plans. Sudan's prioritization of vulnerable sectors was motivated by what is perceived as the link between development challenges and vulnerability to climate change. In particular, Sudan notes that poor rural farmers who depend on rainfall and traditional agricultural practices that are highly vulnerable to climate change dominate its agricultural sector.

Table 3.1: Vulnerable sectors prioritized in the NAPA & national communication

Vulnerable Sector	Nile River Basin Country								
	DR Congo	Egypt	Ethiopia	Kenya	Tanzania	Uganda	Rwanda	Burundi	Sudan
Agriculture	•	•	•	•	•	•	•	•	•
Water Resources	•	•	•	•	•	•	•	•	•
Human Health	•	•	•	•	•	•	•	•	•
Forestry	•			•	•	•			
Livestock				•	•	•			•
Energy			•		•		•		
Physical Infrastructure	•	•		•				•	•
Tourism		•		•	•				
Coastal Zone Management	•	•							
Aquaculture & Fisheries		•		•					

3.4 Priority setting for adaptation activities

Priority adaptation projects identified by the Nile Basin countries are shown in Table 3.2. Although not always explicit in the adaptation action plans, the formulation of priority adaptation projects appear to depend on the how climate change impact is framed in the different countries. These framing issues are likely to affect the implementation of appropriate adaptation measures. The issues are: a) how future development is characterized (e.g., through scenarios or national development goals or vision statements); b) which vulnerable sectors are prioritized; c) whether climate change is viewed primarily as a risk or as presenting both risks and opportunities.

Tompkins et al. (2008) identified three approaches to prioritizing adaptation actions and categorized

them as: 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). According to Tompkins et al. (2008), these approaches differ in their underlying assumptions for evaluating criteria, trade-offs, and prioritization as well as implementation arrangements.

An example of the first type of approach – social vulnerability – is Egypt’s adoption of Environmental Impact Assessment (EIA) requirement for project approval and regulating setback distance for coastal infrastructure. Rwanda seeks to address vulnerability of its agricultural sector to climate change by promoting non-agricultural income generating activities to reduce the vulnerability of rural populations to climate change.

Table 3.2: Priority adaptation projects in the Nile River Basin countries

Priority Adaptation	Country									
	DR Congo	Egypt	Ethiopia	Kenya	Tanzania	Uganda	Rwanda	Burundi	Sudan	
Water resource Management		•		•	•	•	•	•	•	
Promotion of Drought tolerant crops		•	•	•	•	•	•	•	•	
Sustainable Agriculture and Land Management	•	•		•	•	•	•	•	•	
Environmental X Conservation & Bio-diversity/ Land Restoration	•		•	•		•	•			
Early warning systems			•			•	•	•	•	
Diversification of Energy sources				•	•		•	•	•	
Malaria Control	•		•	•	•		•	•	•	
Integrated Coastal Zone /Flood plain Management	•	•		•				•	•	
Strengthening Community Awareness	•	•	•	•	•		•	•	•	
Livelihood diversification	•		•	•			•		•	
Water & Sanitation						•	•			
Indigenous Knowledge						•				
Disaster Risk Reduction/ Risk Transfer				•	•					

Examples of the second approach—resilience approach—include adoption of sustainable agricultural land management, especially the incorporation of trees and shrubs in smallholder farming systems to maintain permanent soil cover, stabilize soil structure, build soil organic matter and enhance infiltration and moisture retention, diversify household incomes. The Swedish Cooperative Centre (SCC)–VI Agroforestry project in western Kenya Community–Based Rangeland Rehabilitation project in Sudan’s Bara province exemplify a resilience approach.

The third approach – targeted adaptation actions to specific climate change risks – is intended to underwrite risk (e.g. pastoralism, agriculture, health) that is affected by a specific climate change impact (drought, flood, disease). The index based risk transfer mechanisms (e.g. index based livestock insurance in Kenya and Ethiopia’s first national index-based disaster insurance program) is a good example of a targeted adaptation action.

3.5 Public awareness & dissemination for climate change adaptation

Communicating and enhancing the public awareness about vulnerability as well as individual/collective adaptive actions is critical. All the Nile Basin countries

mention the importance of awareness raising and communication with different stakeholders to create understanding and catalyze public participation and adoption of adaptation actions. Raising public awareness is intended to mobilize support for ongoing or planned government interventions, enhancing society’s risk perception, eliciting possible adaptation action by policy makers and the public or preparing society for anticipated impacts of climate change.

Tanzania’s NAPA mentioned building awareness and understanding among local communities on the changing epidemiology of Malaria. Similarly, Uganda’s NAPA mentioned indigenous knowledge documentation and awareness creation as well as an approach to disseminate weather and climate information. Egypt’s National Communication presents the most detailed recommendations for awareness creation and education. These include national campaigns for public awareness on climate change for different sectors, i.e. agriculture, water resources, coastal zones and other threatened sectors. Egypt’s Environmental Affairs Agency (EEAA), in coordination with the Ministries of Education and Higher Education, agreed to integrate Environmental Science at all education levels. Kenya’s National Climate Change Response strategy proposes a nationwide communication, education and



awareness program, owing to the fact that climate change awareness is low countrywide.

3.6 Mainstreaming adaptation actions

Mainstreaming of adaptation into new and existing sectoral policies is a stated commitment in all the adaptation programs reviewed. In the context of climate change, 'mainstreaming' refers to integration of climate change adaptation into existing national policy. By implementing mainstreaming initiatives, it is argued that adaptation to climate change will become part of or will be consistent with other well-established public sector policies and program, particularly national development planning (Adger et al., 2007). For instance, Sudan seeks to mainstream NAPA into national policymaking through the interim Poverty Reduction Strategy, the Roll Back Malaria program and through devolved state planning organs such as Environmental Councils. Ethiopia has shown in detail, the complementarities among priority adaptation activities and other Multilateral Environmental Agreements (MEAs) seeks to address crosscutting issues such as poverty and gender dimensions of climate vulnerability.

