GEF

Global Environment Facility

Mohamed T. El-Ashry
Chief Executive Officer
and Chairman

1818 H Street, NW
Washington, DC 20433 USA
Tel: 202.473.3202
Fax: 202.522.3240/3245
Email: melashry@worldbank.org

November 21, 2001

Dear Council Member:

I am writing to notify you that we have today posted in the GEF's website at www.gefweb.org, a medium-sized project proposal from World Bank entitled ***Regional (Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Nigeria, Senegal, South Africa, Zambia, Zimbabwe): Climate, Water and Agriculture: Impacts on and Adaptation of Agro-Ecological Systems in Africa Africa Targeted Research.*** The GEF will contribute $700,000 towards a total cost of $1,320,000.

Agriculture, agro-ecological systems and social aspects are the most vulnerable and important sectors in African countries with respect to climate change. They are especially vulnerable because the present environmental conditions of these countries are already compromised by land degradation, adverse climate conditions and social problems. Using sample countries from the African continent, the targeted research intends to provide both national and regional understanding on the nature of the impact of climate change or variability on agro-ecological systems and possible adaptation.

The project proposal is being posted for your information. We would welcome any comments you may wish to provide by **December 14, 2001**, in accordance with the procedures approved by the Council.

If you do not have access to the Web, you may request the local field office of the World Bank or UNDP to download the document for you. Alternatively, you may request a copy of the document from the Secretariat. If you make such a request, please confirm for us your current mailing address.

Sincerely,

Mohamed T. El-Ashry
Chief Executive Officer
and Chairman

THE WORLD BANK/IFC/M.I.G.A.

OFFICE MEMORANDUM

DATE: September 13, 2001

TO: Mr. Kenneth King, Assistant CEO,
GEF PROGRAM COORDINATION

FROM: Lars Vidaeus, GEF Executive Coordinator

EXTENSION: 3-4188

SUBJECT: **Regional: Climate, Water and Agriculture: Impacts on and Adaptation of Agro-Ecological Systems in Africa**
Submission for GEF MSP for GEF Secretariat Review

1. Please find attached the Project Brief for the above-mentioned targeted research Medium-Sized Grant. The project has been endorsed by GEF national operational focal points (Endorsement letters from 9 countries are attached).

2. In accordance with operational guidance for approval of Medium-Sized Projects, we are submitting this project brief to the GEF Secretariat for action by the Chief Executive Officer (CEO). We are simultaneously circulating copies to UNDP/GEF, UNEP/GEF, STAP for comments within 15 working days, or by October 3, 2001.

3. We look forward to receiving the GEF Secretariat's guidance on the next processing steps for this Medium Size Project by October 17, 2001, particularly with respect to procedures for review of targeted research proposals. Thank you and best regards.

Copies:
E. Torres, UNDP
A. Djoghlaf, UNEP (Nairobi)
K. Elliott, UNEP (Washington, DC)
M. Gadgil, STAP
M. Griffith, STAP Secretariat (Nairobi)

Messrs./Mmes. S. Ganguly, A. Dinar (RDV); A. Kiss, C. Crepin, (AFTES); R. Khanna, D. Aryal (ENV); ENVGC ISC**;** Relevant Regional Files

Medium-Sized Project Brief

Targeted Research Proposal:
Impacts on and Adaptation of Agro-Ecological Systems in Africa

<table>
<tr><th colspan="2">PROJECT IDENTIFIERS</th></tr>
<tr><td>1.Project name: Climate, Water and Agriculture: Impacts on and Adaptation of Agro-Ecological Systems in Africa</td><td>2. GEF Implementing Agency: The World Bank</td></tr>
<tr><td>3. Country or countries in which the project is being implemented: Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, Zambia, Zimbabwe. In three of these countries, namely Cameroon, Kenya and Zimbabwe, the project costs will not include GEF funding but other sources.</td><td>4. Country eligibility:
<u>Country</u> — <u>Ratification date</u>
Burkina Faso — 02/09/93
Egypt — 05/12/94
Ethiopia — 05/04/94
Ghana — 06/09/95
Níger — 25/07/95
Senegal — 17/10/94
South Africa — 08/29/97
Zambia — 05/28/93</td></tr>
<tr><td>5. GEF focal area(s): Climate Change and Biodiversity.</td><td>6. Operational program/short-term measure:

The already unsustainable pressure on natural habitat and biological resources from agricultural practices is expected to increase with climate change as a result of the predicted decline in agricultural yields due to global warming. This is particularly of high concern in the developing world and especially Africa (worse starting conditions, weak adaptability and limited adaptation options for African farmers and agricultural production systems—see also in Project rationale and Annex B). Basically, reduced yields will place more pressure and higher demand for more conversion of lands, extraction of water supply sources for irrigation, introduction of more new exotic plant and animal species, more intensive use of chemical inputs and hence pollution and environmental damage, erosion, etc. seriously accelerating biodiversity loss and extinction.
This Targeted Research project relates to</td></tr>
</table>

	impact of climate change on agro-ecological systems, cross cutting window for OP12 on Integrated Ecosystem Management Conservation and OP13 on Sustainable Use of Biological Diversity Important to Agriculture. *The project will assist Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, Zambia and Zimbabwe establish their current assessment of the economic impact of climate change on their agriculture sectors and determine the economic value of various adaptation interventions. In addition, The research project will allow extrapolation of similar assessment to countries not included in the sample. In doing so the targeted research will develop a generic tool which can be applied to countries in other continents.* *The methodology developed in the targeted research project will allow at the country level to:* *(i) improve national assessment methodologies of impact of climate change and effectiveness of adaptation in agro-ecological systems management and uses.* *(ii) help policy makers and government agencies evaluate intervention policies.* *From an operational point of view the methodology will :* *(i) provide with tools for quantitative, predictive assessment of potential impact on the agro-ecological systems and related activities.* *(ii) complement and amend the IPCC process by providing a more country /sector focused assessment of both the impact and the effectiveness of adaptation, which is currently insufficiently developed, and* *(iii) Establish regional capacity at both scientific and policy levels for further extension of the methodology into other sub-sectors in the sample countries and other countries that are not included in the sample. Further more, use the capacity that will result from the targeted research project to develop similar work in other continents*

	(e.g., Latin America).

