Nile Basin Initiative

Eastern Nile Subsidiary Action Program

Eastern Nile Technical Regional Office

Climate Smart/Proof ENSAP Projects

Final Report, Feb 2011

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EXECUTIVE SUMMARY

The role of ENTRO in regional integration will be greatly enhanced as countries of the Eastern Nile join efforts in addressing the challenges and opportunities associated with climate change. In order for ENTRO to address this important issue, an "Approach Paper" was developed in May 2009 describing a comprehensive strategy on how to respond to climate change. The strategy consists of five pillars which taken together constitute a systematic approach to climate change. Before 2009, climate change related activities within ENSAP projects were carried without the benefit of such coordinated overall strategy. This study on "Climate Smart/Proof ENSAP Projects" has been launched as a follow-up to the "Approach Paper" with a focus on how to achieve climate change proofing within each of the ENSAP projects.

This report describes a new methodology for climate change proofing and its application in the analysis of the ENSAP projects. The methodology seeks answers for specific questions in the context of each project: How does the ENSAP project relate to the processes driving global climate change? What are the climate change impacts most relevant to this ENSAP project? What are the climate change impacts that the project is most vulnerable to? How can the issue of climate change be approached within the context of this specific ENSAP project? How can we use the strategy proposed in the "Approach Paper" to analyze each of the projects? What elements of the proposed strategy are most relevant to each ENSAP project? How can we rank these different elements based on their relevance to the project and its vulnerabilities? Following this methodology, new climate change components are proposed for incorporation within, or as a follow-up to, each of the ENSAP projects. These components take the form of project activities, special studies, or what we call "Climate Smart" concepts.

The report proposes a set of six special studies for consideration and potential implementation by the ENSAP regional project coordinators, with the objective of climate change proofing of ENSAP projects: (i) A special study on the impact of climate change on irrigation water requirements in the Eastern Nile basin, emphasizing the response of the main crops of this region to climate change; (ii) A special study on expanding the Flood Prediction and Early Warning I efforts in capacity building from the area of short term flood forecasting into the area of regional climate modeling; (iii) A special study to assess the impact of the activities of the watershed project related to preservation of vegetation cover and sustainable land use practices and their impact on carbon fluxes; (iv) A special study to define quantitatively and in significant details the likely scenarios of future climate trends in rainfall and river flow in the Nile basin; (v) A special study on incorporation of the changing nature of the regional climate system in the water resources planning process relevant to the Joint Multipurpose Program 1; and (vi) A special study to document the recent transformation of the energy markets in the three countries into one regional energy market and its impact on the process of identification of new clean energy sources for the region.

In addition to these special studies, five "Climate Smart" concepts are recommended for consideration and further action by ENTRO. Each of these concepts targets opportunities associated with climate change, and can be pursued in a limited fashion as a climate change component to enhance the associated ENSAP project, or can be launched as a new initiative. The new potential initiatives are (i) Eastern Nile Irrigation management Information System (ENIIS); (ii) Eastern Nile watershed Observatory for Climate change Detection (ENOCD); (iii) Eastern Nile Center for Regional Climate Prediction (ENCRCP); (iv)Eastern Nile Carbon Trade Project (ENCTP);(v) Baro-Akobo-Sobat Project: A Show-Case for Water Resources Development in a Changing Climate. Preliminary estimates of the associated costs for each initiative are included.



Table of Contents

1. Introduction & Background

1.1 Introduction

The most significant observed trends in the global environment are the ones associated with evident changes in the chemical composition of the atmosphere, and with changes in global land cover. The change in atmospheric chemistry is caused by anthropogenic emissions of greenhouse gases and in particular of carbon dioxide which is a byproduct of fossil fuel burning. These greenhouse gases represent the main forcing of the observed and predicted changes in global and regional climates. The main concern resulting from this global problem stems from the prediction that future climates which will shape future levels of rainfall, river flow, and surface temperature are likely to be significantly different from our current climate. This concern is particularly relevant to the planning and management of water resources projects such as hydropower plants and irrigation schemes. Traditionally such projects are planned and managed assuming that observed climate records of the past provide a sufficient characterization of the likely climate conditions in the future. The predictions of global and regional climate change question this assumption in a fundamental way.

In order for ENTRO to address the important issue of climate change in a systematic manner, an "Approach Paper" was developed in May 2009 describing a comprehensive strategy on how to respond to the issue of climate change. The section of the "Approach Paper" describing this strategy is annexed to this report as Appendix A. The strategy consists of five pillars which constitute a systematic approach to climate change by ENTRO. This study on "Climate Smart/Proof ENSAP Projects" (See Appendix B for the TOR) has been launched as a follow-up to the "Approach Paper" with a focus on how to address climate change issues within each of the ENSAP (Please see Table I below for a list of the ENSAP projects). The approach followed in conducting this study is described in Appendix C. This Report describes a new methodology developed as part of this study and its application in the analysis of the ENSAP projects. The report also describes specific "Climate Smart" initiatives that are proposed by this study. However, before we describe this methodology and its application, we discuss in section 2 the impacts of climate change on ENSAP projects, including impact on key environmental and social background variables on which ENSAP projects are contextualized.

1.2 Impact of Climate Change on ENSAP Projects Areas: Summary Information for Decision Makers

In this section, we respond to Task 1 of the TOR by identifying and analyzing the impact of climate change on ENSAP projects and the associated current environmental and social stresses. We start by reviewing the current state of knowledge regarding the impact of climate change in the Nile basin region. We conclude by providing a concise summary of information needed to prepare the decision makers for reaching informed decisions related to climate change impacts on ENSAP projects.

While nearly all studies agreed that temperatures will increase over the Nile basin, precipitation predictions are less certain. Predictions of response by the Nile river flow to

global climate change vary widely; different studies give conflicting results. The study Yates (1998b) offers a good example of how widely results vary. Further, the predictions in Strzepek (1995) vary from 78% flow reduction in the GFDL simulation to a 30% increase in the GISS model simulations. The results of Yates (1998a) vary from 9% flow reduction for GFDL model to a 64% increase in the GISS model. Although most model results indicate that the Nile flow is quite sensitive to changes in precipitation. Hulme (1994) concludes Nile discharge will decline due to greater evaporation. Similarly, Sene's (2001) suggests a slight increase in White Nile flows. Four climate change scenarios were evaluated by Strzepek et al. (1996) (baseline, GISS, GFDL, and UKMO). They concluded that "The complete impact of climatic changes in the Nile cannot be fully predicted with confidence, as some models forecast increased flows, while others project significant decreases." In summary, our current knowledge based on these studies is limited due to the high uncertainty in current predictions of future Nile flows.

1. EN Watershed Management (ENWSM)
2. Eastern Nile Planning Model (ENPM)
3. Flood Protection and Early Warning
4. EN Irrigation and Drainage
5. EN Joint Multi Purpose Program (ENJMP)
6. Baro-Akobo-Sobat Multipurpose Water Resources Development Project
7. Eastern Nile Power Trade
8. Ethiopia-Sudan Transmission Interconnection

Table I: LIST OF ENSAP PROJECTS

Land use change and climate change are taking place at the same time on the Nile basin. Hence, their separate impacts are mixed, and can be difficult to isolate accurately. The impact of changes in land use on the runoff from the sources the Nile in Ethiopian highlands has been the subject of two recent studies. Hurni et al. (2005)' analysis and interpretation of data support the hypothesis that surface runoff and sediment yield from the Ethiopian and Eritrean highlands into the upper Nile Basin have most probably increased in the long term due to intensified land use and land degradation induced by population increase. However, Bewket and Sterk (2005) concluded that "the observed

adverse changes in the stream flow have partly resulted from changes in land cover/use and/or degradation of the watershed that involved destruction of natural vegetative covers, expansion of croplands, overgrazing and increased area under eucalypt plantations." The conclusions from these two studies, which are based on field data highlight the complexity of the response of surface hydrology to land use change.

The impact of sea level rise associated with global climate change on the Nile delta has been studied extensively: Nicholls and Hoozemans (1996), El-Raey et al. (1997), and El-Raey (1999). The results from these studies predict serious physical and socio-economic impacts. Hence, protection measures must be carried out along the most vulnerable shoreline area.

The most recent IPCC report relevant to Africa was issued in 2007 (Boko et al, 2007). It presents the range of predictions made by different GCMs for the surface temperature over Africa up to the year 2100. All the models simulations and under different emissions assumptions agree in the prediction of a warmer future with annual temperature in 2100 rising by 4 degrees C (+ or – 1 degree C). For current conditions, the magnitude of the observed warming of order 1 degree C over East Africa is consistent with the models simulations. Although, on average models seem to predict an increase in precipitation over the Nile basin, about half of the models considered seem to predict an increase in precipitation while the other half predict a decrease in precipitation. This last conclusion is significant. It points to the high level of uncertainty about the sign of the predicted change in precipitation. While global models seem to agree in predicting warming of surface temperature over this region, the same models disagree on even the sign of the predicted changes in rainfall and river flow.

Based on this review, we summarize in the following the potential impact of climate change on the specific areas of the ENSAP projects. We identify the current environmental stress and issues that aggravate the impacts of climate change in the EN basin in relation to ENSAP projects. The main impacts and secondary impacts are specified, together with the level of uncertainty associated with each impact. The impacts of climate change on ENSAP projects areas are described in the following table. The same table provides a concise summary of the information that is needed to prepare the decision makers for reaching informed decisions related to climate change impacts on ENSAP projects.

Table II: Impact of Climate Change on ENSAP Projects Areas

	Main Impacts	**Secondary Impacts**	**Current Environmental and Social Stresses**
Eastern Nile Irrigation and Drainage Project	(1) Increase/Reduction in river flow (H); (2) Increase in evaporative	(1) Change in crops yield (M)	(1) Water scarcity and shortages; (2) Increasing demand for food products

	demand (L);		
Flood Preparedness and Early Warning Project I (FPEWI)	(1) Increase in frequency of floods and droughts (H)	(1) Changes in the frequency and severity of flash floods (H)	(1) Limited institutional capacity for making accurate forecasts; (2) High vulnerability of populations
Eastern Nile Watershed Management Project)	(1) Change in patterns of rainfall, runoff, and sediment yield (M) (2) Change in ecosystems and vegetation cover as a result of warming (M)	(1) Sea level rise next to the Nile Delta (L)	(1) High poverty levels; (2) Limited capacity among rural communities to adapt to climate change
Eastern Nile Joint Multipurpose Project	(1) Increase/Reduction in the annual flow of the Blue Nile (H); (2) Change in the low flow regime (H)	(1) Increase in surface temperature (L); (2) Increase in reservoir evaporation rates (M) (3) Changes in inter-annual variability of the flow (H)	(1) Lack of established methodologies on how to design water resources projects under changing climatic conditions.
Baro-Akobo-Sobat Multipurpose Water Resources Development Project	(1) Increase/Reduction in the annual flow of the river (H); (2) Change in the low flow regime (H)	(1) Increase in surface temperature (L); (2) Increase in evaporation rates from swamps(M); (3) Changes in inter-annual variability of the flow (H)	(1) High poverty rate; (2) Urgent need for food and energy production; (3) Post-conflict challenges.
(2) Eastern Nile Power Trade & Ethiopia-Sudan Transmission Interconnection Projects	(1) Increase in surface temperature (L);		(1) Increasing demand for energy; (2) Urgent needs for regional integration of energy markets

(H: High uncertainty level; M: Medium uncertainty level; L: Low uncertainty level)

1.3 Current Climate Change Related Activities within ENSAP Projects

Most of the objectives of the ENSAP projects, which will be reviewed in section 3, focus on urgent water resources development needs. None of the objectives refer explicitly to the issue of climate change. However, climate change may have been implicitly included within the broad range of environmental issues that are addressed by each project. Before the summer of 2009 ENTRO did not have an explicit comprehensive strategy to address climate change issues. Hence, climate change related activities within ENSAP projects were carried without the benefit of such coordinated overall strategy. The current study is meant to address this gap. In the following we review briefly some of these past activities.

The watershed project activities focusing on sustainable land use practices are indeed relevant to climate change processes. Any reduction in the rates of degradation of vegetation cover within the Eastern Nile basin translates directly into reduction in potential emissions of carbon to the atmosphere. The watershed project also carried a capacity building activity in Egypt in January 2010 focusing on the issue of watershed and climate change.

The strategic environmental and socioeconomic analysis phase of the JMP1 will include some analysis on the issue of sensitivity of the proposed reservoir system to climate change. The details regarding the specific objectives of this study are not clear at this point.

2. Methodology for Climate Change Proofing of ENSAP Projects

The methodology for climate change proofing, developed as part of this study, consists of the four steps that are outlined in Figure 1. Development of this methodology is an original contribution, applicable to other regions, outside the Nile basin.

Step 1: Broad Context and Connections of Each ENSAP Project to Climate Change

The first step attempts to place each ENSAP project in the broad context of climate change processes. In particular, the analysis at this stage will attempt to define how the project fits within the big picture. Of particular interest is defining the relationship of the project to the processes that drive global climate change such as emissions of greenhouse gases and changes in land cover. This relationship can be positive or negative. For example, a hydropower project may help reduce future emissions of carbon dioxide. Better ecosystem management may help reduce changes in land cover which would effectively reduce future emissions of carbon dioxide too. On the other hand, flooding of forested areas following construction of dams may have the opposite effect by reducing the land area covered by vegetation.

Another important section of the analysis in Step 1 deals with defining the range of potential impacts of climate change on the Nile basin that is relevant to the specific ENSAP project. Climate change may have a wide range of impacts such as changes in rainfall patterns, surface temperature, frequency of floods and droughts, and evaporation. At this step, we will attempt to define for each project what potential impacts are most relevant, and also estimate the associated level of uncertainty regarding the predictions of these impacts. Further, we will attempt to determine which of the potential impacts would have serious consequences for each ENSAP project. In other words, we will attempt to identify critical vulnerabilities in the area of the ENSAP project. For example, irrigation activities may be sensitive to future scarcity of water in general, while a hydropower project may be more sensitive primarily to changes in the low flow season.