Rwanda identified 20 adaptation options across all sectors that were subsequently pared down to 11, based on priorities of the Economic Development and Poverty Reduction Strategy (EDPRS) and the Poverty Reduction Strategy Paper (PRSP). Burundi focused on cross sector impacts and recognized that decline in water resources is linked to agriculture, human health, biodiversity declines, population migrations and hydropower shortfalls. Egypt's National Communication noted that sea level rise (SLR) will have a major impact on other sectors such as tourism, fisheries, human settlement, industry and transport.

Uganda's NAPA observed that the relationship between climate change and socio-economic development is not well understood by planners and policy makers. Hence, climate issues are seldom considered in sectoral investment plans. Uganda has therefore proposed, as a component of its adaptation program of action, development, dissemination and application of mainstreaming guidelines at all levels of development planning. Similarly, Tanzania's NAPA seeks to mainstream adaptation activities into sectoral policies and development goals. Moreover, Tanzania's NAPA is linked with existing national development goals and policies such as the Rural Development Strategy, the Agriculture Sector Development Strategy and the National Strategy for Growth and Reduction of Poverty. Kenya's climate

change response strategy aims to ensure that adaptation actions are integrated in all government planning and development objectives.

The Nile Basin countries recognize that successful adaptation requires cross-sectoral integration of adaptation strategies within government. However, the official national adaptation responses reviewed offer very few clues on how the respective Nile Basin countries will mainstream and coordinate the complex multi sectoral adaptation programs at local, national or regional levels. More importantly, the adaptation responses mark a beginning rather than a culmination of a process. Flexible and routine mechanisms to evaluate implementation, institutional and policy effectiveness will be required.

Although the implementation arrangements of climate change adaptation programs differ among the Nile Basin countries, they represent a fundamental political commitment to addressing the challenge at the national policy level. However, there are many implementation hurdles, including multiple levels of governance, between and within sector policy coordination and integration issues, which present significant barriers as well as opportunities to the implementation of adaptation actions.

In the context of climate change, 'mainstreaming' refers to integration of climate change adaptation into existing national policy

3.7 Developing & maintaining the knowledge base

A considerable amount of information and research on vulnerability, impact and adaptation to climate change already exists. However, the information is seldom shared among government or private or local communities, much less among countries of the Nile Basin region. An effective way to improve knowledge management for climate change adaptation would be to establish a database or clearinghouse mechanism on vulnerability, climate change impact and best practices on adaptation.

To be able to take decisions on how best to adapt, it is essential to have access to reliable data on the likely impact of climate change, the associated socio-economic aspects and the costs and benefits of different adaptation options. More spatially



explicit knowledge is needed on climate impact and vulnerability so that appropriate policy responses and adaptation actions can be developed.

3.8 Lessons learned

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.

Evidently, the development of NAPA is evidently supported by scientific information about the climate system (from global and continental scale models). However, there is a need for downscaled models and scenarios on the climate system, including spatially explicit knowledge of vulnerability, impact and adaptation options. It is important to develop national research programs to give more encourage interdisciplinary studies to assess vulnerability and

adaptive capacity across multiple sectors. There is also need for more social science research on, for example, indigenous technical knowledge, institutions, modes of governance, and estimates of the economic costs/benefits of adaptation.

Although adaptation programs of action have been framed in the larger context of national development priorities or perceived national risks or vulnerability, it would be valuable to examine transboundary or regional implications of the actions. For instance, in the context of inter-annual and inter-decadal variability in Nile discharge 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.

There is potential for valuable cooperation and exchange of experiences on vulnerability and adaptation to climate impacts, and in particular on the transboundary effects of planned adaption actions. There is a clear need to share information among the Nile Basin countries to facilitate access to adaptation related tools, methodologies, processes, or technologies that can be tested or replicated across the basin.

4.0 Evaluation of adaptation practices in the Nile River Basin region

4.1 Introduction

The Fourth Assessment Report (IPCC, 2007) recognizes that adaptation is occurring albeit on a very limited basis and urges for extensive adaptation across nations and economic sectors to reduce vulnerability and to address the impacts of climate change and associated extreme weather. Adaptation to climate change refers to adjustments, or changes in decisions or actions in response to or in anticipation of climatic impacts, which enhance resilience or exploit beneficial opportunities. The focus of these decisions or actions is on managing risk and reducing vulnerability.

Communities in the Nile Basin region have always taken adaptive action by altering cropping patterns, livestock and water management practices. However, these largely autonomous strategies are unlikely to guarantee that livelihoods and economies can be sustained in the face of global climate change. Climate will have impact on a wide range of sectors including agriculture, water, human/animal health, biodiversity and infrastructure. These impacts are expected to be extreme and relatively rapid so that autonomous, unplanned adaptive responses may not be optimal.

Planned and sustained adaptation actions are therefore needed to respond to current and anticipated impacts of climate change and vulnerability in the Nile Basin region. This section examines real-world adaptation practices and processes in the Nile Basin region. The adaptation best practices examined here relate to risk management, disease surveillance, resource planning, livelihoods, sustainable water and land management and diagnostic surveillance.

There are many adaptation initiatives and approaches that are planned or currently under implementation in the Nile Basin region. This review has developed a set of five criteria upon which actions or decisions are assessed for “best practice”. Adaptation actions and decisions are essentially local responses, shaped by perceived site-specific risks and vulnerabilities. In selecting adaptation “best practice”, actions, processes or decisions that meet one or a combination of the following criteria were used:

i. Immediate steps to deal with urgent/current climate risks;

- ii. Long-term arrangements needed to prepare and respond to future climate risks;
- iii. Strengthen the management and mobilization of data, information and knowledge to support knowledge-based adaptation;
- iv. Build the resilience of ecosystems and apply ecosystem-based approaches in adaptation;
- v. Support the adaptation activities of governments and communities of vulnerable regions, including assessments of impacts and vulnerabilities, piloting adaptation, and capacity building in support of policy setting, planning and adaptation practices;
- vi. Focus on the most vulnerable countries, communities and groups of people, and responding to the specific support needs identified by them;
- vii. Provide increased, sustainable and long-term funding to meet the increasing needs for capacity building, technology development and transfer, and adaptation practices.