7. Project linkage to national priorities, action plans, and programs: A*griculture and agro-ecological systems are the most vulnerable and important sectors in African countries. They are especially vulnerable because the climates of many of these countries are already too hot. Further warming is consequently expected to reduce crop productivity adversely. Agriculture and agro-ecological systems are especially prominent in the economies of African countries and have been identified as first priority in national and regional (e.g., SADC, IFAD) action plans, such as Southern African Biodiversity Support Program. In particular, National communications of Egypt (the SNAP project), Ghana (the Netherlands Climate Change Studies Assistance Program); Niger (Impact du Changement Climatique sur l'Agriculture en Afrique); Senegal (the ENERBAT project); Zambia (The Pilot Environmental Fund of the Environmental Support Programme) mention the on-going and proposed work needed to better understand likely impact of climate change on the agriculture and water sectors; and Zimbabwe (Minimum Tillage Project) mention the on-going and proposed work needed to better understand likely impact of climate change on the agriculture and water sectors.*

8. GEF national operational focal point and date of country endorsement:
Burkina Faso: Mr. Kambou Jean Baptiste, Technical Adviser to the Ministry of Environment and Water, and GEF Focal Point, (8/4/00).
Cameron: Ms. Mane OKOTIKO Catherine Ministry of Environment and Forestry, Department of Wildlife and Protected Areas, and GEF Focal Point, (9/2/00).
Egypt: Dr. Ibrahim Abdel Gelil, CEO, Egyptian Environmental Affairs Agency, Ministry of Environment and Natural Resources, and GEF focal Point, (5/1/01)
Ethiopia: Dr. Tewolde Egziabher, General Manager, Ethiopian Environmental Protection Agency (EEPA), and GEF Focal Point, (2/21/01).
Ghana: Mr. E. P. D. Barnes, Chief Director, Ministry of Environment, Science and Technology, and GEF Focal Point, (9/25/00).
Niger: Mr. Oumarou el Hadj, General Secretary to the Ministry of Planning and GEF Focal Point (7/12/00) and Mr. Sala Assane Amadou, President of CNEDD and GEF Focal Point (date not identified).
Senegal: Ms. Fatima Dia Toure, Le Directeur and Focal Point, Direction de l'Environnment et des Etablissements classés, Ministere de l'Envionnment, Dakar, Senegal (6/27/00)
South Africa: Dr. Crispian Olver, Director General, Department of Environmental Affairs and Tourism, and GEF Focal Point, (11/13/00).
Zambia: Lubinda M. Aongola, Director, Planning and Information Department & GEF Operational Focal Point (9/21/00).

PROJECT OBJECTIVES AND ACTIVITIES

9. Project Rationale and Objectives: *Agriculture and agro-ecological systems are the most vulnerable and important sectors in African countries. They are especially vulnerable because the climates of many of these countries are already too hot. Further warming is consequently expected to reduce crop productivity adversely. Agriculture and agro-ecological systems are especially prominent in the economies of African countries, and therefore these countries have a special interest in the project. Using sample countries from the African continent, the targeted research will provide both national and regional understanding on the nature of the impact of climate change on the agricultural sector and possible adaptation.*

The main goal of the project is to develop multipliable analytical methods and procedures for assessing the impact of climate change on agriculture in Africa, to estimate how climate affects the current agricultural systems, and to project how climate change might affect this system in the future.

***Relationship of the GEF financed activities to the baseline or co-financed activities**:*

As can be realized from Annex A-2, there are many localized activities that collect data and evaluate impact of climate change on performance of specific crops in particular locations. The information collected in such activities will be used in the targeted research to implement the proposed methodology. The GEF input will be fundamental in demonstrating the integration and the use of the existing data and information for intervention activities and policy decisions at the country and regional levels.

Objectives:	Indicators:
(a) Conduct national level economic analyses of impact and adaptation.	*(a) National-level analyses of CC impact on the Agricultural sector and adaptation alternatives. Results presented in workshops and reports and based on sound analytical work.*
(b) Conduct cross-national analysis and extrapolate results to countries not included in the sample.	*(b) Regional-level analysis of CC impact on the Agricultural sector and local and regional adaptation alternatives extrapolated to the sample countries and to countries outside the sample. Results presented in workshops and reports and based on sound analytical work.*
(c) Include water supply in the analysis.	*(c) A working hydrological model provides input to economic analyses.*
(d) Enhance the capacity of country experts.	*(d) All national-level work conducted by country teams. Graduate students (where applicable) complete their thesis research.*
(e) Facilitate an intra-country exchange of findings and policy alternatives, among various levels of decision makers from each country.	*(e) Annual regional workshops, of the study teams and policy makers and government officials for exchange of results and deliberation over policy options.*
(f) Develop inter-country exchanges between all the country teams participating in the project.	*(f) Full use of a Learning and Knowledge Sharing Network (LKSN) between teams' members, and involving scientists from*

	countries other than the study sample. Full exchange of data, findings and methodologies among country teams.
10. Project outcomes: *(a) National and regional benefits of understanding the impacts of CC on the agricultural sector.* *(b) National and regional benefits from understanding the performance of various adaptation measures in response to impacts of CC on the agricultural sector.* *(c) Data bases and models to predict CC impact and adaptation.* *(d) Full country dialogue on climate change impact on and adaptation to by the agricultural sector.* *(e) Building expertise in the sample countries*	Indicators: *(a) Quantitative measures of impacts of climate change on the agricultural sector under various conditions.* *(b) Quantitative measures of adaptation to climate change in the agricultural sector under various conditions.* *(c) Website and reports including national climate data and full documentation of the analytical procedures.* *(d) Experts, policy makers, and planners involved in policy discussions at national level, in preparing national action plans.* *(e) Completion thesis by graduate students working as part of the national teams.*
11. Project activities to achieve outcomes (including cost in USD of each activity): *(a) Data collection and analysis of baseline climate change impact and adaptation (Cross section model, FAO agro-ecological zones model, Hydrological model): Between 9-11 national teams, collecting baseline climatic data and agricultural production data for various regions in each sample country. Comparing between "FAO" and the Cross sectional model, and producing a climate sensitivity surface for the individual countries and the region.* *Cost: $480,000* *(b) Analysis of future climate scenarios and effective adaptation measures (Cross section model, Hydrological model): Using GCM results and hydrological model output, several future climate scenarios will be incorporated into the climate sensitivity surface (national and regional) to allow evaluation of policy intervention aimed at producing sustainable adaptation measures.*	Indicators: *(a) Quantitative estimates at district level in each country of relationship between agricultural performance and various climatic variables (e.g., rainfall and temperature).* (*b) Spatial (district-level) representation of the impact of climate change on agricultural performance, for the various climate scenarios. Prioritization of various policy interventions resulting in a set of adaptation measures, for various conditions.*

Cost: $290,000 *(c) <u>Workshops, Reporting and Dissemination</u>: Regional and international interactions between economists, scientists, policy makers and government officials, learning material, national reports and regional report.* *Cost: $550,000*	*(c) One workshop per year (in the first two years) for feedback and exchange of experience and interim results (including all national team members, policy makers and relevant government officials from the sample countries). And one concluding conference to disseminate and deliberate the results between regional and international experts and policy makers. Preparation of learning material for the workshops, including background papers, interim reports and final reports, and policy briefs per country and on a regional basis.*

12. Estimated budget (in US$):

Co-financing for base line:	***$80,000***
The countries involved (in kind)	*$80,000*
Co-Financing for increment:	***$540,000***
IAMZ (in kind)	*$40,000*
U.S. Farm Foundation	*$10,000*
Trust Fund	*$390,000*
The countries involved (in kind)	*$100,000*
GEF:	***$700,000***
Total:	***$1,320,000***

INFORMATION ON INSTITUTION SUBMITTING PROJECT BRIEF

13. Information on Project Proposer:

CHIEAM/IAMZ (Institute for Advanced Agricultural Studies), Zaragoza, Spain is a leading research and educational institute on agriculture, water and climate change in the Mediterranean basin. Being part of a network of 5 institutes, IAMZ has contributed to both the understanding of impact of climate change on agriculture and to the policy dialogue in the Mediterranean and North African countries. IAMZ has built up ties to numerous countries in the developing world through its research and teaching, and especially training of policy makers and government officials in many countries, including African countries. Responsibility for the monitoring and evaluation will be taken by CHIEAM/IAMZ for dates of submission of reports; by the Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria, South Africa, for the quality of the data and the analysis; and by ACMAD/AGRYMET for the learning material, and workshop schedule.