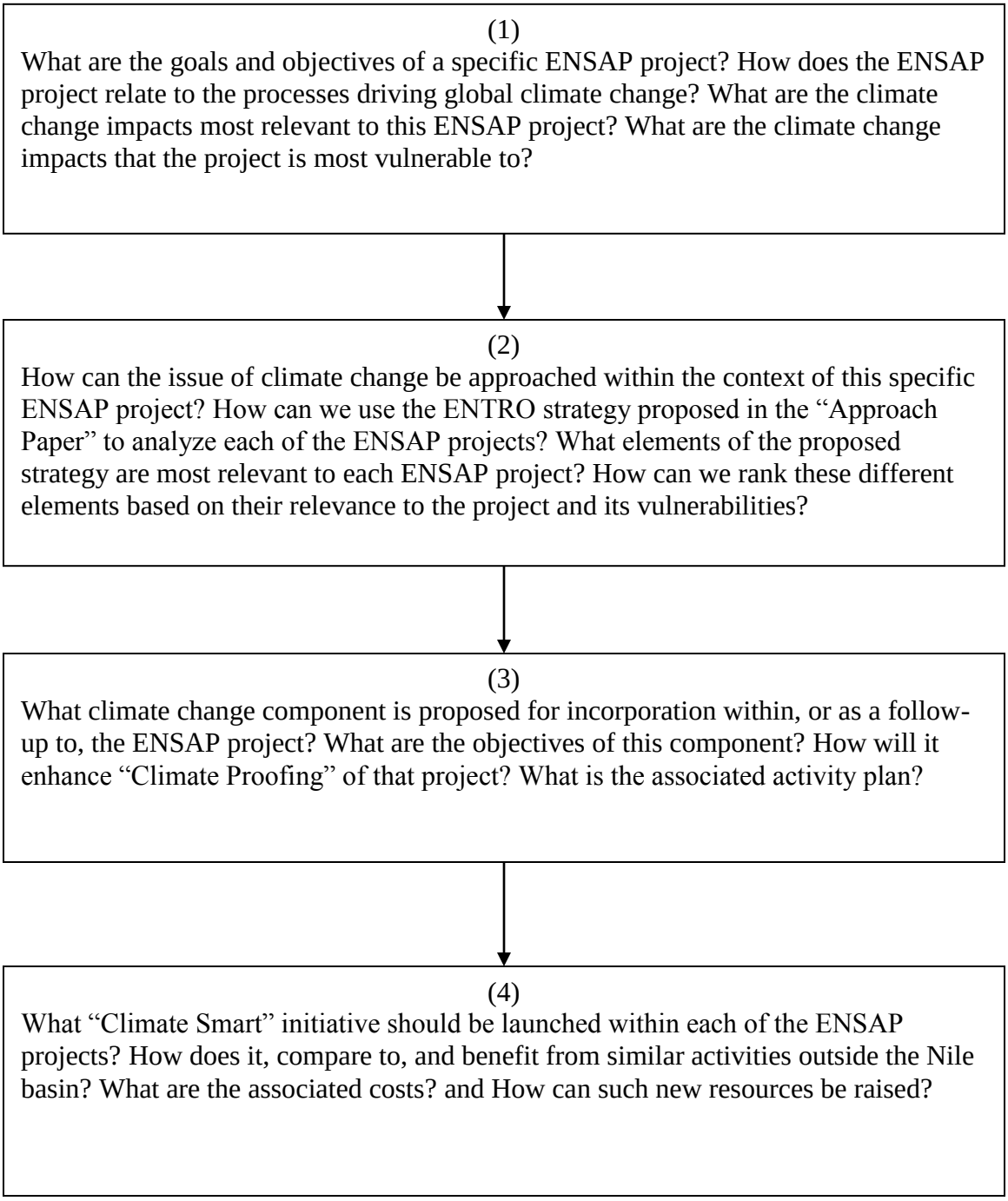

FIGURE 1: METHODOLOGY

Step 2: Use of ENTRO Climate Change Strategy to Analyze Each ENSAP Project

The strategy of ENTRO described in the "Approach Paper", included in Appendix A, proposed a specific strategy for ENTRO on how to approach climate change. In step 2 we plan to use this strategy to analyze each ENSAP project. In particular, we will attempt to list and discuss the issues related to climate change predictions, mitigation, adaptation, opportunities, capacity building and education that are relevant to each ENSAP project. This analysis will represent a detailed look at ENSAP projects through the lenses of the ENTRO climate change strategy. The results of this analysis will be a two dimensional matrix, with one dimension defined by the eight ENSAP projects (Table I) and the second dimension defined by the five pillars of the ENTRO climate change strategy (See Figure 2).

The analysis in Step 2 will be informed by the results from Step 1 and the specific answers to the questions detailed in Figure 1. Although for each ENSAP project and each pillar of the strategy we may be able to define common issues, the real challenge in Step 2 would be to discuss each of the boxes of this matrix and to determine their level of significance given the nature of the ENSAP project. The final result from Step 2 would be a ranking of the different identified climate change issues associated with each ENSAP project in terms of (1) their relevance to the project and (2) their potential to address the impacts that have been identified in Step 1 as the ones with most serious consequences to the area of the ENSAP project. These are the impacts for which the ENSAP project is most vulnerable. The results of this ranking process will inform the design of the climate change component associated with the ENSAP project as detailed in Step 3.

Step 3: Development of Climate Change Component for Each ENSAP Project

Following Step 2, we plan to carry further analysis on each ENSAP project in order to define a coherent set of climate change related activities that are suitable for the project and informed by the ENTRO climate change strategy. This set of activities will constitute the climate change component for the ENSAP project. For some projects this component will be proposed for immediate incorporation within ongoing activities. In the case of completed projects, this component will be proposed as a follow-up activity.

In defining the new climate change components, we will state clear objectives for the proposed set of activities and we will make explicit reference to the analysis performed on the (Climate Change strategy pillar/ENSAP project) matrix described in Step 2. Specific effort will be devoted to specify how the proposed climate change component will enhance "Climate Proofing" of that ENSAP project. By proofing we mean the potential of the proposed activity to address the vulnerabilities identified in Step 1 and hence to improve resilience to climate change in the area of the ENSAP project. The potential benefits of proposed activities beyond the climate change issue will be discussed for each project to enhance the motivation and rationale for adding the climate change component.

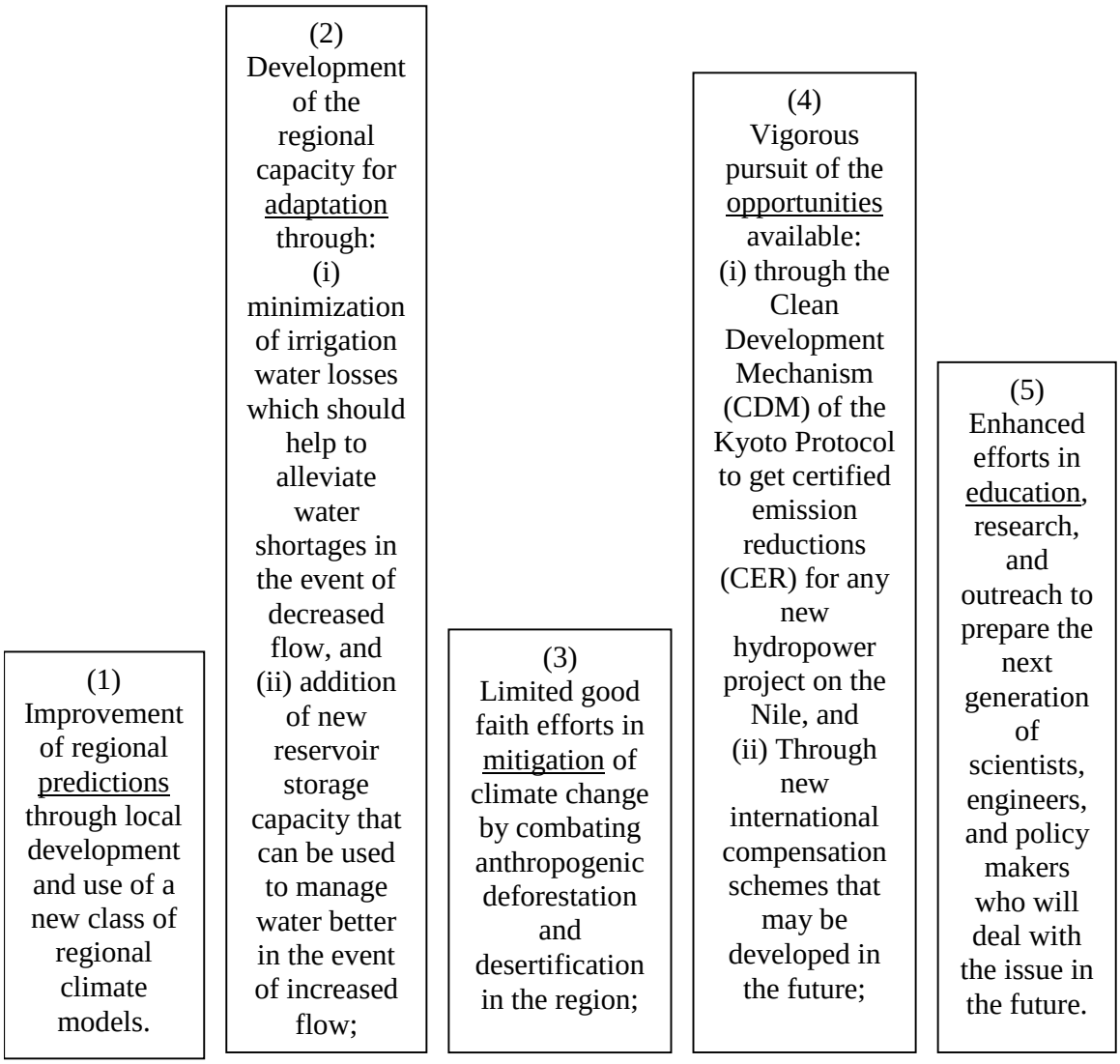

FIGURE 2: FIVE PILLARS OF ENTRO CLIMATE CHANGE STRATEGY

For each project we will attempt to define how the new climate change component will support and enhance community resilience and adaptation to climate change for different social units (e.g. watershed communities, irrigation communities, pastoralist communities, women, etc).

Step 4: "Climate Smart" Initiatives within ENSAP Projects

The final step in the methodology for this study deals with identification of a viable set of initiatives satisfying the following criteria.

Criteria for Identification of New Initiatives:

Each new initiative should be

(i) rooted in specific ENSAP project,
(ii) responsive to the ENTRO climate change strategy, and
(iii) Have excellent chances of succeeding as one of a new breed of projects managed by ENTRO with dual objectives of facilitating water resources development as well as combating climate change.

Initiatives with these three characteristics are labeled as "Climate Smart". The identification of these initiatives will be based on the thorough analysis proposed in Steps 1, 2, and 3. These new initiatives will emerge naturally out of the matrix boxes identified in Step 2 as the most critical set of activities addressing areas of specific vulnerability and/or outstanding opportunity for the ENSAP project area.

The analysis in this phase will try and develop the basic concepts for the "Climate Smart" initiatives by drawing on specific similar activities in other regions of the world. The scope, objectives, and approaches to be adopted in these new initiatives will be outlined. The corresponding budgets will be estimated to provide rough guidelines on the scale of proposed initiatives.

Although significant efforts will be devoted to the study of new "Climate Smart" initiatives, our main focus and attention will be devoted to enhancing and strengthening climate change related activities within the existing projects.

In section 4 we describe the application of this methodology to the projects listed in Table I.

2.1 Other Climate Change Proofing Strategies: Climate Risk Assessment

Before application of our new methodology, we would like to comment on other climate proofing strategies and techniques used and adopted by similar international projects. In particular, the risk assessment approach to climate proofing is an alternative technique that has been adopted by other agencies such as the Norwegian Agency for Development Cooperation (NORAD).

In the risk assessment approach, large scale projects, in sectors that could potentially be impacted by climate change, are assessed regarding their impact on GHG emissions, their



vulnerability to climate change impacts, and the availability and suitability of their adaptation measures. These assessments are designed to cover the mitigation and adaptation processes related to climate change. Although these two processes are important to consider while addressing the climate proofing issue, these are by no means the only important processes related to climate change. As demonstrated in the development of ENTRO climate change strategy of Figure 2, there is indeed other important processes to be considered, namely climate change prediction, opportunities, and education. Hence the climate proofing approach described in the methodology of Figure 1 is significantly more comprehensive than the climate risk assessment approach, due to the fact that a more complete set of processes are explicitly considered.



3.0 Application of Methodology

3.1 Eastern Nile Irrigation and Drainage Project (ENIDP)

3.1.1 Broad context

The main objectives of the Eastern Nile Irrigation and Drainage Project are "(i) to support the development and expansion of irrigated agriculture, and (ii) to improve the productivity of the existing small and large scale irrigated agriculture through efficient water use."

The main processes driving global climate change are anthropogenic emissions of greenhouse gases (such as carbon dioxide, nitrous oxide, and methane) and changes in land cover. Both of these processes are somewhat related to irrigation development. Development of a new irrigation project in an arid region is likely to change land cover significantly and hence should result in anthropogenic flux of carbon from the atmosphere to the land surface. Such flux is quantifiable by the increase in net primary productivity resulting from establishing the irrigation project. On the negative side, the development of a new irrigation project is likely to increase emissions of methane and nitrous oxide from the land surface to the atmosphere, depending on the intensity of integration of animal production such as cattle in the agricultural activity, and depending on the type and rate of fertilizer application. Nitrogen based fertilizers are likely to enhance emissions of nitrous oxide by the soil.

The potential impact of climate change on irrigation in the Nile basin includes the potential on irrigation water requirement. The evaporative demand from irrigated crops is usually computed by multiplying the atmospheric demand for evaporation (Potential Evaporation) by a crop specific coefficient which reflects the water demand characteristics of the crop. Under a warmer climate and an atmosphere that is richer in carbon dioxide, both variables (Potential Evaporation and the Crop Coefficient) are likely to change. In general potential evaporation is likely to increase due to the increase in temperature, while the crop coefficient is likely to decrease because of the carbon dioxide fertilization impact. In any region of the world, and depending on the relative magnitudes of these two changes, which have opposite signs, the overall magnitude of evaporative demand by crops may increase or decrease.