This section describes adaptation actions that have been implemented by communities, governments and development agencies in the Nile Basin region. These actions are typically undertaken in response to multiple risks, and often implemented as part of existing processes or programs, such as agriculture, livelihood enhancement, rangeland management, water resource management, disaster risk management or coastal defense.

4.2 Best adaptation practices in agriculture

4.2.1 Water Efficient Maize for Africa (WEMA)

Under a warming climate, a key challenge in the Nile Basin region is how to produce more food, more efficiently under highly uncertain production conditions and for more people. In addition to increasing productivity, several new varieties and traits will be needed to provide farming communities with greater flexibility in adapting to climate change impacts, especially water stress.

Drought tolerance has been recognized as one of the most important targets for crop improvement programs in Africa. Moreover, biotechnology is considered a powerful tool to achieve significant drought tolerance by the United Nation’s Food and Agriculture Organization. In 2008, Monsanto

announced a public–private partnership called Water Efficient Maize for Africa (WEMA) to develop drought–tolerant maize varieties for Africa. WEMA aims to develop drought-tolerant African maize varieties using conventional breeding, marker-assisted breeding and biotechnology. The goal is to eventually offer the drought-tolerance trait to small farmers in sub-Saharan Africa, royalty-free, so they are able to achieve harvests that are more reliable. During moderate drought, the new varieties are expected to increase yields by 24–35 %. The partnership brings together Bill & Melinda Gates Foundation, Howard G. Buffet Foundation, Monsanto, African Agricultural Technology Foundation (AATF), the International Maize and Wheat Improvement Center (CIMMYT) and national agricultural research systems (NARS) of eastern and southern Africa.

Under a warming climate, a key challenge in the Nile Basin region is how to produce more food, more efficiently under highly uncertain production conditions & for more people

The Bill & Melinda Gates Foundation and the Howard G. Buffett Foundation are contributing \$47 million to fund the first five years of the project. AATF will provide technology stewardship and project management expertise. CIMMYT will provide expertise in conventional breeding and testing for drought tolerance while Monsanto will provide proprietary germplasm, advanced breeding tools and expertise. More importantly, the national agricultural research systems, farmers' groups, and seed companies participating in the project will contribute their expertise in field testing, seed multiplication, and distribution. Furthermore, the project will involve local institutions, both public and private, and in the process expand their capacity and experience in crop breeding, biotechnology, and bio–safety.

The varieties developed through the project will be distributed to African seed companies through AATF without royalty and made available to smallholder farmers. Moreover, promising new traits and varieties, which are mostly still in development, can emerge from traditional breeding techniques that harness existing varieties well suited the local environment as well as from more advanced biotechnology techniques such as marker assisted selection and genetic modification.

4.2.2 Virtual water

Where a country anticipates reduced water availability due to climate change, and where current demand patterns strain existing supplies, one adaptation to climate change may be to move away from water-intensive types of production to other activities where the water requirements are lower per unit of production by value. The changing social use of water is best reflected in the story of “Virtual water”. In this tale Tony Allan (1998) tale narrates how water-starved countries, unable to mobilize enough water to grow the food could instead import water in the form of food.

Egypt is an example of a country that ‘ran out of water’ more than 25 years ago. All the waters of the River Nile were already allocated and no new water was available for additional growth. Today Egypt imports a substantial amount of wheat, which is a way of importing virtual water. Egypt could have chosen the path of self-sufficiency in food production and maintained wheat production, albeit at great cost to the economy.

4.2.3 Sustainable agricultural land management

Swedish Cooperative Centre (SCC)–VI Agroforestry is promoting interventions that promote sustainable agricultural land management practices to: to reduce vulnerability to climate change, sell carbon emission reductions and restore agricultural production. The World Bank BioCarbon Fund will purchase the credits and funds will flow back to participating farmers and their communities. Agricultural carbon finance can enhance capacity of farmers to adapt to climate change by diversifying income streams for rural households.

The project works with farmers in the Kisumu and Kitale regions of western Kenya. The farmers are organized in common interest groups, primary level cooperatives, farmer groups and informal organizations. The adoption area is about 45,000 ha and involves about 60,000 registered households. The participating households are smallholder farmers who practice mixed farming and own less than one acre.

Farmers who integrate crop and tree systems through Agroforestry tend to maintain high levels of soil moisture and organic matter and hence are able to realize higher yields even in drier periods. Agroforestry system maintains permanent soil cover, stabilizes soil structure, builds soil organic matter and enhances infiltration and moisture retention. Agroforestry systems are associated with high crop yields. Thus, diversifying the production

system to include a significant tree component may buffer against income risk associated with climatic variability. Other practices such as the use of mulch cover protects soil from excess temperatures and evaporation losses and can reduce crop water requirements by 30 percent.

SCC–Vi Agroforestry has estimated the cost of Agroforestry-based adaptation at the farm household level farm level, working with 500 households. The total cost per farm household is \$ 50 for 3 years (\$ 17 per household per year. These costs include capacity building and tree seedlings.

4.3 Best adaptation practices for ecosystem management

4.3.1 Community-based rangeland rehabilitation

Agro-pastoralists and nomadic pastoralists in Sudan are extremely vulnerable to drought and water stress, in addition to rangeland degradation due overstocking and unsustainable fuel wood gathering. The 1980–1984 droughts had severe impacts on Sudan, disrupting structures of social capital, exceeding autonomous traditional coping strategies and causing thousands of people to migrate into refugee camps.

In response to the devastating impacts of the drought and the associated land degradation, a UNDP/GEF project 'Community-Based Rangeland Rehabilitation (CBRR) was initiated in 1992 covering 17 villages within Gireighikh Rural Council in the Central Bara Province. The primary aim of the project was to test an approach for reducing the risks of production failure in drought-prone areas by providing alternatives for sustainable production. Through community-based natural resource management, the project promoted re-vegetation (tree and shrub planting), biodiversity preservation, restoration of degraded rangelands and carbon sequestration. Other interventions implemented by the CBRR project include small-scale irrigation for vegetable gardens, improved water management through the construction of water wells. The CBRR project enabled diversification of livelihoods options and contributed to improved socio-economic conditions, leading to decreased out-migration and population stability. In essence, the project included both and adaptation mitigation outcomes.