14. Information on executing agency (if different than project proposer):
IAMZ Institute for Advanced Agricultural Studies (Zaragoza, Spain) in collaboration with (1) Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria (Pretoria, South Africa) for overseeing the data collection and analysis component at the national level, and (2) ACMAD/AGRYMET (Niamey, Niger) for workshops and the knowledge sharing component.
CEEPA is a well established Center that, in addition to many other scientific research activities in environmental economics, including climate change and natural resources, deals also with regional activities that bring together policy makers, government officials, NGO representatives, and private sector. It has a very good quantitative research and teaching capacity, which will be used in the proposed project.
ACMAD/AGRYMET is also a world wide known institute of research and dissemination of whether related work. It has very strong bonds in all African countries, and it benefits from support and collaboration with NOAA in the USA.

INFORMATION TO BE COMPLETED BY IMPLEMENTING AGENCY

15. Implementing agency contact person: (1) *Christophe Crepin, GEF coordinator, Africa Region, The World Bank, 1818 H St NW, Washington, DC, Phone: +1 202 473 9727, Fax: +1 202 614 0893, Email: ccrepin@worldbank.org*, (2) *Ariel Dinar, Rural Development Department, World Bank, phone: +1 202 473 0434, fax: +1 202 614 0793, email: adinar@worldbank.org* (3) *Arne Dalfelt, World Bank AFTE1 202 458 9195 adalfelt@worldbank.org* (4) *Patrick Verissimo, World Bank WBIEN 202 458 0703 pverissimo@worldbank.org*

16. Project linkage to Implementing Agency program(s): *Project fits with WB focus on agriculture and rural development and agricultural bio-diversity in the context of vulnerability to climate change impact, country CASs, Rural development strategies, and NRM and Environmental projects and strategies.*

Medium-Sized Project Brief

Targeted Research Proposal:
Impacts on and Adaptation of Agro-Ecological Systems in Africa

Table of contents

Project Description 9
Incremental Cost Matrix 16
Budget 17
Implementation Plan 18
Public Involvement Plan 18
Monitoring and Evaluation Plan 19
References 20
Annex A: Research Methodologies 23
Annex A-2: Inventory of climate, Water and Agro-ecology data bases 32
Annex A-3: The Proposed Teams for the Targeted Research 35
Annex B: Explain How the Results Contribute to the Objectives of Existing Operational Programs, or the Assessment of Potential Need for New Operational Programs 36
Annex C: Establish the Instrumentality by Describing the Baseline for Relevant Research 38

PROJECT DESCRIPTION

Project Rationale and Objectives

While the introduction of organized agricultural production systems required conversion of natural habitat into controlled and managed cultivation systems, concerns about the impact of this transformation on ecosystems health and biological diversity on earth were not high during the times of natural abundance. As human demands continued to steadily grow with population expansions bringing more and more natural habitat and other resources under managed cultivation of food and fiber and animal feeding systems, the consequences for ecosystems functioning and impacts on biodiversity reached serious levels. Conversion of natural forest, wetland and grassland into crop or livestock grazing lands is the major cause of habitat destruction and extinction of animal and plant species. Habitat alteration and conversion through removal of forest cover, draining of wetlands or damming of fresh surface water courses are the main causes of biodiversity loss. Moreover, introduction of new and exotic species of plants and animals in pursuit of higher productivity is another important factor leading to biodiversity loss and extinction. On top of that, the use of inputs such as chemical fertilizers, pesticides, irrigation and heavy mechanization are also important causes of water quality degradation, species loss and disruption of the natural functioning of ecosystems. At the same time direct harvesting of various ecosystems goods and services (G&S) and natural resources for human survival and economic use reached unsustainable levels in many parts of the world, and especially in Africa, in absence of clearly defined and well established property rights leading to rapid depletion and erosion of nature's capacity to provide the same levels of G&S, of which biodiversity is a crucial one. This in addition to various national development strategies geared towards increased agricultural production and food security policies that distorted the structure of economic incentives in favor of environmentally degrading farming methods and technologies.

The pressure on natural habitat and biological resources from agricultural practices is expected to increase with climate change as a result of the predicted decline in agricultural yields due to global warming. This is particularly of high concern in the developing world and especially Africa (worse starting conditions, weak adaptability and limited adaptation options for African farmers and agricultural production systems, as will be elaborated later). Basically, reduced yields will place more pressure and higher demand for more conversion of lands, extraction of water supply sources for irrigation, introduction of more new exotic plant and animal species, more intensive use of chemical inputs and hence pollution and environmental damage, erosion, etc. seriously accelerating biodiversity loss and extinction.

Analysis of the impacts of climate change suggests that agriculture and agro-ecological systems (AAES) are the most vulnerable and important sectors. Agriculture in low latitude developing countries is expected to be especially vulnerable because the climates of many of these countries are already too hot. Further warming is consequently expected to reduce crop productivity adversely. These effects are exacerbated by the fact that agriculture and agro-ecological systems are especially prominent in the economies of African countries and the systems tend to be less capital and technology intensive. Pre-

dictions of impacts across regions consequently suggest large damages in the agricultural systems of low-latitude (mostly, developing) countries.

Despite these predictions, only a few studies have been conducted in low latitude countries. There have been limited agronomic studies conducted in field stations scattered across these countries (Reilly et al 1996). In addition, only a few published economic studies have been done of the climate sensitivity of developing country agriculture and agro-ecological systems (Rosenzweig and Parry, 1994 of the world; Dinar et al. 1998 of India; Sanghi, 1998 of Brazil, Ouedraogo, 1999 of Morocco, and Balti, 2001 of Tunis).

A comparison between the climate sensitivity of the agricultural sector in developed and developing countries (Mendelsohn, Dinar and Sanghi, 2001) suggests higher sensitivity and lower adaptation flexibility for the latter countries. The problem is expected to be most severe in Africa where current information is the poorest,[1] technological change has been the slowest, and the domestic economies depend most heavily on agriculture. African farmers are used to a certain amount of adaptation to climate variability, but climate worsening may well force large regions of marginal agriculture out of production in Africa (Mendelsohn, Dinar and Dalfelt, 2000; This document is attached to the proposal). This project consequently focuses on the agricultural sector of Africa.