Water use for irrigation purposes is the main consumer of water globally. This region is no exception. As outlined in the "Approach Paper", current model predictions regarding the future levels of water in the Nile are quite uncertain, with both increases and reduction in the Nile flow being possible. Even without any climate change, the mismatch between available supply and the increasing demand on water presents a significant challenge for the Eastern Nile countries. If climate change results in even less water available in the Nile, this would likely create an acute challenge in this region. Hence, we conclude that the activities related to Eastern Nile Irrigation and Drainage project are most vulnerable to any reduction of water availability that may result from climate change.

3.1.2 How can we approach climate change in the context of this project?

The "Approach Paper" describes a general strategy (Figure 2) that is applied here to the EN Irrigation and Drainage project. The elements of the strategy that are relevant to this project are those associated with adaptation, opportunities, mitigation, education, and prediction. These elements are listed in their order of relevance with adaptation being most relevant and prediction is the least relevant.

As discussed in 3.1.1 the challenges addressed by this project are most vulnerable to future reduction in the Nile flow. Hence, adaptation measures that would aim at "minimization of irrigation water losses which should help to alleviate water shortages in the event of decreased flow" are the most important measures for this project. In the event of increased flow in the Nile as a result of climate change, that welcomed change should help meet the increased demands for irrigation development in the three countries of the Eastern Nile.

The opportunities associated with climate change can be pursued in the context of irrigation development in the Eastern Nile countries. As discussed earlier, in section 3.1.1, irrigation development may result in a net flux of carbon from the atmosphere into the land surface. If documented and certified, this carbon flux may receive credit and become an additional financial benefit from the irrigation project. In order for such process to succeed, evidence has to be presented that the decision to channel general economic investment into irrigation development was made with the objective of reducing national emissions of carbon.

On the mitigation side, efforts has to be made to make sure that new irrigation development occurs in lands where the resulting changes in land cover would not result in enhancing emissions of carbon from the land surface to the atmosphere. While this condition is most likely met in the arid regions of Sudan and Egypt, the same may not always be true for all sites in Ethiopia. This would point to the need of avoiding irrigation development in forested areas. This condition can easily be met.

The relevance of education and prediction are minimal in the context of this project.

3.1.3 Climate change components

In the context of the EN Irrigation and Drainage project, we propose the following climate change components as follow up to this project:

(i) A new initiative has to be launched in the area of minimization of irrigation water losses that aims at increasing the water use efficiency in irrigation within the Eastern Nile countries. Such initiative would be quite timely to address the water scarcity challenge in the current climate and as mechanism for adaptation to potentially the most serious threat to this region: less water in the Nile as a result of climate change.

(ii) A special study has to be commissioned with the objective of evaluating the impact of climate change on irrigation water requirements in the Eastern Nile basin. This study should have two objectives: to quantify the potential impacts of climate change on potential evaporation over this region, and to identify the response of the main crops of this region to climate change. The latter



objective should address feasibility, productivity, and water requirements for crops such as wheat, cotton, sorghum as well as other crops that may become more suitable for this region under future climates. The impact of climate change on cropping patterns in the region should be addressed in this study. We estimate that this study should cost about $50K.

(iii) Any new irrigation development project on the Eastern Nile should develop a plan at the earliest stages on how to engage the Clean Development Mechanism (CDM) process in order to secure certified emission reduction (CER) credit which can later be traded in the international markets for the benefits of people in this region. Associated costs will be discussed later.

These three activities, taken together, will enhance climate proofing of this project.

3.1.4 Initiatives

Here we would like to propose the following initiative in the area of this project:

Eastern Nile Irrigation management Information System (ENIIS)

The goal of ENIIS is development of regional capacity for adaptation to climate change in the Nile basin through minimization of irrigation water losses which should help to alleviate water shortages in the event of decreased flow.

The proposed system consists of two components:

1. a network of monitoring stations (of order 10) distributed over the basin to monitor rainfall and other variables that can be used to estimate potential evaporation. The exact number and location of stations will have to be decided after careful analysis of the current and planned irrigation schemes in the region; and
2. a web-based information system that links together the stations and makes their data available in real time to potential users.

The proposed system should (1) be accessible to irrigation engineers in the basin countries to assist in their efforts to minimize wasted water in irrigation schemes; (2) recommend methodologies on how to estimate irrigation requirements based on the observed local climate and crop type.

ENIIS is not meant to be the only effort by Eastern Nile countries to reduce irrigation water losses. Efforts by national institutions to reduce other losses due to aging infrastructure, water management practices should be enhanced, in addition to the ENIIS initiative.

ENIIS is modeled after California Irrigation Management Information System (CIMIS), please see reference list for CIMIS web site address. CIMIS is also described in Appendix D.

Estimated Cost of ENIIS:

(1) 12 Weather stations, distributed between the 3 countries, for measuring rainfall, radiation fluxes, evaporation, sensible heat flux, temperature, wind, humidity and pressure @ $40K per station =$ 480,000

(2) Field installation and testing of stations @$10K per station=$120,000



(3) Central system server; and 12 station servers for data processing, communication through the internet, data storage and transfer to the central server; as well as development and testing of necessary software for communication to stations = $400,000

Initial cost for setting up ENIIS = $1M. (1st year)

(1) Annual cost of one specialist working exclusively on management of the system = $70,000
(2) Annual cost of one support technical staff= $30,000
(3) Annual discretionary budget for maintaining the system=$100,000

The cost of maintaining ENIIS should be in the order of $200K per year, initially for about 5 years.

3.2 Flood Preparedness and Early Warning Project I (FPEWI)

3.2.1 Broad Context

The specific objective of FPEW I, is " to establish a regional institution basis and to strengthen the existing capacities of the EN countries in flood forecasting, mitigation and management, promoting regional cooperation as well as to enhance the readiness of the EN countries for preparation/implementation of subsequent FPEW projects."

The objectives of this project has no direct relationship to the processes driving global climate change such as the emissions of carbon dioxide or the changes in land cover. However the impacts of climate change on the Nile basin are likely to have significant effects on floods, their magnitudes, and their timing. Hence, a level of preparedness that is adequate for today's conditions may or may not be adequate under different future climate scenarios.

3.2.2 How can we approach climate change in the context of this project?

The "Approach Paper" describes a general strategy (Figure 2) that is applied here to the Flood Preparedness and Early Warning Project. The elements of the strategy that are relevant to this project are those associated with adaptation, and prediction. The other elements of mitigation, opportunities, and education are not directly relevant.

As part of this project, flood risk maps have been prepared for sections of the Eastern Nile flood plains. Theses flood risk maps are quite useful for flood preparedness purposes under the current climate conditions. However, as the sign and magnitudes of the climate change impacts on the flooding patterns of the Nile, become more certain, there will be a need for updating these flood risk maps to reflect future climate conditions. Such updates of flood risk maps represent an essential element of any effective adaptation mechanism to climate change in the region.

Some of the activities of FPEWI project involved training of experts from the region on the use of weather prediction models such as the Eta model, for the purpose of short term flood forecasting of flash floods. Future efforts on improving predictions of regional climate change should build on this experience, since the technology of numerical weather prediction is quite similar to the technology of regional climate models.



The potential climate change impact that is most important to the general area of this project is the possibility that future climate change may bring significant increases in the frequency and magnitude of flooding and flash floods over the Eastern Nile region. Any improvement to the flood preparedness mechanisms in the region and the ability of relevant institutions to issue accurate early warnings about flooding of the Nile or flash floods would prepare the region to face one of the potential consequences of future climate change over the Nile basin.

Potential for changes in frequency of extreme flooding events associated with climate change may result in significant changes to the 3-D channel morphology. There is a need for field studies that document the impact of climate change on the channel cross section and the river morphology, including feedbacks into the flow regime itself.

3.2.3 Climate change components:

As a follow-up to this project, we propose that

(i) FPEW II should build on the achievements of FPEW I by strengthening the flood preparedness infrastructure in the region with an eye to the possibility that climate change may cause further increases in the magnitude, extent, and frequency of flooding and of flash floods;

(ii) Similarly the efforts of FPEW I in capacity building in the area of short term flood forecasting should be expanded into the area of regional climate modeling. Capacity building proposed here based on the assessment that prediction is one strategy pillar that is relevant to this project. This should be done with an objective of predicting floods of the future and in coordination with the initiative in regional climate prediction discussed later. We estimate the cost of proposed efforts in capacity building will be in the order of $100K.

3.2.4 Initiatives

No specific initiative is proposed under the umbrella of this project.

3.3 Eastern Nile Watershed Management Project

3.3.1 Broad Context

The objective of this project is to "improve standards of living of the population living within selected watersheds in the Eastern Nile region, decrease population pressures and increase land productivity so that sustainable livelihoods and land use practices can be secured for the target populations."

This project emphasizes land productivity and advocates sustainable land use practices within the Eastern Nile countries. Change in land cover is one of the two processes driving global climate change. Hence, any efforts towards reducing the rates of change in land cover should also help in reducing effective emissions of carbon dioxide to the atmosphere. The climate change impacts that are most relevant to this project are changes in rainfall, river flow, temperature, and the associated distribution of vegetation. The Nile watershed is quite vulnerable to all these changes. There is an urgent need to document the extent of current and future changes of the Nile watershed including all these variables.



3.3.2 How can we approach climate change in the context of this project?

The "Approach Paper" describes a general strategy (Figure 2) that is applied here to the EN Watershed Management project. The elements of the strategy that are relevant to this project are those associated with adaptation, opportunities, and mitigation. These elements are listed in their order of relevance with adaptation being most relevant and mitigation is the less relevant.

As the nature of the climate change impact on the Nile becomes certain, there will have to be significant efforts on how to adapt to the new change. Such efforts will require the capacity to document the spatial extent as well as the magnitude of changes in any of the variables stated. Also, as these impacts become more evident there will likely be opportunities through international mechanisms for compensation to developing countries that contributed very little to the causes of the problem in the first place. In order to assess damages caused by climate change, again we need to have the capacity to document the spatial extent as well as the magnitude of change in the important climate variables stated.

Specific activities were carried in the 3 countries as part of this project with the objective of preservation of land cover over the region and in reducing the loss of vegetation cover. Such past efforts by this project should have the added value of contributing to mitigation of climate change. Therefore, this effort should be studied and quantified so that past efforts can used to guide future activity in the region.

3.3.3 Climate change components

As part of this project, we would like to propose the following climate change components:

(i) Significant effort should be devoted to monitoring of the Eastern Nile watershed, with the objective of creating a reliable data base describing variables such as rainfall, river flow, sediment yield, surface temperature, and vegetation cover. This data base should include historical data sets on these variables, new commissioned observations of variables that were not monitored sufficiently, as well as satellite observations of rainfall and vegetation cover;

(ii) Special study should be commissioned to document and measure in quantitative terms the impact of the activities in this project on enhancing preservation of land cover and reducing loss of vegetation cover, and the associated reduction in carbon flux. We estimate the cost of this special study would be in the order of $50K.

3.3. 4 Initiatives

Eastern Nile watershed Observatory for Climate change Detection (ENOCD)

The goal of ENOCD is to establish and coordinate a monitoring network of flow, sediment flux, rainfall, temperature, and vegetation cover to enable documentation of the impact of climate change on the Eastern Nile watershed. The new observatory will consist of (i) enhancement and maintenance of existing networks of standard surface

observations of rainfall, river flow, sediment loading, and surface temperature, (ii) incorporation and integration of new satellite data sets on rainfall and vegetation cover, and (iii) a web-based information system for data management and dissemination.

As a similar observatory system, we describe in Appendix D the Observatory for Environment and Sustainable Development of Senegal River Basin. Though the scale and general design of both observatories may not be very different, their goals and hence their specific designs are likely to be quite different. Unlike the Senegal observatory, ENOCD is proposed to enhance the capability for detection of climate change impact on the Nile basin.

Estimated Cost of ENOCD:

The scale of ENOCD will depend on the scale of the observatory and the number of new field stations. Here, we propose a medium scale observatory with 12 field stations

(1) 12 Automatic monitoring stations, distributed between the 3 countries at locations with calibrated stage discharge relationships, for measuring temperature, rainfall, river stage level @ $20K per station =$ 240,000
(2) Field installation and testing of stations, and construction of river stage monitoring gauges @$30K per station=$360,000
(3) Central system facility for storage and analysis of satellite and field data; and 12 station servers for data processing, communication through the internet, data storage and transfer to the central server; as well as development and testing of necessary software for communication to stations = $400,000

Initial cost for (1st year) setting up ENOCD = $1M.

In addition for operational purposes:

(1) Annual cost of: one specialist working exclusively on management of the system = $70,000; a GIS specialist working on archiving and analysis of data sets = $70,000; one support technical staff= $30,000
(2) Annual discretionary budget for maintaining the system=$130,000

The cost of maintaining ENOCD should be in the order of $300K per year, initially for about 5 years.

3.4 Eastern Nile Planning Model (ENPM)

3.4.1 Broad Context

The development objective of the ENPM Project is that "countries in the Eastern Nile operationalise an improved decision support modeling framework to identify water-related investments and evaluate them in a regional context. The project is intended to strengthen the knowledge, modeling, and stakeholder interaction, and capacity of regional and national institutions to plan for water resources investments in a regional context, with appropriate regard to economic, environmental and social aspects."

Given that ENPM project is entrusted with the panning of *future* water resources projects at the regional scale, it should have the major role to play in relation to *future* climate change. In general the uncertainty about the levels of rainfall and river flow in the future due to climate change makes the issue of planning much more challenging. Planning any future projects will have to include serious considerations not only for trends in

population, economic activity, water demand but also future trends in climatic variables such as rainfall and river flow.

In the positive side, the issue of climate change bring with it many opportunities, such as those associated with carbon trade, that will have to be engaged in a constructive manner and for the benefit of the people of this region.