Other benefits accruing from the CBRR project include:

1. Enhanced human capital through training and capacity building for natural resource management, introduction of women's gardens

- and changing building practices to conserve wood;
2. Improved natural capital owing to improved land management and rehabilitation of degraded land;
3. Financial capital was improved through access to local and national markets, greater access through revolving credit funds and production of marketable sheep;
4. Social capital benefits include the formation of community development committees and enhanced living conditions of women through participation in community gardens and other activities.

4.3.2 Humbo assisted natural regeneration project

The main causes of tree cover loss and land degradation in Humbo, Ethiopia has been deforestation and unsustainable sale of wood products, especially to compensate for food shortages created by low and stochastic rainfall.

The Humbo Assisted Natural Regeneration Project has restored more than 2,700 hectares of degraded land in the impoverished highlands of southwestern Ethiopia since 2007. Conventional approaches to reforestation require the costly replanting of trees from nursery stock. However, over 90 percent of the Humbo Project area has been reforested using Farmer Managed Natural Forest Regeneration, which encourages new growth from tree stumps previously felled but still living. Using this method, indigenous forest species, some of which are endangered, have been restored.

The main causes of tree cover loss & land degradation in Humbo, Ethiopia are deforestation & unsustainable sale of wood products, especially to compensate for food shortages created by low & stochastic rainfall

The sale of carbon credits under the BioCarbon Fund will provide an income stream of more than US\$700,000 to the local communities over the next decade. Additional income for the community will come from the sale of fodder, forest fruits and in the future, from the selective harvest and sale of wood products. Other tangible benefits, besides revenue from carbon credits, include improved land management and reduced vulnerability to mudslides in the rainy season.



The project will also provide significant biodiversity benefits. Once regenerated, the Humbo forest will provide habitat for birds, mammals and other native animals including species on the IUCN Red List of Threatened Species. The forest will provide a strategic wildlife corridor between the Nechisar National Park, Lake Abaya and Lake Chomo. The Nechisar National Park has some 73 species of mammals and 342 species of birds including two endemic birds.

The Humbo Project is the outcome of collaboration across organizations and continents, involving World Vision offices in Australia, the World Bank, the Ethiopian Environment Protection Agency, local and regional government and the community. Humbo is the first large-scale forestry project registered under the Clean Development Mechanism of the Kyoto Protocol in Africa.

4.4 Best practices in livestock management

4.4.1 Autonomous adaptation practices in Kenya & Ethiopia

Pastoralism is an adaptive strategy evolved over hundreds of years to cope with spatial and temporal patchiness of savannah, arid and semi-arid resources (forage and water). McPeak and Barrett (2001) and McPeak and Doss (2005) have focused on the coping strategies used by pastoralists during recent droughts in northern Kenya and southern Ethiopia, and the longer-term adaptations that underlie these strategies.

- Mobility is the most important adaptive behavior of pastoral societies in response to spatio-temporal variations in the quality of pastures and water resources. In wet and in dry years pastoralists utilize fallback grazing areas unused in 'normal' years. However, individual property rights and government policies that promote sedentary life to improve access human services (education, health, sanitation) have severely limited pastoral mobility;
- Herd accumulation is a form of insurance against drought or disease. However, today small proportion of pastoralists now hold some of their wealth in bank accounts, and others use informal savings and credit mechanisms through local shopkeepers;
- Increasingly, pastoralists are using supplementary feed for livestock, purchased or lopped from trees, paying for access to water from boreholes and using veterinary services to manage livestock diseases;
- Inter-household transfers are a traditional social insurance arrangement that provides informal

transfer of a breeding cow when a pastoralist's household suffers herd losses. However, these transfers or local re-stocking purchase schemes cover only idiosyncratic losses and break down in the event of covariate or aggregate losses typical of extreme events such as severe, drought, floods or disease.

4.4.2 Grazing management in Kenyan rangelands

- The combined effects of land use change and increased climatic variability will have far reaching implications for livelihood options of pastoralists, biodiversity conservation and ecosystem services in semi-arid and arid rangelands of the Nile Basin:

Pastoralism is an adaptive strategy evolved over hundreds of years to cope with spatial & temporal patchiness of savannah, arid & semi-arid resources (forage & water)

- In the rangelands of the Lake Victoria Basin, some possible strategies for reducing vulnerability of pastoral livelihoods and preserving adaptive capacity include the development of fodder banks (dry season forage reserves), designating conservation areas and marketing programs.
- The African Conservation Centre (ACC) has piloted a livestock breed improvement program and is working with local communities to set aside land for pasture re-seeding and development into drought refuges. These drought refuges also act as wildlife concentration areas, which in turn support ecosystem services and tourism. Due to rapid population growth and land fragmentation, maintaining landscape connectivity and other critical ecological processes and services is an essential component of enhanced resilience.
- Local grass-root institutions are critical to the success of adaptation approach of the African Conservation Centre. These institutions enable and empower local landowners to engage directly in the stewardship of rangeland resources. One such institution is the South Rift Association of Landowners (SORALO), which brings together 14 group ranches in Narok and Kajiado districts. Other institutions supported by African Conservation Centre include the Maasai Mara Management Association (MMMA), the Amboseli

Ecosystem Trust and The Northern Rangelands Trust. These organizations give local landowners a platform to participate in policy formulation and decision-making.

4.4.3 Index based livestock insurance

In Kenya's arid and semi arid lands catastrophic drought induced livestock is the most pervasive hazard encountered by pastoral households. Formal insurance, especially against covariate livestock loss, is rarely available for pastoral households due to barriers such as covariate risk, high transaction costs and asymmetric information.

Index based livestock insurance (IBLI) presents an opportunity to overcome these barriers. In contrast to traditional insurance, which makes indemnity payments based on the actual loss of what is insured, IBLI pay out is based on an objective and transparent index (e.g., rainfall, predicted livestock loss based on a measured vegetation condition) that is strongly associated with insurable loss but cannot be influenced or varied by both contract parties.