Even without climate change, there are serious concerns about agriculture in Africa because of water supply variability, soil degradation, and recurring drought events. Experts are concerned that the agriculture sector in Africa will be especially sensitive to future climate change and variability. The current climate is already marginal with respect to precipitation in many parts of Africa. Further warming in these semi-arid locations is likely to be devastating to agriculture there. Even in the moist tropics, increased heat is expected to reduce crop yields. Agronomic studies suggest that yields could fall quite dramatically in the absence of costly adaptation measures. The current farming technology is basic, and incomes low, suggesting that farmers will have few options to adapt. Presently, public infrastructure such as roads, long-term weather forecasts, and agricultural research and extension are inadequate to secure adequate adaptation.

The main goal of the proposed project is to support the OP12 on Integrated Ecosystem Management and the OP13 on Sustainable Use of Biological Diversity Important to Agriculture by developing multipliable analytical methods and procedures for assessing the impact of climate change on agriculture in Africa, to estimate how climate affects the current agricultural system, and to project how climate change might affect this system in the future. The project intends to develop suitable plans for adaptation, working closely with policy makers in the interpretation process.

The analysis will compare farmer decisions and outcomes in one climate zone against choices farmers make in other zones. The study will introduce several innovations. First, this study will attempt to include water supply in the analysis. Second, this study will attempt to conduct cross-national analyses for the first time. Existing analytical technique will have to be modified to include both of these innovations.

[1] Many programs have been conducted in African countries, which produced valuable information. This information was not fully realized. For a list of many of the projects, see Annex A-2. For an interim literature review see an attached document.

The project also pursues the following interrelated secondary objectives. First, it will enhance capacity on the African continent by conducting training activities that enable African experts to run country studies on the effects of climate change on agriculture.[2] Secondly, the project will help experts in Africa to apply these analytical concepts to measure the expected adverse impacts on agriculture, and to identify what adaptation measures are likely to be sustainable cost-effective countermeasures in their country. Thirdly, the data generated by the project will be used for a regional analysis that will be extrapolated to surrounding countries not in the database. Finally, the project will generate results relevant for the design of policies for sustainable development in the rural sector at a country level, as well as for the Africa region as a whole.

Each of the country teams (see Annex A-3 for list of country experts on board) will help collect the data, perform the research work, and develop the policy implications. The project will consequently achieve the following objectives: (a) enhance the capacity of country experts; (b) develop inter-country exchanges between all the country teams participating in the project; and (c) facilitate an intra-country exchange of findings and policy alternatives, among various levels of decision makers from each country. In addition, each country team will also document traditional-indigenous adaptation management practices in various parts of the country.

By accomplishing these objectives, the project will contribute to a better understanding of the impact of and the adaptation to climate change by the agricultural sector, and therefore to integrating the protection of the global environment into national activities in the African countries that participate in the study.

Current Situation

Although there are well-established concerns about climate change effects on various sectors in Africa, there is little quantitative information concerning how serious these effects will be. Existing agricultural studies cover only a small fraction of Africa, and few of the African studies include data of actual farmer behavior (adaptation includes responses such as planting dates, harvest dates, use of fertilizer, and crop choice). Existing studies (see preliminary review by Rosenthal, 2000 attached to this proposal) mostly examine how individual crops behave in controlled experiments, addressing largely grain crops. Only one study known to address regional impacts in Zambia (Munalula et al., 1999) suggests decrease in net revenue per hectare in various regions in Zambia between 60 and 100%, depending on the region and the climate scenario. There have been numerous programs and projects in various African countries, funded by various donors (See Background document by Rama, 2001 and Annex A-2 for more information). Projects and programs address water supply variability, drought implications and technology transfer. Because many of these projects and programs are done at a country level, or at a sub-regional level, results are not replicable, and in many cases, information produced is not used.

[2] While we focus in this study in agriculture, the capacity gained by the participating African experts will allow them to use the methodology in assessment of impacts of climate change on other sectors as well.

Linkage to other Implementing Agency On-going or Under-preparation Projects

This project is compatible with other initiatives in Africa and in the world, while not duplicating these efforts. In Africa one of these initiatives is the UNEP "Stage II Adaptation to Climate Change for Southern and Eastern Africa". The UNEP proposal focuses on 2 regions in Africa and exhibits a potential for collaboration with this proposal over the agricultural sector work, which is the relative advantage of this proposal. Collaborative activities may include joint workshops, exchange of data, and extrapolation of analysis to various sectors. Another project, UNDP/GEF & UNSO PDF B proposal "Regional Africa: Coping with Drought and Climate Change, Best Use of Climate Information for Reducing Land Degradation and Conserving Biodiversity" is being considered for funding. This project, will cover part of the countries included in this proposal, and will address issues that can both contribute to and benefit from the work on this proposal (data sharing, joint workshops, etc…).

There are clear complementarities between The UNDP/GEF & UNSO project. While the proposed project's unit of observation is the district, the UNDP/GEF & UNSO's focus are individual farmers. Therefore, on the one hand UNDP/GEF & UNSO project could provide detailed information on farmer decision-making particularly an elaboration of adaptation strategies for climate variability, which are key to adaptation for climate change. On the other hand, the results from water modeling components in this project could further reinforce UNDP/GEF &UNSO project implementation.

The proposed project is also very closely related to on-going work funded also by CHIEAM/IAMZ on Impact of Climate Change on Agriculture in the Mediterranean, Europe, and North Africa (see Annex A under ***Institutional Framework and Responsibilities in Project Implementation***). Existing data that has been collected in previous projects in Morocco and Tunisia will be added to the data base to be produced by the proposed project.

Expected Project Outcomes with Underlying Assumptions

The project will implement a series of activities over a three year period leading to the enhancement of research and policy capacity in Africa, both at national and regional levels, concerning climate change impact on agriculture. Currently, not many experts in the world, and in Africa, systematically investigate how climate might affect African agriculture. This study is intended to provide new insights into how climate change will impact African agriculture and how Africa can adapt. The research will use existing data[3] and information (see Annex A-2 and background paper by Reddy, 2001) to analyze how current climate affects African farmers. By examining how farmers have adapted and perform in different climate zones within Africa, the study will estimate the impact of current climate on current agricultural systems. Building on these empirical relationships and predictions of how climate might change in the future, the study will explore potential future impacts under different economic and climate scenarios, and possible adaptation strategies.

The proposed study will produce objective assessments of impact of climate change on the agricultural sector in African countries and the relative effectiveness of various

[3] The project will attempt to use existing data and information, but also, to collect new data and information only as a last resort.

adaptation measures. One major outcome is the increased understanding on the economics of impact and adaptation and the creation of a common methodology for comparison and deliberations. The extensive consultation within and between national teams of the sample countries and government agencies during the preparation and the execution of the project are a central objective of the project. The overriding assumption is that the local experts could benefit from employing an empirical methodology, and are interested in conducting the scientific work leading to the implementation of the suggested methodology. The participation of local experts and the exchange of results between national experts and policy makers is the key to the success of the project.