3.4.2 How can we approach climate change in the context of this project?

The elements of the strategy, outlined in Figure 2, that are most relevant to this project are prediction, and opportunities. Both of these elements will have to be addressed in a fundamental way within the context of this project. The elements of adaptation, mitigation, and education are also relevant to ENPM Project but of less immediate urgency. These 3 elements will have to be considered as secondary objectives in the planning of future water resources development projects.

3.4.3 Climate change components

In addressing the climate change issue within this project we propose the following components:

(i) Commissioning of a special study to define quantitatively and in significant details the current best projections of future climate trends in rainfall and river flow. These projections should then inform all future planning of new water resources projects in the region (We estimate the cost of this study would be about $100K);

(ii) Development of the human capacity and the appropriate modeling tools in the region with the objective of narrowing significantly the current range of uncertainty regarding future climatic conditions. This a long term effort that should have a time frame of one decade;

(iii) Development of the human capacity and the tools for engaging all potential opportunities that may emerge in the area of climate change. The potential for engaging carbon trade mechanisms should be explored at the earliest stage of the planning process for all new water resources development projects in the region.

3.4. 4 Initiatives

In the area of the ENPM project we propose the following two initiatives, which parallel the two climate change components (ii), and (iii) above:

Eastern Nile Center for Regional Climate Prediction (ENCRCP)

The goal of ENCRCP is reduction of uncertainty level about climate change predictions through local development and use of a new class of regional climate models; and through capacity building and education of young researchers from the Nile countries.

The high level of uncertainty in predictions of future climate of Africa presents tremendous opportunity for young researchers looking to pursue a career in research related to the Nile water resources and climate change. There is an urgent need to motivate and inspire young minds to address this important and challenging issue. We

estimate that the cost of this center will be about $1M for initial cost, and $1M per year for operational costs, initially for about 5 years.

Eastern Nile Carbon Trade Project (ENCTP)

The Clean Development Mechanism (CDM) was established under the Kyoto Protocol. (Please see the reference list to learn more about CDM through their web site.) It allows approved projects in developing countries to earn Certified Emission Reductions (CERs) credits measured in tonnes of CO2. These CERs can then be sold to industrialized countries for use in accounting of their emission reduction targets. The CDM offers an opportunity for all the new hydropower projects on the Nile to obtain CERs. This process should be engaged by Nile basin countries at the early stages in the planning of any new projects.

As recommended in the Climate Change Strategy, the role of ENTRO should focus on facilitation and capacity building at national and regional levels for:

(i) using the existing structure more efficiently;

(ii) negotiation of better mechanism structure that enables better African participation in the future

The followings are the specific steps that are to be followed in order to engage the CDM process:

(1) A project participating in the CDM has to first be approved by a designated national authority as contributing to their sustainable development.
(2) The next step is formal registration by the Executive Board of the CDM.
(3) The project has to establish a baseline scenario to determine emissions levels assuming that the project is not developed.
(4) The project has to meet the "additionality" requirement which establishes that the planned reductions would not occur without the additional incentive provided by the CERs credits.
(5) The project has to be monitored over a pre-specified accounting period to determine the difference between actual emissions and the corresponding emissions under the baseline assumptions. This difference is then credited to the project as a CER.

The goals of ENCTP is (i) to develop the human capacity needed in the three EN countries in order to engage the process of securing carbon credit for any new development activity in the region; and (ii) to recommend a specific methodology for water resources development projects in the Eastern Nile, such as JMP, on how to engage international institutions dealing with this topic. There is an urgent need for a focused effort from ENTRO to effectively address these two issues. Both the EN JMP1 and the Baro-Akobo-Sobat project would benefit significantly from an initiative in this area.

Estimated Cost of ENCTP

We estimate an initial cost of about $200,000 for initial launching of this project. A consulting firm specialized in Carbon Credit Estimation and Trade should be hired to help in selection and initial training of staff.



We estimate an operational budget of about $500K per year, initially for about 5 years. The project should have permanent staff of two specialists ($140,000 per year) and should engage in a program of short training courses ($200,000 per year), as well as special studies on specific new water resources projects on the Eastern Nile ($100,000 per year).

3.5 Eastern Nile Joint Multipurpose Program (ENJMP)

3.5.1 Broad Context

The long term objective of this project is "to contribute towards transformational and sustainable socio-economic development, economic integration and stability in the EN region. A more immediate development objective of the first joint multipurpose project (JMP 1) is to undertake cooperative and sustainable development and management of the shared Blue/Main Nile water resources through identification and definition of an investment package for JMP1 that would provide win-win opportunities to the three riparian states, and that would address their needs for more power, food production and environmental sustainability"

Since the identified investment package is supposed to address the needs for environmental sustainability for the three countries, this requirement can be interpreted in the broad sense as addressing the challenge of climate change. Depending on the nature of the choices made in JMP1 to meet the needs for more power and food production, e.g use of hydropower and minimum changes in land cover, the future emissions of carbon dioxide would be impacted significantly.

The planning of any new water resources project, including JMP1, should acknowledge the changing nature of the climate system at regional and global scales. Neglecting climate change impacts may result in unpleasant surprises.

3.5.2 How can we approach climate change in the context of this project?

All elements of the strategy, described in Figure 2, are somewhat relevant to this project. However, the elements of the strategy that are most relevant to this project are mitigation, opportunities, and adaptation.

First, the choice to meet the demands of more power through clean hydropower technology should be underlined as a choice that will help in mitigation of future climate change since alternatives to hydropower would likely include generation of electricity through fossil fuel burning, especially in Sudan and Egypt.

Second, efforts should be made to engage the potential opportunities associated the CDM mechanism of the Kyoto Protocol in order to secure certified emission credits for any new project that may be recommended by JMP1.

Third, water resources planning related to any proposed investment package should be carried with explicit recognition of the potential impact of climate change on the river flow. In the case of increased flow in the Blue Nile as a result of climate change, any new reservoirs would be a welcomed addition for more efficient management of the added water resource.

3.5.3 Climate change component

As part of the activities of the EN Joint Multipurpose Program (EN JMP), we propose the following components:

(i) Development and execution of a specific plan on how to engage the CDM process; This plan should specify in details the steps to be taken by the Eastern Nile Countries in order to secure Certified Emission Reductions (CER) credits for any reductions in the potential emissions of carbon dioxide that will be avoided as a result of the proposed investment package, as well as the timing of these steps. (For costs see ENCTP above)

(ii) Development and execution of a plan on how to accommodate the changing nature of the regional climate system in the water resources planning process relevant to JMP1. This plan should include specification of the most possible range of future scenarios of water flow in the Blue Nile based on the IPCC reports. Application of such plan to any recommended set of reservoirs would insure that planning of this new project incorporates consideration for the potential impact of climate change on the Nile river. We estimate the cost for a special study to develop and implement this plan to be around $100K.

3.5.4 Initiatives

No initiatives are proposed under this project.

3.6 Baro-Akobo-Sobat Multipurpose Water Resources Development Project

3.6.1 Broad Context

The long term objective of this project is to "promote social and economic development in the region in an environmentally sustainable manner". The immediate objective of this project is " multi-purpose development of the Baro-Akobo basin, so as to bring regional benefits to all countries, to adopt an integrated approach and address issues such as flood management, hydropower development, environmental and natural resource protection, water conservation, irrigation, rural social and economic development and navigation. "

This project is at the early stages compared to other projects. Climate change processes will affect all aspects of this water resources development project. The choices made about the pattern of development in this region will have impact on the processes driving global change namely emissions of carbon dioxide associated with energy production or changes in land cover associated with land use changes. On the other hand all the potential regional impacts of climate change may impact the functioning of future water resources projects in this region, from changes in rainfall or runoff and river flow to the spatial extent of wetlands and their biogeochemistry. All other impacts such as changes in

surface temperature and evaporation patterns can also impact the hydrology of the river and the associated ecosystems. This project is most vulnerable to regional impacts of climate change on rainfall distribution and variability at seasonal to annual and decadal time scales.

This project is concerned with development issues in a region that has two important features. First, the current energy production and energy use levels are extremely low compared to most other regions of the world. Second, the region has large potential for both non-renewable sources of energy from fossil fuel burning, given the large oil reserves in Southern Sudan, as well as renewable sources of energy form hydropower production at suitable locations on the river. As development options are outlined, these two alternative routes for energy production should be addressed explicitly and compared at early stages of this planning process.

3.6.2 How can we approach climate change in the context of this project?

All elements of the strategy, described in Figure 2, are somewhat relevant to this project. However, the elements of the strategy that are most relevant to this project are opportunities, adaptation, and mitigation. As proposed in the strategy document, climate change considerations should be addressed proactively at the earliest stages of the water resources planning processes. The fact that this project is currently (August 2010) at early stages of formulation offers a good opportunity for developing a show-case for how climate change considerations can be incorporated in water resources planning over the Nile basin. This show-case should demonstrate how opportunities associated with climate change such as the CDM process can be engaged effectively and at an early stage, in ways that would mitigate some of the driving processes of climate change.
On the other hand, adaptation to the potential impacts of climate change can be given careful consideration by addressing the two potential scenarios of less (or more) water on the Nile in the future.

3.6.3 Climate change component

As part of the activities of the Baro-Akobo-Sobat Multipurpose Water Resources Development project, we propose the following components:

(i) Formulation of the entire project as a prototype or a show-case on how sustainable water resources development projects can be planned in ways that explicitly incorporate at early stages considerations for the health of ecosystems and the environment as well as the changing climate. The project should be highlighted for funding and financing emphasizing this new formulation.

(ii) Preparation of two development plans of the Baro-Akobo-Sobat basin, one describing the traditional approach that relies for energy sources on burning of fossil fuels, and relies for agricultural development based on extensive changes in land use and intense changes in land cover. The other scenario should describe an environmentally friendly approach that relies on renewable sources of energy such as hydropower, and emphasizes land and soil conservation approaches. The project should then try and utilize all opportunities available through the CDM or any other international funding mechanism to secure resources for executing the environmentally friendly plan. (For costs see ENCTP above)

3.6.4 Initiatives

Here we propose that ENTRO launches a new initiative:

"**Baro-Akobo-Sobat Project: A Show-Case for Water Resources Development in a Changing Climate**"

This initiative should have the objective of formulating this project as a show case for development and demonstration of a methodology on how to carry the process of water resources planning while explicitly acknowledging climate change processes, starting at the earliest stages of the planning process. A proposal should be drafted by ENTRO and submitted to funding agencies requesting additional financial resources to be used in development and application of this methodology. The approach advocated in this initiative is distinctly different from the limited approach proposed in the UNDP funded study on the Pangani river basin of Kenya (please see appendix D). Here, we propose a proactive approach that uses this project to highlight and emphasize the importance of climate change beyond the limited regional scope of the original project.

This initiative should provide the umbrella for the two climate change components outlined above. In addition, the new initiative should deal with the following tasks: (i) development of better regional predictions of climate change impact on the Baro-Akobo-Sobat basin, (ii) outlining of specific methodology on how to incorporate these predictions of climate change impact on the design of new water resources systems (iii) demonstration of how choice of the water resource development route will result in



mitigation of climate change through reduction of potential emissions of carbon dioxide, (iv) outlining of a general methodology and specific plans on how to address opportunities associated with the CDM process. We anticipate significant synergy between this initiative and ENCTP. We estimate that the costs associated with this initiative will be about $1M distributed over 3 years.

3.7 Eastern Nile Power Trade & Ethiopia-Sudan Transmission Interconnection Projects

3.7.1 Broad Context

The objective of the Eastern Nile Power Trade project is to "promote EN regional power trade through coordinated planning and development of power generation and transmission interconnection and creation of an enabling environment." The objective of Ethiopia-Sudan Interconnection project is to "facilitate, through high voltage transmission line, cross-border power trade between Ethiopia and Sudan, and thus optimize utilization of existing and planned generation capacity". The two projects are complementary, while the former emphasizes institution building and policy formulation; the latter is concerned with infrastructure development and optimization of the utilization of generation capacity.

These projects will have important impact on the region. Taken together, the two projects transform the energy market in the Eastern Nile countries from three national independent markets into one regional integrated market. The three EN countries have different types of natural resources that can be used for enhancing electric generation capacity: Ethiopia is relatively rich in hydropower potential; Sudan is relatively rich in oil resources; and Egypt is relatively rich in natural gas resources. Following integration of the three national markets into one regional market, planners in the Eastern Nile region will have the opportunity to compare under a single framework the two options for expanding electric generation capacity: generating electricity from hydropower; or generating electricity from fossil fuel (oil, or natural gas) burning. These two options can be compared in their profitability. However, one important way to compare these two options is relative to their impact on the environment and in particular their impact on anthropogenic emissions of carbon dioxide, and hence on the process of climate change. Without the connectivity introduced between the three countries, the two options for electricity generation may not be both feasible for each country taken separately.

3.7.2 How can we approach climate change in the context of this project?

All elements of the strategy, described in Figure 2, are somewhat relevant to these projects. However, the elements of the strategy that are most relevant to this project are the ones addressing opportunities associated with climate change. The conclusion of these two projects will make it feasible for the Eastern Nile countries to make use of the potential opportunities offered through the CDM mechanism. Simply stated, each project on hydropower generation in Ethiopia can now be posed as a conscious choice for using a clean technology (hydropower) over other economically feasible options (burning of fossil fuels). As a result the Eastern Nile countries can then receive certified emissions reductions credit for making this choice through the CDM mechanism.

3.7.3 Climate change component

As part of the follow-up activities of the Eastern Nile Power Trade and the Ethiopia-Sudan Interconnection project, we propose the following component:
Commission of a special study with the following objectives: (1) Documentation of how these two projects transformed and integrated the energy markets in the three countries from three different national markets into one regional market; (2) Analysis of how the integration of the markets offers an opportunity for a different screening criterion to be used in selection of new energy sources for the region; (3) Illustration with examples on how integration of the three markets can be used within the CDM process to secure certified emission credits. We estimate that the cost of this special study is about $50K.

3.7.4 Initiatives

No specific initiative is proposed under the umbrella of these projects. However, the proposed climate change component can interact significantly with the Eastern Nile Carbon Trade Project (ENCTP) initiative that was described earlier.