The International Livestock Research Institute (ILRI) has implemented an IBLI pilot in the Marsabit district of northern Kenya. The index is based on the Normalized Difference Vegetation Index (NDVI). NDVI is a satellite-derived indicator of the amount and vigor of vegetation, based on the observed level of photosynthetic activity. NDVI measurements have been available (in near real time every 10 days) since late 1982. Images of NDVI are computed reliably at a spatial resolution of 8 km² from satellite-based Advanced Very High Resolution Radiometer (AVHRR).

An empirical forecasting relationship between seasonal area-average livestock mortality and vegetation index was estimated using 10 years of Kenya Arid Lands Resource Management Program (ALRMP) and NDVI data. The NDVI series were standardized to control for heterogeneity of non-climate factors across locations. The seasonal forecasting relationships were based on the cumulative nature of drought-induced livestock loss and the cumulative vegetation outcome (good or bad-vegetation regime). This approach captures how livestock mortality in response to vegetation conditions, differed between a good and bad rainfall year.

In the pilot, seasonal IBLI contracts were developed using location-specific seasonal livestock mortality index based on historical observations of NDVI data and a regime-switching model that predicts a good or bad-vegetation regime (year). Pastoralists pay a premium before the season starts and receive an indemnity payment at the end of the season if the predicted mortality index exceeds the



4.4.4 Disaster preparedness & response

United Nations Joint Program on Climate Change is assisting vulnerable populations in adapting to the impacts of climatic changes in Uganda. The program will be implemented in eastern Karamoja and the Mount Elgon watershed, areas prone to drought, flooding and landslides. The Joint Program is led by the Government of Uganda and brings together a wide range of partners including WFP, FAO, UNDP, UNEP, UNESCO, UNCDF, UN-HABITAT, UNFPA, OCHA, WHO. One of the three priority projects supported under this program is Preparedness and Response: The project proposes to achieve preparedness and response through Climate monitoring systems, early warning systems and community-based planning.

The preparedness and response project aims to ensure that 80 % of the population in eastern Karamoja and Mount Elgon has functioning Automatic Weather Stations (AWS). It is envisaged that climate monitoring and early warning systems will be critical to planning and decision-making processes at the district and community level. More specifically, early warning systems will provide communities with the information they need for timely and effective response to potential climate-related shocks.

pre-specified level. Both the premium and the indemnity are proportional to the total value of livestock insured, which the pastoralist chooses.

The IBLI contract designed for the study described above was launched as pilot in January 2010 in the Marsabit district of northern Kenya. The participating organizations are UAP (commercial insurer), Provincial Insurance Company Limited (retail distribution/brokerage firm), Equity Bank (leading commercial bank), Swiss Reinsurance (international reinsurance company) and the International Livestock Research Institute (ILRI) leading the monitoring and evaluation.

IBLI shows considerable promise in the pastoral areas of East Africa. By addressing the constraints of covariate risk, asymmetric information and high transactions costs that have precluded the emergence of commercial insurance in these areas to date, IBLI offers a novel opportunity for the deployment of financial risk transfer mechanisms for pastoralists. The basic design is replicable and can be applied in other locations where covariate risk exposure is significant and existing insurance products do not adequately meet household insurance needs.



4.4.5 Management of drought risk

Index-based risk transfer approaches such as insurance have played a role in alleviating climate risk in many parts of the world. Index-based risk transfer approaches are not available for smallholder subsistence farmers in the countries of the Nile Basin region. Index insurance is essentially a disaster risk transfer mechanism that can form a critical part of a comprehensive disaster risk reduction and climate change adaptation for the poor.

Ethiopia provides an example of how index insurance is being used to revolutionize disaster response. Ethiopia's first national index-based disaster insurance program was implemented in 2006. The pilot project was developed through a partnership of the World Food Program (WFP), USAID and the Government of Ethiopia. The reinsurance company AXA Re provided the insurance for the pilot project. The premium was set at US\$ 930,000 and USAID settled a large part of the premium. WFP signed the contract on behalf of the Government of Ethiopia.

The contract stipulated a maximum payout of US\$7,100,000 in the event of severe drought. The Ethiopia Drought Index (EDI) was developed using historical rainfall data from the national meteorological agency, and a crop-water balance model. Rainfall was monitored daily at 26 weather stations across the country. Remote sensing of rainfall was used to ensure that there was no tampering with station-based rainfall data. The EDI had an 80% correlation with the number of people in need of food aid during the 1994 to 2004 droughts, indicating that it is a good proxy for human need when drought strikes.

The conventional response system is based on ex post evidence that people are hungry before appealing to donors and eventually providing relief, which misses the opportunity to act in time to prevent famine. However, impending drought-related famine can be detected early and used to trigger an index insurance payout during the growing season. In 2006, rainfall was above normal hence, there was no payout but the project successfully demonstrated that there is sufficient quality meteorological data in Ethiopia for disaster index insurance. More importantly, this pilot included capacity building with government and local partners and a more robust National meteorological reporting network.

In preparation for the second phase of the Ethiopia drought insurance project, WFP and the World Bank have developed software called LEAP, which stands for Livelihoods, Early Assessment and

Protection. Based on the FAO Water Requirement Satisfaction Index (WRSI), LEAP allows users to quantify and index drought and excessive rainfall risk in a given administrative unit in Ethiopia. LEAP will be applied to monitor this risk, and to guide disbursements for the scaling up of Ethiopia's Productive Safety Net Program, which targets the chronically food-insecure populations.

Impending drought-related famine can be detected early & used to trigger an index insurance payout during the growing season

LEAP uses ground and satellite rainfall data to cover the whole of Ethiopia, even areas where weather stations do not exist, so that every administrative unit in the country can be included. It runs localized models to convert rainfall data into crop or rangeland production estimates and subsequently into livelihood stress indicators for vulnerable populations. LEAP can estimate the financial magnitude of the livelihood-saving interventions households need in the event of a climate induced shock. Thus, LEAP provides a good proxy estimate of the scale of resources and response needed to protect the vulnerable livelihoods of transiently food-insecure households.