The project will consequently achieve five specific outcomes that will boost knowledge and policy awareness on the impact of climate change on agriculture:
(a) Realized national and regional benefits from understanding the impacts of CC on the agricultural sector. The research will quantify the impact of climate change on various agricultural systems under different climatic conditions in each country, and would be able to compare impacts between the sample countries. The methodology will also allow extrapolation of the results to countries not participating in the research, therefore, providing a multiplier effect. A special attention will be given to traditional-indigenous adaptation management practices in the various countries.
(b) National and regional benefits from understanding the performance of various adaptation measures in response to impacts of CC on the agricultural sector. The research will quantify the benefits from adaptation to climate change in various agricultural systems under different climatic conditions in each country, and would be able to compare various adaptation measures across the sample countries. The methodology will also allow extrapolation of the results to countries not participating in the research, therefore, providing a multiplier effect. The traditional-indigenous adaptation management practices in the various countries will be compared and possible introduction from one country to another will be examined.
(c) Data bases and models to predict CC impact and adaptation. The research will prepare a data base that can be used by many others for various estimates in the field of impact assessment and policy intervention. It will also lay the foundation for a continuation of data collection and further analysis.
(d) Full country dialogue on climate change impact on and adaptation to by the agricultural sector. The on-going discussions within national teams, between national teams and country policy makers and officials, and among the entire group in the study is by itself a uniques outcome, leading to build up of awareness and a process of integration of climate change considerations in national and regional policies.
(e) Building expertise in the sample countries. As in the case of India, Morocco, and Tunisia, one major outcome of the project is the build up of expertise by fact that a cadre of young experts will participate in the study and conduct the research as part of their graduate work.

Activities and Financial Inputs Needed to Enable Changes

(a) Data collection and analysis of current climate change impact and adaptation (Cross section model, FAO agro-ecological zones model, Hydrological model): Between 9-11 national teams, collecting baseline climatic data and agricultural production data for various regions in each sample country. Comparing between "FAO" and the Cross sectional

model, and producing a climate sensitivity surface for the individual countries and the region. Country experts will analyze the data of their country and develop reports explaining what effect current climate has on local agricultural systems, including livestock production. They will explain how agricultural performance varies across climate zones in their country and how farmers have adapted to local climate for example by changing crops or planting dates. This component will allow the understanding of the interaction between the existing systems and existing climates in various countries.

The incremental cost of this activity is $400,000, of which $400,000 is requested from GEF.

(b) Analysis of future climate scenarios and effective adaptation measures (Cross section model, Hydrological model): Using Global Circulation Models results and hydrological model output, several future climate scenarios will be incorporated into the climate sensitivity surface (national and regional) that was estimated in the previous component, to allow evaluation of policy interventions aimed at producing sustainable adaptation measures. This component will allow a sound comparison between various alternatives and will prepare the ground for interaction between policy makers and climate change experts.

The incremental cost of this activity is $290,000, of which $250,000 is requested from GEF.

(c) Workshops, Reporting and Dissemination: Regional and international interactions between economists, scientists, policy makers and government officials, learning material, national reports and regional report. Through a final workshop targeted at the ministerial level, the project could enhance capacity among African senior-policy makers. This would raise the awareness in government institutions dealing with environment about the UNFCCC, its various programs, and their implications for signatory countries. It would also raise the awareness, among policy makers about climate change, African impacts, various policy interventions, and their relative effectiveness and associated costs.

The incremental cost of this activity is $550,000, of which $50,000 is requested from GEF

Sustainability Analysis and Risk Assessment

An a priori set of 13 countries has been identified based on the selection criteria discussed earlier. The working relation among the team members has been enhanced through the literature review process and the LKSN technology. They provide both the substance and the mechanism for sustainable interaction. Three experts from three countries (South Africa, Zambia, and Zimbabwe) that have already been identified, participated in a brainstorming workshop held in Zaragoza, Spain (3/16-17, 2000). This activity had been funded by The International Center for Advanced Mediterranean Agronomic Studies (CIHEAM/IAMZ) in Spain, and by The Farm Foundation in the USA. These three trained experts will help train the 'newcomers'. Following an identification/exploration mission in June of 2000, Uganda has been removed from the sample, because we could not identify adequate local researchers, and availability of data has not been confirmed.

In attempting to insure sustainability, necessary level of capacity and data availability in countries to be sampled was identified. It is expected that the project will have positive externalities that will affect other countries in Africa. The Learning and Knowledge Sharing Network (academia, research, government institutions) will play a central role in extending project activities both across Africa, and over time to increase its sustainability. Experts who participated in the project would serve as resource persons for those countries who would like to replicate the project activities at national level via the LKSN and the workshops. In the same vein, policy-makers could share the implications the project results have had on their decision-making process when designing policies for sustainable rural development. While the network will initially be an integral part of the project, it is anticipated that it will eventually become self-sustained after the project terminates. It is expected that the new stock of knowledge and the new generation of young experts that will graduate from the project, will be the foundation to a wider and stronger group of professionals with high awareness to economics of natural resources, climate impacts and agro-ecology. The continuous interaction with experts from Europe, Northern Africa and the USA will provide additional incentives for sustainability. In addition, a similar project may be proposed for South America. 'Graduate' experts from the African project may serve as trainers of newcomers to the new project in South America, when it will take place.

There are two major issues associated with the project. First, the sampling of countries from a continent with so much variation may create some operational problems (for example, languages, equipment, etc…). This will be addressed by having a very close escort of the national teams by a dedicated Bank staff, that speaks both English and French. Second, technical capacity of the national teams may not be equal and may result in an un-level quality of the country analyses and reports, and even affect the regional analysis. This issue will be addressed by having the 3 workshops look closely at the problems in each country and allow for cross fertilization among country teams. In addition, the 'first-aid' team coordinated by the University of Pretoria will assist in quality control, as was explained earlier.

Specific risks in the project and remedies include:

Political unrest in some of our sample countries during the study. The sampling process included political stability as a factor to minimize this risk.

Difficulties to obtain appropriate data. Time was spent during identification missions to African countries to identify baseline data available in the sample countries, and during the preparation of the proposal (Annex A-2), in order to minimize this risk. Incremental data collection may be needed, and was taken into account, and also some of the likely missing data will be produced by the agro-ecological zones model (FAO).

Not sufficient policy awareness in the countries. It is possible that the project will not achieve full impact because policy makers will not accept findings. The purpose of the three workshops, in which policy makers will be fully integrated, is to insure a full and broad dialogue between the experts and the policy makers within and among the participating countries. Moreover, policy awareness will go beyond the sample countries by having a concluding conference with participation from countries that were not part of the study.

Stakeholder Involvement and Social Assessment

A group of 3 African economists (from South Africa, Zambia, and Zimbabwe), with prior work experience in economics of climate change met during March 16-17, 2000 in Zaragoza, Spain with a group of 6 economists already working on measuring the impact of climate change in 4 countries (Morocco, Tunisia, Spain, United Kingdom). The purpose of this workshop was two fold: first, to familiarize the African economists with the problems and opportunities associated with the two suggested approaches, and second, to discuss possible solutions to these problems. The 3 African economists assisted in identifying colleagues from other countries, in collaboration with the GEF country focal points.