3.8 Communities Resilience, Capacity Building, and Education:

Here, we will attempt to define how some of the proposed new initiatives will support and enhance community resilience and adaptation to climate change for different social units (e.g. watershed communities, irrigation communities, etc).

The Eastern Nile Irrigation Management Information System (ENIIS) will enhance community resilience and adaptation to climate change at the level of irrigation schemes and at the national level. More efficient use of irrigation water will have many benefits beyond the climate change issue, not the least among them is the increased awareness of the value of water and the urgent need for water conservation.

The Eastern Nile watershed Observatory for Climate change Detection (ENOCD) will help bring together the national efforts in data collection and sharing towards the common goal of documentation and detection of regional climate change over the Eastern Nile basin. The common fate of the communities living on the watershed of the Nile river, as they get together to combat the potential hazards from climate change, may become a unifying factor at the national and regional levels. The capacity of watershed communities to adapt to regional climate change would be enhanced significantly by the additional tools for detection and rigorous quantification of the extent of climate change impact on the eastern Nile basin.

The presentation of the Baro-Akobo-Sobat Project as A Show-Case for Water Resources Development in a Changing Climate will help in raising awareness and further education regarding the process of climate change. Such initiative will highlight to watershed communities as well as the society at large the need for proactive action to address the challenges posed by climate change.

This report emphasizes the importance of capacity building in climate change proofing of ENSAP projects. Two of the proposed initiatives: ENCTP and ENCRCP have capacity

building as one of their main objectives. Both address urgent needs related to regional climate prediction in the case of ENCRCP, and opportunities associated with carbon trade in the case of ENCTP. In addition, the report proposes a special study on expanding the Flood Prediction and Early Warning I efforts in capacity building from the area of short term flood forecasting into the area of regional climate modeling. However, the proposed efforts should be designed to address capacity building needs at several levels. Each of the ENSAP projects should devote significant efforts to the area of capacity building related to climate change in the context of the specific project. At the level of regional and national experts, capacity building efforts should focus on the processes of climate change: prediction, mitigation, and adaptation in relation to the Nile basin communities. Workshops and short training courses should be organized to enhance ENSAP projects activities in this area.

Education represents one of the most important pillars of the ENTRO climate change strategy. The emphasis should be on broad education at the level of stake holders and broader community organizations. Stakeholder engagement in issues related to climate change should be emphasized by project coordinators. The technical concepts about climate change should be simplified and presented in concrete terms that are easily accessible. For example, how climate change could result in more or less flooding?, how climate change may impact irrigation water requirements?, and what simple actions at the grass roots level such as land use choices may impact climate change?. These concepts are better presented as an integral part of the main educational message adopted by any of the ENSAP project, rather than being presented as a side issue that has to be dealt with separately. Community preparedness should be enhanced through these educational activities. The watershed project has a significant role to play in this area building on past experiences.

3.9 Estimation of Carbon Footprints for Activities related to ENSAP Projects

Methodologies for estimation of carbon footprint vary from those designed to estimate carbon footprint at the scale of countries (e.g the UK) as demonstrated by Wiedmann et al. (2010), to those that are designed for the scale of small company (Tanger (2010)). At the large end of this spectrum, the interest is in describing long term emissions by entire economic sectors of a country's economy. At the small end, the interest is in the operations of a single company and their associated carbon footprints. Both of these approaches may not be suitable for activities related to ENSAP projects. Here, we recommend a hybrid approach that separates the short term and long term carbon footprints and deals with them separately.

The type of activities related to ENSAP projects that are likely to leave a significant carbon foot print include primarily:

(i) development of a new hydropower project;

(ii) expansion of irrigated agriculture; and

(iii) reforestation within a specific watershed.

There are two types of carbon footprint associated with any of these activities: (a) short term carbon foot print in the initial stage of the activity associated with the construction and/ or establishment phase; and (b) long term carbon foot print associated with the operating phase of the activity. We expect the long term carbon footprint of any of these activities to be more significant in size and hence more important to consider while evaluating the impact of the overall activity.

The short term carbon footprint can be estimated using the detailed methodology described in the reference list (Tanger (2010). This methodology is easily applicable to the contractor/company executing the establishment phase of the activity e.g the contractor responsible to the hydropower project.

The long term carbon foot print calculation will depend on the nature of the specific activity:

(i) For hydropower development, the long term carbon foot print can be estimated as the (electric power generated by the plant per year) multiplied by (the tonnage of carbon emitted by a typical plant that uses fossil fuels to generate a unit of electric power). An assumption will have to be made about the type of fossil fuel, which should match resources available in the region.

(ii) For irrigation expansion, the long term carbon foot print can be estimated by the carbon equivalent of the harvest produced by the irrigated land less the carbon equivalent of greenhouse gases emitted as a result of application of fertilizers and in the operation of the scheme.

(iii) For reforestation activities, there is no long term carbon foot print beyond the period required for full growth of the forest. The corresponding short term carbon footprint should span the period required for growth of the trees to mature stage. This carbon footprint is the net ecosystem exchange rate in tonnage of carbon per year estimated for this growth period.

All these three carbon footprints are negative in the sense that they reduce emissions of carbon to the atmosphere.

4.0 Action Plan

In this report, we propose five "Climate Smart" concepts that are recommended for consideration and further action by ENTRO. Each of these concepts targets opportunities associated with climate change, and can be pursued in a limited fashion as a climate change component to enhance the associated ENSAP project, or can be launched as a new initiative. These initiatives represent the proposed program activities. Table III describes the five initiatives, their estimated costs, and overall periods. These initiatives, if implemented, would enhance the set of activities that are likely to have the most impact in climate-proofing of ENSAP projects.

Two specific projects are recommended for top-priority designation: ENIIS and ENCTP.

Criteria for Prioritizing of New Initiatives

The criteria for prioritizing new initiatives elevates those initiatives that address areas of (a) specific, acute, and well defined vulnerability for the ENSAP project ; and/or (b) outstanding, promising opportunity that would help in enhancing ENSAP projects and eventually help in generating new financial resources for the region. Following this criteria, we provide the following rational for recommending the two projects.

(i) The reason for recommending ENIIS is the fact that this initiative addresses the most serious potential impact of climate change on the Eastern Nile, which is the possibility for less water in the Nile as a result of climate change. Even in absence of any climate change impact, ENIIS addresses the most serious challenge for Eastern Nile countries: how to match supply and demand on the Nile water. Efficient water use in irrigation is the most promising approach towards balancing the demand and supply of the Nile water.

(ii) The reason for recommending ENCTP is the urgent need for enhancing the regional capacity for responding to opportunities associated with climate change. ENCTP will have two distinct objectives: capacity building for individuals and institutions in the region, and coordination of specific studies on how new water resources projects in the region engage international mechanisms for clean development and carbon trading.

In addition to the initiatives of Table III which are recommended for programmatic consideration by ENTRO, we propose six special studies for consideration and implementation by the ENSAP projects coordinators:

(i) A special study on the impact of climate change on irrigation water requirements in the Eastern Nile basin, emphasizing the response of the main crops of this region to climate change. ($50K); (ENIDP)

(ii) A special study on expanding FPEW I efforts in capacity building from the area of short term flood forecasting into the area of regional climate modeling. ($100K). (FPEW II);

(iii) A special study to assess impact of the activities of the watershed project on preservation of land cover and reducing loss of vegetation cover and the associated carbon footprint, in order to provide guidance for future activities. ($50K); (ENWSM)

Table III: Proposed New Initiatives and their Estimated Costs: Initiatives 1 and 4 (in bold) are given top-priority status

	Primary project	Related projects	Estimated Cost & Total period
(1) Eastern Nile Irrigation Management Information System (ENIIS)	**Eastern Nile Irrigation and Drainage Project**		**Initial cost of $1M. operational cost of $200K /year for a period of 5 years: Total cost=$2M**
(2) astern Nile watershed Observatory for Climate change Detection (ENOCD)	Eastern Nile Watershed Management Project	Eastern Nile Planning Model (ENPM)	Initial cost of $1M. operational cost of $300K /year for a period of 5 years: Total Cost=$2.5M
(3) Eastern Nile Center for Regional Climate Prediction (ENCRCP)	Eastern Nile Planning Model (ENPM)	Flood Preparedness and Early Warning Project I	Initial cost of $1M. operational cost of $1M /year for a period of 5 years: Total Cost=$6M
(4) Eastern Nile Carbon Trade Project (ENCTP)	**Eastern Nile Planning Model (ENPM)**	**Baro-Akobo-Sobat Multipurpose Water Resources Development Project** **Eastern Nile Joint Multipurpose Program (ENJMP)** **Eastern Nile Power Trade & Ethiopia-Sudan Transmission Interconnection Projects**	**Initial cost of $200,000. operational cost of $500K /year for A period of 5 years: Total Cost= $2.7M**
(5) Baro-Akobo-Sobat Project: A Show-Case for Water Resources Development in a Changing Climate	Baro-Akobo-Sobat Multipurpose Water Resources Development Project	Eastern Nile Planning Model (ENPM)	Total Cost of $1M distributed over 3 years

(iv) A special study to define quantitatively and in significant details the likely scenarios of future climate trends in rainfall and river flow in the Nile basin. ($100K) (ENPM)

(v) A special study on how to accommodate the changing nature of the regional climate system in the water resources planning process relevant to JMP1. ($100K) (ENJMP)

(vi) A special study to document the recent transformation of the energy markets in the three countries from three different national markets into one regional market and its impact on the process of identification of new clean energy sources for the region ($50K). (ENPT & E-STIP)

4.1 Potential Programmatic Linkages between Proposed Initiatives

The proposed initiatives are rooted in different ENSAP projects. However, the nature of some of the proposed initiatives may require significant coordination at the programmatic level in ENTRO. In particular, ENNIMIS and ENOCD, both involve deployment of new field stations that will be used to collect environmental data. In case both projects are adopted by ENTRO and selected by funding agencies, significant gains can be made by harnessing some synergy between the two efforts. The data collected by ENIIS can be included as an additional data set for archiving and dissemination by ENOCD. In another instance, ENCTP and the Baro-Akobo-Sobat project, if both adopted by ENTRO and selected for funding, could both benefit from coordination at the programmatic level. The Baro-Akobo-Sobat, or some of its elements, may provide the context for some of the early viable case studies for ENCTP.

4.2 ENTRO Role in Climate Change with respect to National Activities

The role of ENTRO in the climate change area should be designed to complement national efforts by focusing on initiatives and activities that are designed, consistent with the stated strategy, to

(i) Address the climate change challenge at Basin and climate scales which are larger than the scale of any of the 3 countries;

(ii) Capitalize on the benefits gained from integrating the energy markets in the 3 countries as discussed in 3.7 above;

(iii) Engage the international institutions as a unified regional bloc to maximize the chances for accessing opportunities related to climate change;

(iv) Enhance transfer of knowledge and expertise between the 3 countries towards the objective of fruitful cooperation between the Eastern Nile basin countries.

Although the recommended climate change components for ENSAP projects were not designed with the explicit purpose of supporting the objectives of NAMA's, NAPA's and other regional and national strategies, the shared goals of the proposed components and these other strategies should insure complementarities. During the implementation of the proposed activities these complementarities should be highlighted and exploited, whenever possible.

4.3 Institutional Arrangements within the Countries related to Proposed Initiatives

The implementation of the proposed climate smart initiatives may require significant new institutional arrangements within the countries, depending on the nature of each initiative. In the following we discuss these arrangements.

ENIIS

ENIIS will require establishment of a central office, preferably located within ENTRO for managing operational aspects of the project. This office will gather information from field stations and will disseminate information to the users through the WWW technology. Since the field stations will be located within irrigation projects in the 3 countries, some arrangements will have to be made with the management of theses irrigation projects directly to insure that minor problems related to electric supply etc will be taken care of without the need for direct intervention in the field by staff from the central office. More significant problems related to malfunction of equipment or needs for recalibration of instruments should be handled during visits by the project staff.

ENCTP

ENCTP will require establishment of a central office, preferably within ENTRO for managing this project. The activities in this office will include workshops and short courses for capacity building purposes, as well as special studies related to new development projects. The national institutions with significant potential interest and some experiences are the energy and electricity authorities specially in Egypt and Sudan. However, ENCTP should seek engage a broad range of agencies including those related to water resources, irrigation, environment, as well as private corporations.

ENCRCP

ENCRCP will be hosted in one of the three Eastern Nile countries. Egypt seems to have significantly more expertise in this area. ENCRCP will primarily engage the meteorological authorities in the three countries. However, activities related to prediction of climate impact should engage a broader set of institutions including those dealing with water resources, forestry, environment, and agriculture.

ENOCD

ENOCD will have a central office, preferably within ENTRO. Activities within this observatory will involve data collection, archiving and dissemination to the users in the 3 countries. Arrangements will have to be made between ENOCD and the agencies responsible for collecting observations on hydrologic and meteorological variables within the Eastern Nile basin regarding sharing of data with ENOCD as well as access to the ENOCD archived data sets.

Baro-Akobo-Sobat Show-Case Project

The institutional arrangements related to this project will follow similar protocols as in the current project, with the only exception that links to institutions responsible for climate change and the environment in the 3 countries will have to be strengthened.

4.4 Estimated Costs and Potential Funding Partners



In this section we offer approximate estimates of the cost for each of the proposed initiatives, and identify partners for potential funding of these initiatives. The identified partners are selected as only potential targets proposed to ENTRO for further consultations that seek to confirm their interest in potentially funding such initiative.

We propose Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) as a potential partner for ENIIS. In particular, ENIIS is likely to fit within the "Climate Protection Program for Developing Countries", which has been launched by GTZ under the more general theme of Environment and Climate Change.

We propose the Norwegian Agency for Development Cooperation (NORAD) as a potential partner for ENOCD. In particular, ENOCD is likely to fit within the "Adaptation to Climate Change" program, which has been launched by NORAD under the more general thematic area of Climate Change and the Environment.

We propose the US Agency for International Development (USAID) as a potential partner for ENCRCP. In particular, ENCRCP is likely to fit within the "Global Climate Change Program", which has been launched by USAID.