The insurance targets the 'transiently food-insecure' people who would be directly at risk should a drought occur. Transiently food-insecure households start coping with an impending disaster relatively early, even before harvest failure. Early coping strategies tend to involve less costly actions such as sale of non-productive assets or migration of family members. However, when households exhaust all the options available for an initial response, they are often forced to sell productive assets in the later stages.

Short-term shocks such as droughts and floods have long-term consequences on livelihoods and have the potential deepen poverty traps. Studies show that households that suffered substantially during the 1984-5 drought, which resulted in a large-scale famine, continued to experience 2 to 3 percent less annual per capita growth during the 1990's as compared with those who were not hit as hard.

4.5 Best practice in coastal zone protection

4.5.1 Management of low elevation coastal zones

The dominant feature of Egypt's coastal zone is the low-lying delta of the River Nile, with its large cities, industry, flourishing agriculture and tourism. The Nile Delta and Mediterranean Coast account for 30-40% of Egypt's agricultural production and half of Egypt's industrial output. Based on projections on relative sea level rise (RSLR), Egypt's Mediterranean coast and the Nile Delta are highly vulnerable to abrupt sea level rise due to climate change.

Egypt has implemented a coherent set of policies, regulations and actions to reduce disaster risk in the Low Elevation Coastal Zone (LECZ) areas. Risk reduction strategies, policies and practices (measures) have been integrated into land use and national development plans following the adoption of the National Climate Change Action Plan. Environmental Impact Assessment that accounts for climate risk is a requirement for approval as well as regulating the setback distance of all coastal infrastructure.

The "Living Shorelines" approach has been adopted for protection against the effects of Sea Level Rise (SLR) on low-lying coastal areas. This "soft" approach focuses on an innovative set of bank stabilization and habitat restoration techniques to reinforce the coastline, minimize coastal erosion, protect natural habitats and maintain coastal processes. Pilots of the "Living Shoreline" measures in the Nile delta are focused on specific stretches of coastline that have already been identified as areas of sand accretion due to the installation of hard coastal protection structures. These areas offer a strategic opportunity to monitor the adoption of innovative shoreline protection techniques and to evaluate the potential benefits of expanding the measures to other shoreline areas along the Nile Delta.

The Living Shoreline approach involves local communities in the actual design of the on-the-ground measures hence ensuring community ownership and buy-in. Communities are also involved in the monitoring and evaluation schemes to gauge the actual effectiveness and viability of the 'soft' coastal stabilization measures.

4.6 Best practice in water management

4.6.1 Integrated water resource management

Egypt went through an unprecedented period of prolonged drought between 1978 and 1987. The fact that Egypt was very close to a major water shortage

because of the drought led to a set of responses and anticipatory planning to cope with such events in the future. As research on the implications of climate change on the Nile Basin began to appear in the early 1990s, the focus was on drought and its implications for Nile water management (Hulme, 1994; Conway and Hulme, 1993).

Egypt has made emergency plans to counter future drought conditions, including reduction in the annual releases from the Aswan High Dam through more efficient regulation, extension of the winter closure period of the irrigation system, reduction of the area under rice and improvement of the Nile's navigable channel to maintain supply to irrigation outtakes.

In 1988, the Ministry of Water Resources and Irrigation (MWRI) developed a simulation model to review several options for reservoir operation under different Nile flow and downstream release scenarios. Currently the MWRI's Nile Forecast Centre (NFC) operates a modeling system designed to predict inflows to Lake Nasser with as much lead time as possible.

Based on projections on relative sea level rise (RSLR), Egypt's Mediterranean coast & the Nile Delta are highly vulnerable to abrupt sea level rise due to climate change

In 1999, Lake Nasser reached the highest point since its completion. Egypt was forced to use the Toshka overflow canal to avoid overtopping the Aswan High Dam owing to limited capacity handle increased releases downstream of the dam (Conway, 2005). Hence, in 2002, Lake Nasser Flood and Drought control Project was established. The purpose of the project was to analyze the impacts of climate variability, especially flooding, on the operation of the Aswan High Dam reservoir.

The decadal variability in the Nile flows has prompted a series of adaptive responses by the MWRI to improve early warning of Nile flows and build capacity to handle the impacts of multi-year episodes of high and low flows more effectively. Although classified as water scarce, Egypt has an estimated annual water supply of 63.7 km³ against an estimated annual use of 61.7 km³ (Conway, 2005). However, this headroom could easily be



wiped out by inter-decadal variability going by events in the last decade.

Equal measures to deal with prolonged high flows must be considered. Changes in supply due to climate change should be considered alongside the certainty of demographic trends, potential abstractions by upstream riparian countries. Egypt's water vision for the 21st century includes focus on policies to shift supply approaches to integrated which include both supply and demand management (MWRI, 1999). MWRI has strong technical expertise and capacity in water management – supply side options – but less capacity in terms of socio-economic and institutional management options to regulate demand.

4.6.2 Agricultural water management

The agricultural sector in the countries of the Nile Basin region is particularly vulnerable to the adverse impacts of climate change. Soil and water conservation technologies have been suggested as a key adaptation strategy in light of climate change induced water stress, especially floods and drought.

Examples of adaptations to climate change in the water sector in the Nile Basin countries are less

documented. However, a number of conventional adaptation solutions have been implemented in the Nile Basin countries. These include water harvesting, storage dams, irrigation schemes and development of groundwater resources.

After a series of debilitating rainfall failures in northern Ethiopia, a micro dam construction program was initiated in the 1990s to harvest rainwater. As well as being a response to climate variability, these new reservoirs generated their own microclimates. The dams led inadvertently to a seven-fold increase in childhood malaria incidence near the dams (Ghebreyesus et al., 1999).

Of the potential adaptations to increased climate induced water stress, measures implemented at local or national level will have transboundary implications. For example, expansion of water storage and irrigation facilities in the Ethiopian highlands and in the Lake Victoria basin may reduce flow to downstream riparian countries. This will be particularly true if their design does not incorporate the likelihood of changing river flows due to inter-annual and inter-decadal rainfall variability in the Nile River Basin region.