The process of establishing the country teams in Africa is well underway. These teams, include climate change experts working in the region. These initial contacts alert African groups working on climate change impacts of the project, help identify potential participant countries and help identify potential team members from these countries. Following the sampling procedure, field visits were conducted to the countries. During the visits, the project concept was presented and discussed with various stakeholders in academia, research institutes and governments. A small team of experts has been identified in several countries. The team is composed of an economist (most likely an agricultural economist) and an agricultural scientist (most likely an agronomist). The proposal, as well as background material (e.g., literature review) were shared electronically with the various country team members and a process of exchange of comments has been taken off. In addition, several team members responded to the literature review by adding additional sources, including their own work. A mailing list has been established and communications among the group members have been taking place since the inception off the draft proposal. For names and affiliation of the identified country team members see Annex A-3)

Incremental Cost Matrix

	Baseline	**Alternative**	**Increment (GEF and other)**	
Global Environmental Benefits	Baseline information and analysis not properly incorporated into policy actions and adaptation is not effective. Climate change adversely affects agro-ecological systems management and the economy in African countries.	Climate change impact is understood, adaptation measures are effectively incorporated into sectoral policies.	1. Capacity building training of young experts. 2. Assess impact of and adaptation to climate change in several countries, and extrapolate to the region. 3. Possibility of extrapolating to all countries in the region.	
Domestic Benefits	Local projects and data collection.	Sectoral data collection and analysis, using a systematic approach.	1. Provide information for policy makers to develop national policies.	
Costs	**Baseline**	**Alternative**	**Non-GEF**	**GEF**

Data collection and analysis of present climate impact and adaptation	$80,000 estimates of data collection activities in the sample countries	$400,000	0	$400,000
Analysis of future climate scenarios and effective adaptation measures	0	$290,000	40,000	$250,000
Regional workshops, reporting and dissemination	0	$550,000	500,000	$50,000
Total	***$80,000***	***$1,240,000***	***$540,000***	***$700,000***

Budget

Component	**GEF**	**Other sources**	**Project total**
PDF:	0	0	0
Personnel:	0	0	0
Subcontracts:[1]	340,000	80,000	420,000
Training and institutional support:[2]	80,000	520,000	600,000
Equipment:[3]	40,000		40,000
Travel:	210,000	20,000[4]	230,000
Miscellaneous:	30,000	0	30,000
Project total (PDF + project costs):	700,000	620,000	1,320,000

[1]For the national teams and the regional consultants
[2]Including IAMZ, CEEPA, ACMAD/RYMET work, material preparation, and workshops.
[3]One computer, and printer per national team
[4]Domestic (country teams), for incremental data collection

IMPLEMENTATION PLAN

Project duration 3.5 years

Duration of Project (in months):										
Activities	Project-months									
Completion of project activities	6	12	18	24	30	36	42	48	54	60
Preparation of Literature review and Inventory of climate/Water/Agro-ecological Projects and data.	xx									
Establishing the learning and knowledge sharing network (LKSN)	x									
Launching workshop	x									
Data collection / Hydrological modeling	xxxx									
Second workshop			x							
Country level analyses	xxxxxxxxxxxxxx									
Regional analysis			xxxxxxxxxxx							
Interim reports			xxx		xxx					
Final reports						xxx				
Final conference							x			
Publication of the results and conference proceedings							x			

PUBLIC INVOLVEMENT PLAN

Stakeholder identification

The main stakeholders are the national experts and the policy makers in the various sample countries and those in other countries in Africa. These initial contacts alert African groups working on climate change impacts of the project, help identify potential participant countries and help identify potential team members from these countries. Policy makers to participate in deliberation during the workshops will be identified and invited at a later stage.

Information dissemination and consultation

The data and results gained in this study will be disseminated in various ways. First is to establish a website in which papers and reports will be posted for the benefit of the public at large. In the final conference, it is planned to allow participation of scientists and policy makers from any country, having the results of the study disseminated to a larger group of parties. A product of the study that will assist policy makers will be a country policy note, and a regional policy note. The policy notes will be a non-technical versions of the main finding of the study and the policy recommendations derived from our deliberations in the various workshops.

Using pedestrian dissemination routes the national reports and the regional report will be published in a limited number of copies; technical economic and policy papers will be published and submitted for publication consideration in international and regional journals. It is also planned to have the results of the project assembled in a book.

Stakeholder participation

The main stakeholders are the national experts and the policy makers in the various sample countries and those in other countries in Africa. National experts and policy makers will participate in the workshops and in the deliberations that will take place.

MONITORING AND EVALUATION PLAN

Monitoring and evaluation plan will be tailored to the study, following the suggested set of indicators: Each of the workshops will be evaluated by the participants and a report will be prepared, comparing workshop objectives and achievements. Each team will have three products to produce over the course of the project. Each national team will provide a complete set of data for their country, a draft report of their national study, and final project report. The regional team will put together a regional data set combining the data from each country, a draft regional analysis, and a final report. The national-level analyses and the regional analysis will be reviewed by external reviewers.

Responsibility for the monitoring and evaluation will be taken by CHIEAM/IAMZ for dates of submission of reports; by CEEPA at the University of Pretoria, South Africa, for the quality of the data and the analysis; and by ACMAD/AGRYMET for the learning material, and workshop schedule. A proposed plan with benchmarks and indicators for the duration of the project will be prepared at the first workshop, discussed with the country teams, presented to all parties involved and to the World Bank. The Project Task Manager will maintain a schedule with designated deadlines for completion of specific activities, and for the completion of progress reports for preparation of learning material for the workshops and the website.

REFERENCES

Antle, J. M. 1995. Climate Change and Agriculture in Developing Countries. *American Journal of Agricultural Economics.* 77 (August): 741-746.

Balti, N.M. (2001), "Evaluación económica de los efectos del cambio climático en Túnez y España." Tesis de Master, CIHEAM – IAMZ, Zaragoza.

Bennholdt-Thomsen, V., 1982. "Subsistence Production and Extended Reproduction; A Contribution to the Discussion About Models of Production." *Journal of Peasant Studies* 9:241-254.

Cline, W. (1996), "The Impact of Global Warming on Agriculture a Ricardian Analysis: Comment." *American Economic Review* 86: 1308-1311.

Darwin, R. (1999), "The Impact of Global Warming on Agriculture: A Ricardian Analysis: Comment" *American Economic Review*.

Darwin, R., Tigras, M., Lewandrowski, J. and Raneses, A. 1995. "World Agriculture and Climate Change: Economic Adaptations". U.S. Dept. of Agriculture, Economic Research Service, Publication # AER-703, Washington, D.C.

Dinar, A., Mendelsohn, R., Evenson, R., Parikh, J., Sanghi, A., Kumar, K., McKinsey, J., Lonergan, S. (1998), *Measuring the Impact of Climate Change on Indian Agriculture*, World Bank Technical Paper No. 402, Washington, D.C.