We propose the African Development Bank (AfDB) as a potential partner for ENCTP. In particular, ENCTP is likely to fit within the "Environment and Climate Change" program, which has been launched by AfDB under their Medium Term Strategy "to address the climate change challenge in Africa, primarily through work on the special challenges of adaptation and climate-proofing."

We propose the Global Environment Facility (GEF) as a potential partner for the Baro-Akobo-Sobat Project. In particular, the proposed project is likely to fit within the "Climate Change Adaptation" program. The GEF manages two separate, adaptation-focused Funds — the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF), which mobilize funding specifically earmarked for activities related to adaptation. Both funds are relevant to the proposed project.

Table IV Proposed Potential Funding Partners and Cost

Initiative	ENSAP Project	Proposed Funding Partner	Estimated Cost
(1) Eastern Nile Irrigation Management Information System (ENIIS)	Eastern Nile Irrigation and Drainage Project	GTZ	Total cost=$2M
(2) Eastern Nile watershed Observatory for Climate change Detection (ENOCD)	Eastern Nile Watershed Management Project	NORAD	Total Cost=$2.5M
(3) Eastern Nile Center for Regional Climate Prediction (ENCRCP)	Eastern Nile Planning Model (ENPM)	USAID	Total Cost=$6M
(4) Eastern Nile Carbon Trade Project (ENCTP)	Eastern Nile Planning Model (ENPM)	AfDB	Total Cost= $2.7M
(5) Baro-Akobo-Sobat Project: A Show-Case for Water Resources Development in a Changing Climate	Baro-Akobo-Sobat Multipurpose Water Resources Development Project	GEF	Total Cost = $1M



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Appendix A
(Section 2 of the Approach Paper)

2. Strategies to Address Climate Change

So how can we approach the issue of climate change given this uncertainty? We need an approach that is *flexible* since it needs to evolve as climate change predictions become more certain. The same approach has to be *comprehensive* since a wide range of potential impacts will need to be considered. *Low cost* approaches should always be desirable, and more so given the level of uncertainty. Approaches that have multiple objectives, beyond the issue of climate change, would offer attractive alternatives under these conditions.

The issue of climate change can be approached differently depending on the nature and mandate of the institution considering this important issue. Local, national, and regional institutions may share the same vision, but have different roles to play. The recommended approach to the issue of climate change is tailored to suit ENTRO: a regional organization, with a limited mandate focusing on the Nile water resources, and guided by the NBI vision.

Before we describe the proposed strategy we need to define a general framework to discuss the issue of climate change. Figure 5, taken form the IPCC, 2007 report outlines the main set of climate change processes (prediction, adaptation, mitigation, etc) taking place, within the Earth system, within the Human system, and as two way interactions between the two systems. This Figure serves as a general framework to define climate change processes.

Here, we recommend a proactive approach that addresses:

- Prediction,
- Adaptation,
- Mitigation,
- Potential opportunities, and
- Education

In recommending a *proactive* approach we seek a strategy that would consciously serve to avoid any future surprises, relative to climate change, in the Eastern Nile basin. The recommended approach is tailored to suit ENTRO: a regional organization, with a limited mandate, aligned with NBI vision

Here, we propose a *comprehensive, flexible, and low cost* strategy that has five pillars:

(2.1) Prediction of Climate Change

We need new research tools to develop:

- more relevant (e.g. how hydropower generation will be impacted?);
- more specific (e.g. what would happen to base flow?); and

- more accurate predictions that would narrow the range of uncertainty about the impact of climate change on water resources in the Nile basin

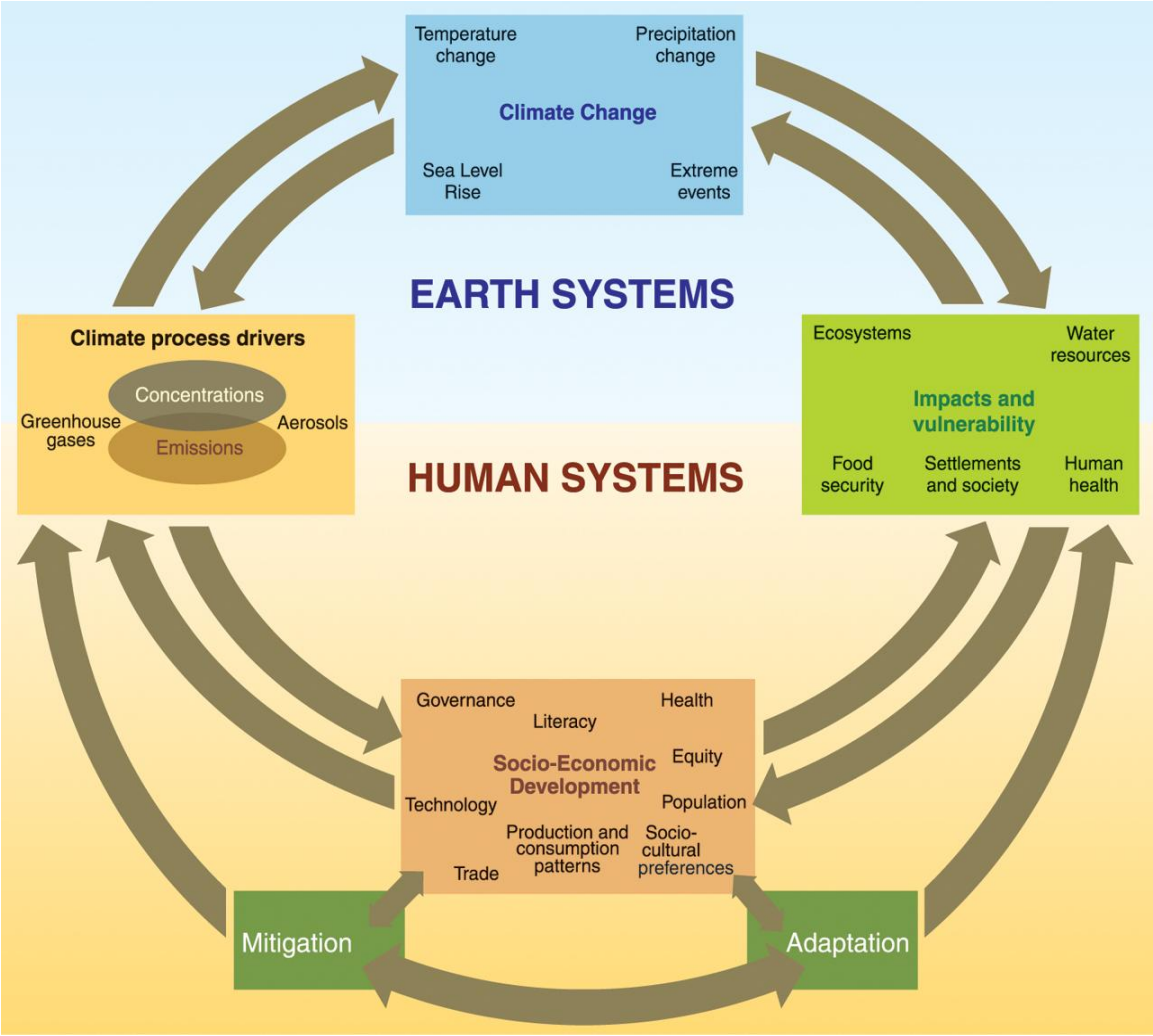


Figure 5: Climate Change and the Earth-Human System, IPCC report 2007

Some of the limitation of climate change predictions in Africa stem from the fact that the upper air observations network in Africa has a relatively poor density. There is an urgent need for enhancement of upper atmospheric observations network.

Due to their relatively coarse resolutions GCMs are more suited for studies that are carried at the global scale. They provide adequate accuracy in simulations of globally

averaged climate variables. In order to address regional climate issues, regional climate models offer better tools that can be tailored to study the impact of climate change in specific regions such as the Nile Basin. Regional climate models have finer resolutions and can be calibrated to reproduce details of the regional climate considered. Regional climate models can also be used to drive fine resolution hydrologic models for detailed impact assessment. **Here we recommend "improvement of regional predictions through local development and use of the new class of regional climate models"**

(2.2) Adaptation to Climate Change

Based on paleo-climatic evidence, migration towards (from) the Nile valley has been the main adaptation mechanism for past climate change in this region. However, with the development of modern irrigation and hydropower projects on the Nile valley, mobility of the population is increasingly constrained since these projects are located along the Nile valley.

In the short term, we propose two specific adaptation mechanisms

1. New projects planned under the umbrella of NBI/ENSAP (e.g. JMP) should incorporate the uncertainty/risk associated with climate change at early design stages. This is the best approach to avoid costly surprises later.
2. The operation and management of existing water resources projects should be revised as new knowledge about climate change becomes available.

However, in the long term, there is significant uncertainty about how the Nile river flow will respond to climate change. Both outcomes of decreased flow or increased flow are possible. Hence, we propose a *flexible* approach that addresses the two possibilities. In the event of a decreased flow, the most efficient adaptation mechanism would be to target comparable reductions in water demand. Since the agricultural sector is the main consumer of the Nile water, this demand management approach has to target reduction of water use for irrigation. Given the trends in population and economic development in the region, the objective of improving the efficiency of water use in irrigation is a desirable objective irrespective of the issue of climate change.

In order to enhance the regional capacity for adaptation to climate change, we propose development of an Eastern Nile Irrigation Management Information System (ENIIS). The proposed system consists of two components: a network of monitoring stations (~10) distributed over the basin to monitor rainfall and other variables that can be used to estimate potential evaporation; and a web based information system that links together the stations through the web and makes their data available in real time to potential users. The proposed information system should also provide recommended methodologies on how to estimate irrigation requirements based on the observed local climate and crop type. This information should be available regularly to irrigation engineers in the basin countries to assist in their efforts to minimize wasted water in irrigation schemes. The proposed system is modeled after the California Irrigation Management Information System (CIMIS). The technology used as well as the experience gained in water conservation efforts in California can be quite valuable if transferred to the Nile basin.



In the event of increased flow in the Nile, this would be a good outcome that offers opportunities for additional water use in the Nile basin. However, in order to make optimal use of this new resource, creation of additional reservoir storage capacity could be of great value for efficient management of this new source. We are not recommending building of new reservoirs in adaptation to climate change, not yet. However, there has been recently renewed interest in development of new dam projects on the Nile valley for hydropower generation and expanded irrigation. These projects will add significant storage capacity to the overall system. This added storage capacity will be of even greater value in the event of increased flow due to climate change. We are suggesting climate change as an additional reason for investment in building these new reservoirs.

Any new identified set of proposed reservoirs, and their sequencing, should be analyzed using simulation models to determine their relative performance under different future climate scenarios. The capacity of the proposed design to manage water under a wetter climate should be one of several factors that are used to guide the planning process.

Here we recommend "development of the regional capacity for <u>adaptation</u> through: (i) minimization of irrigation water losses which should help to alleviate water shortages in the event of decreased flow, and (ii) addition of new reservoir storage capacity that can be used to manage water better in the event of increased flow; "

(2.3) Mitigation of Climate Change:

Most of the emissions of greenhouse gases that cause climate change occur outside the Nile basin and Africa. Hence, Africa and the Nile basin countries would have only limited role to play in mitigation of climate change. However, it has been estimated that about 10% to 30% of the global emissions of carbon dioxide are associated with changes in land cover. Since the vegetated land surface plays a significant role in the global carbon cycle by emitting and absorbing carbon dioxide, any anthropogenic degradation of land cover should be associated with effective release of carbon dioxide into the atmosphere. Figure 6 shows the global concentration of carbon dioxide in the last three centuries. There has been significant increase in carbon dioxide concentration even before the industrial revolution, mostly due to changes in land cover over Europe and North America. This figure presents a clear evidence that changes in land cover contribute significantly to the climate change problem.

Sustainable development of the Nile basin should aim at restoration and protection of vegetation cover**. Here we recommend "limited good faith efforts in <u>mitigation</u> of climate change by combating anthropogenic deforestation and desertification in the region"**

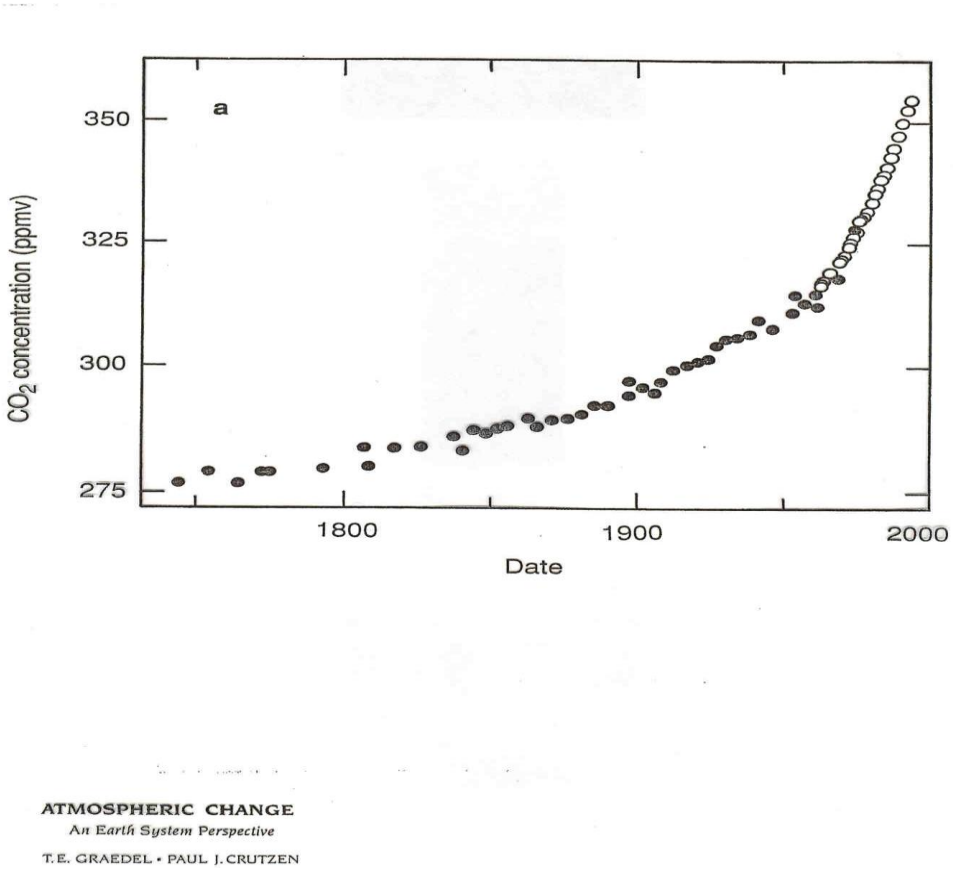


Figure 6: Global concentration of Carbon dioxide 1725-2000

(2.4) Potential Opportunities

Most water resources development projects on the Nile valley involve adding new capacity for hydropower generation. Hydropower is a clean technology with almost zero emissions. Carbon emission trading is well established in Europe. Recently, this mechanism is gaining grounds even in the US. At the international level, the Clean Development Mechanism (CDM) was established under the Kyoto Protocol. The CDM allows approved projects in developing countries to earn Certified Emission Reductions credits measured in tonnes of CO2. These CERs can then be sold to industrialized countries for use in accounting of their emission reduction targets.