Hence, adaptations based on demand management are likely to be particularly important in these water scarce basins. Demand management measures (such as more efficient water supply and irrigation systems combined with drought-resilient farming practices) must given priority among the countries of the Nile Basin region.

Egypt is implementing policies that reduce the demand for water such as:

- Gradually replacing sugarcane with sugar beets especially in Upper Egypt taking into account the lifetime of current sugar factories, which were designed to process sugarcane;
- Reducing the cultivated rice area to about 1x10⁶ feddans (1 feddan = 1.04 acres) and prevent soil salinization and seawater intrusion;
- Replacing currently used varieties of rice with the new shorter-life rice varieties, which have a higher productivity and lower water requirement due to their shorter lifetime;
- Using genetic engineering to develop new crop varieties that have higher productivity and consume less water.

The cost of malaria treatment will disproportionately impact poorer households, who pay a higher share of their incomes on health & who do not have the opportunities non poor households have to control malaria

More than 50 % of the Sudd inflow is evaporated out of the Sudd swamps, resulting in less water availability in the downstream areas, especially for Egypt's agriculture. To gain extra water downstream, the governments of Egypt and Sudan have proposed to build Jonglei canal around to Sudd area. However, the consequences of building the canal, especially on wetland biodiversity, are still relatively unknown.

4.6.3 Micro-water harvesting for climate change adaptation

All the NAPA and the National Communication on Climate Change documents have prioritized the harnessing of surface runoff for domestic and agricultural use. In Ethiopia, water harvesting is regarded as the main pillar of national food security strategy.

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. Water harvesting is regarded as an important adaptation action and an integral part of the Tigray extension programs to supplement rain-fed agriculture during the critical stages of the growing season when rainfall is inadequate.

Water harvesting has enabled the cultivation of two or more crops a year in Tigray. Water harvesting has enabled farmers to diversify into high value crops and hence increased the use of high quality inputs, reduced the risk of crop failure and increased household income. An overall increase in income and household welfare has led to investment in land, which is a positive contribution to reducing poverty-induced environmental degradation.

Kusa village in Kenya's Lake Victoria Basin receives an average annual rainfall of 900mm. However, Kusa village has water harvesting potential of 190 million liters. With financial and technical assistance from the Regional Land Management Unit (RELMA in ICRAF), over 800–5m³ tanks have been constructed using ferro-cement, bricks and steel. The ownership of the tanks is at the individual household level. Women generally are the managers and most of the tanks are built through a revolving kitty commonly known as the merry-go-round.

The most significant impact of the Rain Water Harvesting in Kusa is the assured supply of domestic water at the household level. The water tanks have changed activity time budgets for women and children hence freeing up more time for other activities. More importantly, the water tanks have led to significant improvements in household and community level hygiene. Other water sources developed by the project include springs shallow wells, earth dams and sand dams.

Water harvesting, especially through open micro dams, tanks, canals, may have some critical drawbacks. Ubiquitous construction of micro dams, tanks and canals could increase availability of breeding sites for mosquitoes. The associated increase in the abundance of vector mosquitoes will lead invariably to high malaria transmission. Moreover, the availability of open waters in the dry season owing to improved storage will lead to a larger transmission window (Ijumba and Lindsay, 2001). Ghebreyesus et al. (1999) showed that the overall incidence of malaria for the villages close to dams was 14.0 episodes/1000 child months risk compared with 1.9 in the control villages – a sevenfold ratio.

In poor smallholder households, increased illness and morbidity could have serious consequences

on labor productivity, owing to actual illness and time diverted to attending to and caring for the sick, especially children. The challenge is how to harness the capacity of water harvesting to drought-proof agriculture, enhance food security and incomes without exposing poor households to an elevated risk to malaria infections (Hagos et al., 2006). The cost of malaria treatment will disproportionately impact poorer households, who pay a higher share of their incomes on health and who do not have the opportunities non poor households have to control malaria.

Therefore, to the extent that micro-dams and other open water harvesting receptacles exacerbate malaria risk, it may be considered as a maladaptation. Barnett and O'Neill (2010) define maladaptation as action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups. Water resource management clearly impacts the health sector. Hence, there is an opportunity to align adaptation measures across multiple sectors and take a more holistic systems perspective to planning and implementing climate change adaptation.

4.6.4 Cross-scale water management

The NAPA and National Communications reviewed cite soil and water management as a means to reduce the risks of floods and droughts and to improve the productivity and profitability of agriculture. However there is no articulation of what it takes to plan for and manage uncertainty and considerable inter-annual and inter-decadal variability of water supply in the Nile River Basin.

Significant variability experienced locally and regionally in the headwater regions of the Nile and internationally through its effects on downstream Nile flows in Sudan and Egypt does not appear to have informed the decisions to prioritize irrigation or storage infrastructure as adaptive strategies. To achieve optimal water management at a the Nile River Basin scale, responses to climate change induced water stress must move beyond local or national irrigation and storage provisions to address cross-scale integrated water management. As Lankford and Beale (2007) have argued, it is through examining water management in the context of Nile Basin wide agro-ecological systems and local-to-basin institutional frames, that optimal adaptive capacity to cope with uncertainty and variability of water can be constructed.

Under scenarios of increased warming, land use change and rapid population growth in the Nile River





Basin, national claims on Nile water resources has been identified as flashpoint for conflict. Hence, in terms of cross-scale adaptation, the Nile River Basin fundamental questions regarding the role of scarcity in catalyzing or inhibiting collective action over transboundary water resources and for the need to consider flexibility in the design of institutions and accords for international water management.

The Nile Basin Initiative (NBI) has embarked on a new path of cooperation through a Cooperative Framework Agreement (CFA). The CFA is an attempt by the Nile River Basin countries to come up with a legal framework to guide the use, development, protection, conservation and management of the River Nile Basin and its resources. This review argues that the CPA offers the best opportunity for integrated water management strategies. This would involve educating public perceptions on upstream-

downstream rights and obligations, reshaping national planning processes, regional coordination land and water resources management, recognizing water quantity and quality linkages, protecting and restoring natural systems, and including consideration of climate change into water sector related national development plans.