Dinar, A., and D. Zilberman. 1991. "The Economics of Resource-Conservation, Pollution-Reduction Technology Selection, The Case of Irrigation Water" Resources and Energy 13:323-348.

Dinar, A., M. Campbell, and D. Zilberman. 1992. "Adoption of Improved Irrigation and Drainage Reduction Technologies Under Limiting Environmental Conditions" Environmental and Resource Economics, 2:373-398.

El-Shaer, H. M., C. Rosenzweig, A. Iglesias, M. H. Eid, and D. Hillel, Impact of Climate Change on Possible Scenarios for Egyptian Agriculture in the Future. Mitigation and Adaptation Strategies for Global Change, 1:233-250, 1977.

Food and Agriculture Organization of the United Nations (FAO). 1992. *Agrostat*. Rome, Italy.

FAO (2001), "Global Farming Systems Study: Challenges and Priorities to 2030, Regional Analysis Sub-Saharan Africa". Rome: FAO and World Bank.

GEF (1997): Operational guidelines for Expedited Financing of Initial Communications from Non-Annex I Parties. GEF Communiqué from February 1997

GEF (1999): Operational Guidelines for Expedited Financing of Climate Change Enabling Activities. Part II: Expedited Financing for (interim) measures for Capacity Building in Priority Areas. GEF Communiqué from October 1999

GEF (2000): Information Note on the Financing of Second National Communications to the UNFCCC. GEF Council Communiqué from April 2000 GEF/C.15/.Inf.12.

Greperrud, S., 1997. "Poverty, Land Degradation and Climatic Uncertainty." Oxford Economic Papers 49:586-608, October.

Iglesias, A., and M. I. Minguez. 1997. "Modeling Crop-Climate Interactions in Spain: Vulnerability and Adaptation of Different Agricultural Systems to Climate Change" Mitigation and Adaptation Strategies for Global Change, 1:273-288.

Jin, Z., Ge, D., Chen, H., and Fang, J. 1994. Effects of Climate Change on Rice Production and Strategies for Adaptation in Southern China. pp. 1-24. In Rosenzweig, C., and Iglesias, A., eds. *Implications of Climate Change for International Agriculture: Crop Modeling Study*. Washington, D.C.: United States Environmental Protection Agency, Office of Policy, Planning and Evaluation, Climate Change Division, Adaptation Branch.

Kapetanaki, G. and C. Rosenzweig. 1997. " Impact of Climate Change on Maize in Central and Northern Greece: A Simulation Study with Ceres-Maize" Mitigation and Adaptation Strategies for Global Change, 1:251-271.

McKinsey, J. and Evenson, R. (1998), "Technology-Climate Interactions: Was The Green Revolution in India Climate Friendly?" In: A. Dinar, R. Mendelsohn, R. Evenson, J. Parikh, A. Sanghi, K. Kumar, J. McKinsey, S. Lonergan, Measuring the Impact of Climate Change on Indian Agriculture, World Bank Technical Paper No. 402, Washington, D.C.

Mendelsohn, R., W. Nordhaus, and D. Shaw. (1994), "The Impact of Global Warming on Agriculture: A Ricardian Analysis", American *Economic Review* 84: 753-771.

Mendelsohn, R. and W. Nordhaus. (1996), "The Impact of Global Warming on Agriculture: Reply", *American Economic Review* 86: 1312-1315.

Mendelsohn, R. and Neumann, J. (eds). (1998), *The Impact of Climate Change on the Economy of the United States*, Cambridge: Cambridge University Press.

Mendelsohn, R. and Schlesinger, M. (1999), "Climate response functions." *Ambio* 28**:** 362-366.

Mendelsohn, R., Morrison, W., Andronova, N., and Schlesinger, M. (1999), "Country Specific Market Impacts From Climate Change", *Climatic Change* (forthcoming).

Mendelsohn, R., A. Dinar, and A. Dalfelt, 2000. "Climate Change Impacts on African Agriculture." Background Paper, The World Bank, Mimeo, July 12, 25 pages.

Mendelsohn, R., A. Dinar, and A. Sanghi, 2001 "The Effect of Development on the Climate Sensitivity of Agriculture", Environment and Development Economics,6:85-101.

Mendelsohn, R. and A. Dinar, 2001. "Climate, Water, and Agriculture" Manuscript, Yale School of Forestry and Environmental Studies, New Haven CT.

Munalula. Themba, J. Nkomoki, S. Kamocha, and M. Nawiko, 1999. *Estimating the Impact of Climate Change on Rainfed Agriculture A Cross Sectional Analysis of Impacts on Medium and Small Scale Agricultural Revenue in Zambia*. Report Submitted to Pilot Environmental Fund, Lusaka, Zambia, ESF/006, December.

Pearce, D., W. Cline, A. Achanta, S. Fankhauser, R. Pachauri, R. Tol, and P. Vellinga. 1996. "The Social Cost of Climate Change: Greenhouse Damage and the Benefits of Control." In *Climate Change 1995: Economic and Social Dimensions of Climate Change*, ed. J. Bruce, H. Lee, and E. Haites. Cambridge: Cambridge University Press.

Ouedraogo, Mathieu, 1999. "Contribution a l'évaluation de l'Impact Economique des Changements Climatiques sur l'Agriculture Marocaine », Thesis de Master, Royaume du Maroc, Institut Agronomique et Vétérinaire Hassan II Rabat-Instituts, Maroc, September.

Reddy, Rama Chandra (2001). "Climate, water, and agro-ecology: projects and relevant databases related to the countries in the targeted research proposal" "Background Paper, The World Bank, Mimeo, May 19, 16 pages.

Reilly, J., N. Hohmann and S. Kane. (1994), "Climate Change and Agricultural Trade: Who Benefits and Who Loses?", *Global Environmental Change* 4: 24-36.

Reilly, J. et al. (1996) "Agriculture in a Changing Climate: Impacts and Adaptations" In *Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific Technical Analysis (R. Watson, M. Zinyowera, R. Moss, and D. Dokken (eds)* Cambridge: Cambridge University Press.

Rosenthal, Shane, 2000. Review of literature on the effects of climate change on agriculture and forestry in Africa, Draft Report, World Bank, Washington, D.C.

Rosenzweig, C. and Parry, M. (1994), "Potential Impacts of Climate Change on World Agriculture", *Nature* 367: 133-138.

Sanghi, A. (1998), "Global Warming and Climate Sensitivity: Brazilian & Indian Agriculture". Ph.D. dissertation, Department of Economics, University of Chicago.

World Resources Institute (2001), "World Resources 2000-2001 People and Ecosystems", Washington DC: World Resources Institute.