A project participating in the CDM has to first be approved by a designated national authority as contributing to their sustainable development before formal registration by

the Executive Board of the CDM. The project has to establish a baseline scenario to determine emissions levels assuming that the project is not developed, and has to meet the additionality requirement which establishes that the planned reductions would not occur without the additional incentive provided by the CERs credits. Then the project has to be monitored over a pre-specified accounting period to determine the difference between actual emissions and the corresponding emissions under the baseline assumptions. This difference is then credited to the project as a CER. The CDM offers an opportunity for all the new hydropower projects on the Nile to obtain CERs. This process should be engaged at the early stages in the planning of such projects.

The role of ENTRO should focus on facilitation and capacity building at national and regional levels for:

(i) using the existing CDM structure more efficiently;

(ii) negotiation of better mechanism structure for CDM that enables better African participation in the future

In a recent development, a report commissioned by the WWF, UK environmental group, suggested that the world already had compensation deals for accidents from nuclear power, oil spills, or even objects launched into space. But there were no U.N. schemes for damage from climate change. "The likelihood of legal action against major-emitting countries is increasing". This was the conclusion of to a study of options written by two climate lawyers. Among options were an international compensation fund set up by some future U.N. treaty to compensate victims, according to the report, released on the sidelines of December 2008 U.N. talks in Poland on fighting climate change. In the long term, countries of the Nile basin should advocate and prepare to participate in any such compensation fund.

Here we recommend "vigorous pursuit of the <u>opportunities</u> available: (i) through the Clean Development Mechanism (CDM) of the Kyoto Protocol to get Certified Emission Reductions (CERs) for any new hydropower project on the Nile, and (ii) through new international compensation schemes that may be developed in the future"

(2.5) Education

The review of section 2 concluded that there is a high level of uncertainty in predictions of future climate over the Nile basin which presents tremendous opportunity for young researchers in the region. There is urgent need to motivate and inspire young minds to consider a career in research and/or policy in global change science. There is also a need to invest in training programs, and before that careful analysis to determine critical training needs. NBI training programs are positioned to play a significant role in offering education about climate change to a broad constituency of stakeholders. ENTRO can be play an enhanced role by sponsoring seminars and lecture series on the topics of sustainable development and climate change targeting young scientists, researchers, and engineers. **Here we recommend "enhanced efforts in <u>education</u>, research, and outreach to prepare the next generation of scientists, engineers, and policy makers**

who will deal with the issue of climate change as impacts become more evident and models become more accurate."

All five pillars of the proposed strategy represent objectives that would be of great benefit to society and should be pursued under all circumstances. Their relevance to climate change adds to their, otherwise sound, rational.

Appendix B

NBI/Nile Basin Initiative
Eastern Nile Technical Regional Office (ENTRO)

Terms of Reference
Climate Smart/Proof ENSAP Projects

I. Introduction

Set up on February, 1999 NBI is an institution of the ten riparian countries[1] designed to promote, on the basis of a Shared Vision, basin-wide cooperation for a coordinated, integrated and sustainable management and development of the shared Nile resources. The NBI seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits, and promote regional peace and security. The NBI started with a participatory process of dialogue among the riparian that resulted in their agreeing on a shared vision: to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources," and a Strategic Action Program to translate this vision into concrete activities and projects. The NBI's Strategic Action Program is made up of two complementary programs: the basin-wide *Shared Vision Program* to build confidence and capacity across the basin, and *Subsidiary Action Programs* to initiate concrete investments and action on the ground at sub-basin levels. The programs are reinforcing in nature. The Shared Vision Program, which focuses on building regional institutions, capacity, and trust, lays the foundation for unlocking the development potential of the Nile, which can be realized through the subsidiary action programs. These investment-oriented programs are currently under preparation in the Eastern Nile and the Nile Equatorial Lakes Regions.

The investment projects in the two regions are subsumed under two Subsidiary Action Programs: ENSAP, the Eastern Nile Subsidiary Action program and NELSAP, the Nile Equatorial Lakes Subsidiary Action Program. ENSAP and NELSAP projects are considered critical for confidence building, more so among the majority of the disadvantaged populations of the basin who live in degraded environments and whose livelihood is being increasingly threatened; suffer the impact of climatic variation and consequently food shortages; have no access to basic social and physical amenities: e.g., to electricity, safe drinking water and sanitation, health, education and transportation facilities. ENSAP and NELSAP projects are expected to demonstrate that NBI can deliver and make a difference in terms of improving the lives of the poor; particularly in achieving the Millennium Development Goals (MDGs), to which the riparian countries have committed themselves.

ENSAP seeks to realize the NBI Shared Vision for the Eastern Nile region, and is aimed at the reduction of poverty, achieve economic growth, and the reversal of environmental degradation in the EN Region. Background on ENSAP projects is given

[1] Member countries include: Burundi, DRC, Egypt, Ethiopia, Kenya, Rwanda, Tanzania and Uganda. Eritrea is an observer.

in Annex 1.

II. RATIONALE AND OBJECTIVES

2.1 Climate Change Impacts

Impacts of climate change, in combination with other drivers of global change, are compromising our ability to address global economic, security and social priorities. As floods, drought and other impacts of climate change on water become more frequent or intense, economies and livelihood security will weaken. Adapting to such impacts by building resilience is integral to addressing these global priorities. As water is at the centre of climate change impacts, this demands a focus on resilience to impacts on water. As climate change is expected to raise the number of extreme situations of flooding and drought, both in frequency and in duration, transboundary management of these water resources becomes more essential to reduce the impact of these extremes.

Half the models used in the fourth IPCC report predict an increase in precipitation while the other half predicts a decrease in precipitation. This last conclusion is significant. It points to the high level of uncertainty about the sign of the predicted change in precipitation. While global models seem to agree in predicting warming of surface temperature over this region, the same models disagree on even the sign of the predicted changes in rainfall and river flow. Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by interaction of multiple stresses, occurring at various levels, and low adaptive capacity (high confidence). Climate change will aggravate the water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress (very high confidence). Action on climate change is needed now, even as regional knowledge about climate change and variability needs to be dramatically improved. Lack of historical data, the limited number of hydromet stations, and the generally low capacity in the field are some of the related challenges, however we need to engage early while refining the knowledge on climate change and variability in the EN basin and we need to adapt to unknown risks due to climate change.

The impact of climate change on the Nile water availability is likely to have significant economic implications. A recent study conducted by a research group at MIT demonstrated that hydropower generation in the Blue Nile and the main Nile are likely to be more sensitive to changes in the low flow regime. Changes during the flooding season are less likely.

2.2 ENSAP Projects and Climate Change

ENSAP projects preparation and implementation have advanced significantly to a variable degree and the projects are at various stages ranging from identification to physical implementation. ENSAP projects have been and are being prepared at costs amounting to millions of dollars. When implemented, the costs of these projects will amount in the billions of dollars. Considering the scale of investment, it is therefore only prudent to think ahead and prepare for any potential adverse impact Climate Change might bear on these investment projects. The scale and expected costs of ENSAP projects

makes it inevitable to address climate change issues ranging from impacts such as droughts and floods to opportunities to render them as strong adaptation measures besides their original intended objectives. In addition, if unaddressed climate change impacts will dissipate gains and the benefits accrued so far.

The issue of climate change is progressing at a faster pace and therefore, components of climate change in each project need to be updated and strengthened to meet planned project objectives, enhance viability, build resilience, and make the best of the opportunities that exist. It is now becoming evident that ENSAP projects need to be "CC proofed", which is one of the rationale for commissioning this consultancy.

ENSAP projects such as ENPM can be used as a prediction tool for climate change impacts on hydrology; flood preparedness, watershed, irrigation and drainage, Baro-Akobo-Sobat, and JMP-1 can contribute significantly to the adaptation component as well as mitigation component and possibilities to mobilize resource and all the projects can be used as platforms to build capacity, raise awareness and mainstream climate change in water resources development activities.

The development of guidance and activity plan is also aiming at encouraging mutual understanding between, and within, countries as well as between technical teams and decision-makers. In a transboundary context, this understanding can best be built through emphasizing intensive cooperation on institutional issues, water resource management issues and role of environment and ecosystems in the process of climate change management as well as long-term efforts in changing human behavior and the supporting policies and political will.

To this end and based on the recently developed ENTRO's five pillar approach to climate change (Annex 2) a consultancy with the following key objectives is planned:

- To assess the climate change impacts associated with ENSAP projects and how are they addressed currently. In addition provide methodologies/guidance for addressing climate change in ENSAP project activities including modelling and downscaling options.
- To establish the practice and standardized methodology of integrating climate change issues of potential large scale water development infrastructure (climate change proofing ENSAP projects).
- To develop climate change activity plan for each ENSAP project (to integrate a Climate Change component into each ENSAP project) with a particular emphasis on improving resilience to climate change and future engagement in global carbon trade to add value for sustainable implementation of the ENSAP projects.
- To provide ENSAP projects with state of the art climate change information over the areas of interest and build capacity within the area of climate change, through literature review, recommendation of a climate change mainstreaming tools to be used and training and capacity development activities.

- To allow for new projects planned under the umbrella of NBI/ENSAP (e.g. JMP) to incorporate the uncertainty/risk associated with climate change at early design stages.

III. APPROACH AND METHODOLOGY

The overall approach is to develop, adapt and build-in Climate Change Activity Plan for ENSAP projects (to improve their resilience/adaptability to the impact of Climate Change) to strengthen the climate change component in each project. Through this action plan climate change components of each project will be weighted and commented upon, and climate change impacts on the projects will be elaborated upon and opportunities to climate proof ENSAP projects will be addressed. This work will follow to a great extent the Climate Change Approach of ENTRO.

An important aspect of the approach adopted is a systematic analysis of the climate change risks and impacts, adaptation, mitigation, capacity building and opportunities existing within the framework of climate change.

The project objectives are addressed through the following key activities:

- Review of the climate change related activities of ENSAP projects
- Identification of climate change impacts on ENSAP projects and opportunities there exist (e.g. for adaptation, mitigation, carbon trade, etc.).
- Development of an activity/implementation plan to strengthen climate change component of each ENSAP project
- Training, dissemination, and capacity development

IV. Consultancy Scope and Tasks

In line with the developed ENTRO Climate Change Approach, come up with a short term ENTRO climate change strategy by undergoing detailed activity as follows:

1. Discuss the major typologies and likelihood of climate change impacts on ENSAP projects, including impact on key environmental and social background variables on which ENSAP projects are contextualized/situated (e.g. climate change induced land degradation; river flow regime characteristics change; ecosystem and habitat loss; CC-change induced social conflicts e.g. natural resource based including water stress related, migration related conflicts, etc.). Review existing information to assess and analyze the current environmental stress and issues that aggravate the impacts of climate change in the EN basin in relation to ENSAP projects.
2. Identify priority information needs that can better prepare the decision makers for reaching informed decisions related to climate change impacts on ENSAP projects.
3. Assess ENSAP projects in terms of their readiness to address relevant climate change issues:
    a. Develop assessment criteria
    b. Weigh projects against criteria



   c. Rate projects climate change relevance and categorize as adaptation, mitigation, etc. as per the approach pillars and
   d. How ENSAP projects fits within the NAMA's, NAPA's and other international, regional and national strategies and initiatives.
4. Comment on climate change resilience of ENSAP projects
   a. Review climate proof strategies and techniques used/adopted in similar and relevant projects internationally (such as risk assessments etc.). Provide copies of new publications, documents, and websites of interest.
   b. Briefly present the status of climate change components in ENSAP projects.
   c. Comment on currently in use approaches and elaborate on possible alternative approaches.
5. List and describe in detail opportunities to strengthen climate change components in ENSAP projects (by project) and create synergies between projects.
   a. Also identify capacity building needs, including target groups to enhance awareness on climate change impacts, adaptations and mitigation measures.
   b. Develop a tool/methodology to determine ENSAP projects carbon foot-print.
   c. Potential opportunities associated with new climate change funds will be explored towards enhancement of existing ENTRO projects or development of new climate change driven projects. This effort shall be started during this assignment at a preliminary level, with the potential for more significant follow-up efforts.
6. Outline key activities and prepare action plan to strengthen climate change components in ENSAP projects and to promote climate proof development concepts. The key activities shall be categorized into project activities, program activities, and global activities and linkages
7. Estimate costs and identify potential partners/donors to team up with
8. Investigate institutional arrangements within the countries and identify policy niches.
9. Prepare and conduct a regional dissemination workshop with day-1 involving high level decision makers and partners/donors to discuss cooperation opportunities, day-2 dedicated to project coordinators to discuss detailed activities, day-3 to strengthen countries, and facilitate support.