4.7 Best practice adaptation in health

Current adaptation actions to reduce the burden of disease attributable to climate change impacts include strengthening public health infrastructure, providing access to safe water, improved sanitation and implementing integrated disease surveillance programs for early detection and timely response to outbreaks of diseases such as malaria and RVF. However, weak public-health systems and or limited

access to primary health care present a major challenge and contribute to low adaptive capacity for the countries of the Nile Basin region.

Despite economic recent upward trends in economic growth, Nile Basin countries are likely to remain poor and vulnerable over the medium term, with few options and a low adaptive capacity to climate change. In the Nile Basin region, investments to support adaptive capacity to climate sensitive diseases must focus on building human capacity and infrastructure necessary to respond to epidemics, strengthening integrated disease surveillance and ameliorating stressors (e.g. water, sanitation and food security) that could undermine resilience to climate change impacts.

Sachs and Malaney (2002) have argued that health in Africa must be treated as a high priority investment in the international development. Although funding health programs is critical to reducing vulnerability, it is not a universal panacea. Public awareness, effective use of local resources, appropriate governance arrangements and community participation are necessary to mobilize and prepare for climate change (McMichael, 2004).

4.7.1 Improved prediction of Malaria

A consortium of researchers drawn from Kenya Medical Research Institute, (KEMRI), Tanzania's National Institute for Medical Research (NIMR), IGAD's Climate Prediction and Application Centre, the International Centre for Insect Physiology and Ecology (ICIPE), have been testing a malaria prediction model that can detect an epidemic two to four months before it occurs. In the absence of adequate control, these predictions are crucial in understanding the possible future geographical range of the vectors and the disease, which could facilitate planning for various adaptation options (Tonnang, et al., 2010).

With sufficient lead-time, health officials can respond by mobilizing adequate medical supplies to deal with increased caseloads and taking preventive measures such as distributing mosquito nets and draining or spraying mosquito breeding grounds. The NAPA documents identified the community emergency preparedness programs, better health education, improved access to primary health care such as distribution of treated mosquito nets and malaria surveillance program.

4.7.2 Disease surveillance

Disease surveillance is a critical component of adaptive strategies because it enables early detection, assessment and response to climate-

sensitive infectious diseases. Surveillance of infectious diseases, including RVF, malaria, and cholera, is vital for making public health response decisions to control disease outbreaks as well as to anticipate the potential human health and economic impacts. Hence, disease surveillance is critical adaptive response to climate-sensitive diseases.

Having identified the need for common action plans for the identification, monitoring and control of infectious diseases, Kenya Uganda and Tanzania established the East African Integrated Disease Surveillance Network (EAIDSNet) under the auspices of the East African Community (EAC) in 2000.

Disease surveillance is a critical component of adaptive strategies because it enables early detection, assessment & response to climate sensitive infectious diseases

In 2003, EAIDSNet received funding from the Rockefeller Foundation. The objectives of EAIDSNet were to:

1. Strengthen communication and collaboration among the East African partner states in all aspects of disease surveillance;
2. Strengthen the capacity of collaborating institutions and district health management teams of border (transboundary) districts in strategic and operational approaches in disease surveillance and control; and
3. Build and strengthen collaboration on development of training programs for staff to implement disease surveillance and control activities.

In March 2010, with funding from FAO, experts in the three sectors; humans, animals and plants met in Kampala to plan for the establishment of the East African Centre for Infectious Disease Surveillance (EACIDS). The centre will complement EAIDSNet by:

1. Facilitating cross border cooperation in the detection and response to disease outbreaks;
2. Building laboratory capacities, harmonizing and standardizing best practices and;
3. Linking medical and veterinary institutions from the five East African countries to improve their capacity to detect, identify and monitor infectious diseases.

Conclusion

Climate change induced water stress in the Nile Basin region will affect livelihoods and national economies through complex and inter-related causal pathways including drought or flood induced crop failure, damage to infrastructure, loss of livestock, and epidemics of infectious diseases (e.g. malaria, cholera and Rift Valley Fever). The impacts of climate change on livelihood options 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, healthcare, disaster response and risk management).

Although communities in the Nile Basin region have responded to climate variability by altering cropping patterns, livestock and water management practices, these largely autonomous adaptation responses are unlikely to build long-term resilience of livelihoods, ecosystems and economies to the projected scale and impact of climate change. Planned best 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.

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.

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.

Moreover, there is little systematic understanding of the feasibility, costs, efficacy, and limits of adaptation actions. The limits to adaptation are closely linked to the rate and magnitude of climate change, as well as associated key vulnerabilities discussed in section 2. For example, rapid sea-level rise that inundates the coastal cities of Egypt and coastal settlements is likely to limit the efficacy of any innovative set of bank stabilization and habitat restoration techniques to reinforce the coastline. Similarly in the Sudan and northern Uganda, inter-annual and inter-decadal patterns of below-average rainfall and droughts in the late 20th century have constricted physical and ecological limits by contributing to land degradation, diminished livelihood opportunities, food insecurity, internal displacement of people, cross-border migrations and civil strife.

The inter-annual and inter-decadal variability experienced in the Nile basin headwaters (Ethiopian highlands and Lake Victoria Basin) its effects on downstream Nile flows in Sudan and Egypt does not appear to have informed the decisions to prioritize irrigation or storage infrastructure as adaptive strategies. This report argues that to achieve optimal water management at the Nile River Basin scale, responses to climate change induced water stress must move beyond local or national irrigation and storage provisions to address cross-scale integrated water management.

The Nile Basin countries have prioritized knowledge and awareness of climate change as an adaptation activity. However, there is no evidence to show that information or awareness leads to adoption of adaptation among target groups or beneficiaries. Among rural communities in the Nile basin uncertainty about future climate change combines with social cultural perceptions of risk and values to influence judgment and decision-making concerning climate change. This poses serious limitations to what can be achieved through early warning systems and disaster preparedness programs.



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