V. Consultancy Outputs

The main outputs shall include: (i) Inception Report defining the consultants approach and deadlines in hard and soft copies (ii) Draft Final Report detailing main consultancy work in hard and soft copies; (iii) Regional workshop to present the key findings to regional audience to solicit comments and incorporate comments and remarks in the final report. This regional workshop is also targeted towards development partners who can support the developed activity plan. ENTRO will make the necessary arrangements to hold this workshop; and (iv) Final Report incorporating comments and remarks from the Regional Workshop.

VI. Consultant Qualifications

The consultant shall hold a minimum of *MSc.* in hydro-climatology, environmental engineering science, or related field. The consultant is expected to have extensive (a minimum of 10-year) practical experience addressing hydrology and climatic issues and familiar with ENSAP projects. The consultant should also be conversant in the latest approaches to addressing environmental and broader sustainability issues in the context of large infrastructure projects context.

VII. Consultant Supervision

The consultancy will work closely with ENTRO-WRPU, mainly the environment management specialist and consult with the senior technical and projects coordinators. The consultant will regularly communicate and work closely with the environment management specialist and seek clarifications or further guidance, as needed, during the course of the work. During the inception the consultant is expected to spend time as necessary at ENTRO to consult with the water resources development unit staff.

VIII. Reporting Requirement.

Deliverables and Time Lines: The time lines for delivering the various outputs are given below:

Reporting Requirement	**Time from Signing the contract**	
Inception	Four weeks	
Draft final report	12 weeks	
Consultative dissemination workshop	14 weeks	
Final report	16 weeks	
Total		

IX. Level of Effort and Approximate Budget

40-50 days over maximum of five month period. The Consultants are expected to start in April, 2010 and to complete the assignment by end of August, 2010. The consultant shall submit a complete financial offer including consultancy fees, workshop fees, and reimbursables including airfares accommodation etc.

Appendix C

Approach in Conducting this Study

The approach of this study includes five main tasks:

(1) Meetings, consultation, engagement with the Regional Project Coordinators of the ENSAP project to solicit their views and inputs about how climate change activity can be integrated into the different projects. The motivation here is to accommodate a bottom-up input to the formulation and conclusions of this study. Such approach is likely to facilitate implementation of any recommendations that may result from this study. This task has been accomplished during a trip by the Consultant to Addis Ababa in the period 7th, 8th, and 9th of April 2010.

(2) Review of all relevant ENTRO supplied documents and presentations that describe the ENSAP projects. This information will be important for the analysis proposed as part of the methodology described in section 2 of this document.

(3) Literature review of published books and articles that are relevant to the subject of this study. Of particular interest is identification and utilization of experiences in other regions of the world on how climate change issues have been incorporated into the agenda of water resources development projects and river basin management organizations.

(4) Application of the methodology of Figure 1 to the ENSAP projects listed in Table 1, following the four outlined steps and resulting in the design of a specific climate change component for each ENSAP project, and a proposal of a specific set of "Climate Smart" initiatives.

(5) Organization of a regional workshop in August of 2010 to present the findings of this study to the climate change and water resources experts and to the policy makers from the Eastern Nile countries as well as representatives of funding and development agencies. We will solicit feedback from participants for incorporation into the final report.

Appendix D

Relevant International Experiences

Mainstreaming Climate Change in Integrated Water Resources Management in Pangani River Basin Project Components: (A UNDP Project, Kenya, from web site cited above)

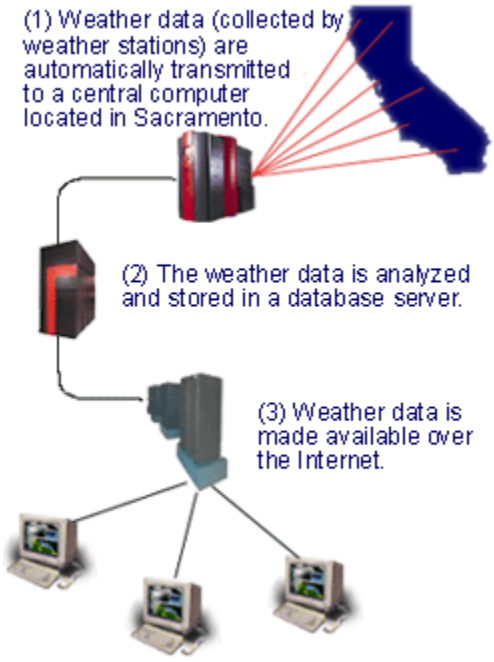
Specific actions include:

(1) conducting an assessment of water flows for the Pangani River;
(2) training 10 technicians to understand climate change implications for river flow;
(3) establishing a catchment forum to discuss water management and other stakeholder management forums to build awareness and political will to resolve conflicts;
(4) promoting basin-level participation in national climate change and water management; and
(5) developing and disseminating awareness materials on the implications of climate change and various likely river flow scenarios among local authorities, decision makers, communities and the private sector.

Expected Outputs:
Outputs: Management and allocation of water in Pangani Basin includes climate change preparation and adaptation and environmental considerations in a sound Integrated Water Resource Management (IWRM) framework

California Irrigation Management Information System (CIMIS) (developed by California Department of Water Resources, and University of California, Davis, taken from CIMIS web site cited above)

CIMIS Overview
The California Irrigation Management Information System (CIMIS) is a program of the Office of Water Use Efficiency (OWUE), California Department of Water Resources (DWR) that manages a network of over 120 automated weather stations in the state of California. CIMIS was developed in 1982 by DWR and the University of California,
Davis to assist irrigators in managing their water resources efficiently. Efficient use of water resources benefits Californians by saving water, energy, and money.



Data Collection and Transmission

CIMIS weather stations collect weather data on a minute-by-minute basis, calculate hourly and daily values and store them in the dataloggers. A computer at the DWR headquarters in Sacramento calls every station starting at midnight Pacific Standard Time (PST) and retrieves each day's data.

In case of a communication problem between the central computer and a given station, the computer skips that station and calls the next station. After all other stations have reported the polling computer comes back to the station with a communication problem trying to establish a connection at predetermined time intervals. The interrogation continues into the next day until all of the station data have been transmitted.

Data Processing

Once the data is transmitted, the central computer analyzes it for quality, calculates reference evapotranspiration (ETo - for grass reference and ETr - for alfalfa) and other intermediate parameters, flags the data (if necessary), and stores them in the CIMIS database. Evapotranspiration (ET) is a loss of water to the atmosphere by the combined processes of evaporation from soil and plant surfaces and transpiration from plants. Reference evapotranspiration is the loss of water from standardized grass or alfalfa surfaces over which the stations are sitting. Irrigators have to use crop factors, known as crop coefficients, to convert ETo/ETr into an actual evapotranspiration (ETc) by a specific plant.

Since most of the CIMIS stations are sitting on standardized grass surfaces, reference evapotranspiration is commonly referred to as "ETo" in this web site. However, it is

worth mentioning that a few CIMIS stations are sited on standardized alfalfa surfaces and therefore evapotranspiration from such surfaces is referred to as ETr.

Data Retrieval

Estimated parameters (such as ETo, net radiation (Rn), dew point temperature, etc.) and measured parameters (such as solar radiation (Rs), air temperature (T), relative humidity (RH), wind speed (u), etc.) are stored in the CIMIS database for unlimited free access by registered CIMIS data users. In the past, users were accessing the CIMIS database via the dial-up and telnet systems. CIMIS then developed an older version of its current web site, during which time users were able to access the database using the dial-up, telnet, and/or the web systems. Once the web site became fully functional, the dialup and telnet options were terminated. Currently, the web system is the only platform for retrieving the CIMIS data. In addition to the web, CIMIS developed an ftp site for those interested in automated access of the data. However, the ftp site only provides daily data for the previous 7 days and monthly data for the previous 12 months. Also available at the ftp site is one year's worth of rolling daily ETo data. This means that the beginning and ending dates of this data advance forward by one day everyday.

Selecting Representative Stations

The CIMIS weather stations are randomly distributed throughout the State of California. It is very important that the selected station represents the same microclimate as the area of interest. Some resources available to assist you in this regard include the CIMIS web site, local water districts, farm advisors, consultants, and CIMIS staff.

Contact information for CIMIS staff at the Sacramento headquarters and the DWR districts are provided in the CIMIS Staff link on the Home Page. Questions regarding the selection of a CIMIS station, installation of new station, missing data, and/or information on how to use the data can be directed to the CIMIS staff in your DWR district. There are four DWR districts in California. To find out in which district your County lies, click here, for district location maps. If you have problems contacting the CIMIS staff in your district, you can Contact Us at headquarters in Sacramento

Trends in CIMIS Data Users

Although CIMIS was initially designed to help agricultural growers and turf managers administering parks, golf courses and other landscapes to develop water budgets for determining when to irrigate and how much water to apply, the user base has expanded over the years. In addition to those mentioned above, current CIMIS data users include local water agencies, fire fighters, air control board, pest control managers, university researchers, school teachers and students, construction engineers, consultants, hydrologists, state and federal agencies, utilities, lawyers, weather agencies, and many more.

The number of registered CIMIS data users has also been growing steadily over the years. Currently, there are over 6000 registered CIMIS data users. It is worth mentioning here that this number reflects only those that are primary users of the CIMIS data. It has been established that many users get the CIMIS data from these primary users for various



uses. Examples include local water districts and consultants providing the CIMIS data to their clients. Therefore, there are secondary and tertiary CIMIS data users that have not been accounted for by the figure presented here.

An Observatory for Environment and Sustainable Development of Senegal River Basin (developed by Organization for the Development of Senegal River, based on web site cited above**)**

The Organization for the Development of Senegal River is an integrated cooperation institution between riparian States (Senegal, Mali, Mauritania, and Guinea) for coordinating the development of Senegal River Basin, «with everyone, for everyone»

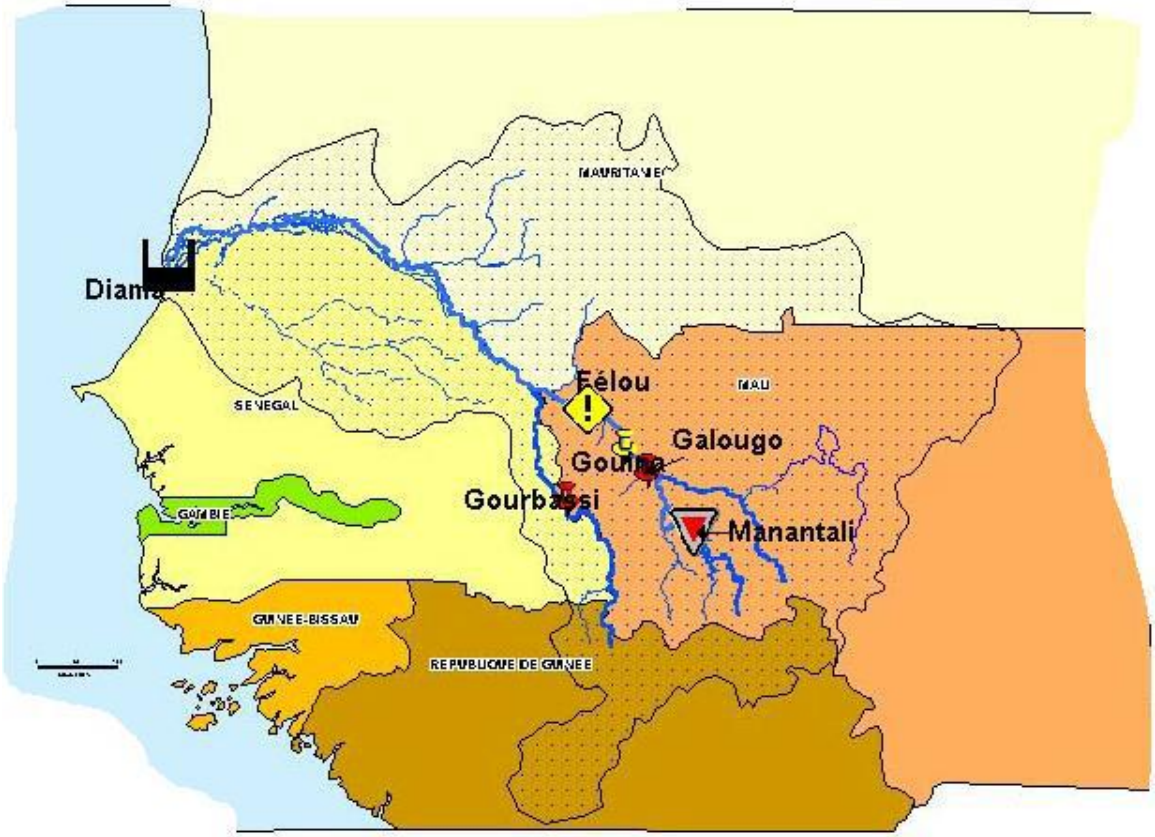
The two last decades the Senegal basin have seen important modifications,with the building of two major dams (Manantali and Diama) and the related developments (dykes, agriculture developments, nationalparks…)Those modifications have led to significant improvements (socio-economic aspects). However, environmental and sanitary assessments have also shown some negative impacts, which are not easily described or quantified. In order to cover these data gaps and limits, the Observatory was set-up in 2000.

The mission of the observatory is:

(1) Reducing riparian states economic vulnerability against hydrologic and climatic risks;
(2) Ensuring conditions for food security for basin populations;
(3) Enhancing economic development by fostering cooperative use of basin opportunities ;
(4) Preserving the overall balance of the hydrologic system;
(5) Securing and enhancing incomes of populations

The main objective of the Observatory for Environment and Sustainable Development Senegal River Basin is too monitor the evolution of the state of environment and natural resources in the Basin, in order to provide member states with necessary information for assessing impacts of infrastructures and to implement actions for limiting them. The observatory was set up in 2000 to carry the following functions:

(1) Organize data collection and processing for systematic environment monitoring;
(2) Process gathered information and produce relevant indicators;
(3) Ensure dissemination of the information;
(4) Analyze the information and detect situations requiring actions by decision-makers;
(5) Propose a framework for participation and consensus building in order to develop measures required to address any negative impacts


Diama
MAURITANIE
SENEGAL
Félou
MALI
Galougo
Gourbassi
Manantali
GUINEE-BISSAU
REPUBLIQUE DE GUINEE