ANNEX A: RESEARCH METHODOLOGIES

Several African countries have been selected to participate in the project. The selection procedure was based on climate variation, regional coverage, ecosystem representation (see section below, in this annex), data availability, human resources, country size, political stability. A literature review of existing studies on impact of climate change on agriculture in Africa will provide a common ground for countries to establish a benchmark knowledge stock. Experts in each country have been approached and asked to comment and provide input (based on their existing experience in their countries) and update to the review as a first step.[4] A learning and knowledge sharing network (LKSN), linking academia, research, development, and political institutions, is now being established (covering Europe, USA, and Africa). The network is using a web-based platform to enhance the dialogue, exchange ideas, and dissemination of relevant information among the member countries. The LKSN will thus provide an enabling environment for enhancing climate change capacity in Africa. The LKSN will be an open access resource to other countries in Africa, and elsewhere, allowing them the read-only option. When the project will be completed, the LKSN, may be open to the public.

Further, experts in each country will be trained in methodologies, and data collection techniques in order to analyze their own data using empirical cross sectional approaches[5]. Additional information on the cross sectional approach can be found in the section ***The Cross Sectional and the Crop Modeling Approaches*** below. These national studies will be carefully supported through a series of workshops. Both the African experts and experts from other countries, that applied the alternative empirical approaches, will meet in several workshops during the project period to share experiences and results. The final workshop will include policy makers from all countries as participants. In addition, there will be on-going exchange and feedback by int'l experts and experts at the University of Pretoria, South Africa into the national studies.

The national studies will be supported by a regional study of Africa that uses the same approach on a regional level. By comparing the national studies and the regional analysis, the project will be able to generate more reliable estimates of the effect of climate change on African agriculture. The analysis will generate not only national estimates of impacts for the participating countries but also impacts in surrounding countries. Thus, every country in Africa is expected to benefit.

The regional study makes an important innovation in the cross-sectional literature, and for GEF policies and strategies, by moving from single nation to multiple nation analysis. Previous cross-sectional studies have all been conducted one country at a time. National policies and national data sets are all controlled in these single country studies because all the farms are subject to the same set of rules and data collection. However, when moving to multiple countries, the study must cope with alternative data definition and collection methods and country specific agricultural policies. For example, soils data

[4] At this point in time, experts from Egypt, Kenya and Ethiopia already provided input to the literature review, which is in the process of being updated. A Background Draft Literature Review by Rosenthal (2000) is attached.

[5] The cross sectional, or as it is called, the 'Ricardian' approach, uses actual observations on farmers performance in various climatologic regions (e.g., Mendelsohn et al., 1994 applied it to the USA; Dinar et al., (1997), applied it to India; Sanghi (1998) applied it to Brazil; Ouedraogo (1999) applied it to Morocco; and Balti, (2001) applied it to Tunis).

are collected using various definitions of soils that have been developed by experts from France, Great Britain, and the United States. Different countries record their soils using different approaches. The study will have to either find a regional source of soil data, for example from FAO, or find a mechanism to cope with multiple methods of characterizing soils.

The second problem that the study must overcome is national agricultural policies that might distort what farmers do in one country versus another. For example, if a country subsidizes a specific crop, farmers may be drawn to planting more of that crop than natural conditions would suggest. The empirical study will have to identify such policies and correct for them in the analysis. For example, the study could introduce a corn subsidy dummy variable for a country that subsidized the price of corn. If multiple countries engage in a subsidy for a crop but they use different rates of subsidy, the study could introduce the rate of subsidy for each country and apply it to the observations from the country.

Another innovation that the study would like to pursue is an explicit modeling of water supply. Initial research on United States data by Mendelsohn and Dinar (2001) suggests that water supply from runoff has an important effect on farms. Farms that can draw from runoff are more likely to use irrigation and earn higher net revenues. Although irrigation has a limited role at the moment in Africa, it may play a much larger role in the future both to adapt to current climate as well as climate change. By modeling runoff across Africa, we can take into account how much runoff affects existing farms. By modeling how climate change might alter runoff, we can also explicitly capture how runoff changes would interact with direct climate changes and affect farms in the future.

The study approach will examine adaptation closely. Climate impact studies have revealed that adaptation measures are extremely important (Mendelsohn and Neumann, 1998). The project will identify ways that African farmers are currently adapting to their climates, such as crop switching and timing of important agricultural activities. Further, the project will explore additional adaptations, including the use of capital and technology (for example, irrigation or high yield varieties (HYVs)) as a mechanism for adapting to future climates.

The proposed methodology will be adapted to include indicators of ecosystems health, carbon sequestration and biodiversity loss in the analysis of impact and adaptation scenarios. For example:

1. Impacts on water quantity and quality (various indicators of environmental health, water pollution – BOD, etc. and rates of chemical use, land erosion and sedimentation, water logging, etc.)
2. Impacts on land use and land conversion (reduced forest, grassland, wetland covers, etc.)
3. Increased use of introduced plant and animal species further narrowing the genetic base and diversity and loss of wild relatives and species, etc.

In addition to the Ricardian analysis that focuses on variation in net revenue, the study will also pursue a more detailed cross sectional analysis of farmer decisions. The study will explore a methodology of modeling crop choices first developed by FAO (1992). This method begins with detailed information on soils and climate and calculates crop practices, crop choice, planting dates, and crop yields. The method will pro-

vide more detail than the Ricardian approach provides concerning how farmers change their behavior in response to climate. Further refinement of this method is expected to fit available data, to match economic analysis, and to explore desired adaptation methods.

The project will also extend these two approaches to livestock. One method will estimate the net revenue of livestock operations and see how this varies with climate. The second approach will examine the inputs to livestock operations and will explore how these inputs vary across climate zones. For example, the study will examine how forage, fodder, water holes, and species might all vary across climate zones.

The first stage of the project will focus on building empirical models that capture the effect of current climate on existing farms in Africa both at the national and regional level. The second stage of the project will explore the effect of climate change on African farms. Using predictions from climate models (General Circulation Models), the project will examine a selected set of climate projections for Africa. For each projected climate, a hydrological model will be used to predict changes in runoff across the continent. Given the runoff changes and the climate changes, the empirical models will then be used to predict what will happen to African farms across the landscape. The modeling approach will allow detailed projections to be made in each area as it is expected that impacts will vary from place to place depending upon initial climate conditions, economic development, and the magnitude of climate change.

The results of the project will be widely dispersed around Africa. The program will identify and train regional experts who could assist other countries in the region. The results of selected individual country studies will be developed into training material and shared. Finally, a regional analysis will be conducted that will provide estimates of impacts for additional countries in Africa. At the end of the project, the results will be presented in a regional conference with the assistance of the United Nations Environment Program (UNEP) in Nairobi.

Finally, the project proposes to enhance capacity at ministerial level by allocating an adequate number of training modules during the annual workshops, to raise awareness about the UNFCCC and other international initiatives addressing issues related to climate change and the environment. These modules could then be mainstreamed into a broader capacity building component using appropriate distance learning technology.

Agro-ecological Zones in Africa

There are 8 agro-ecological Zones in Africa. Because the purpose of the study is to compare how farmers behave across climate zones, the study has carefully tried to select countries from each zone. This sample selection process provides good coverage across climate zones and it also encourages a good distribution of countries across the geography and political spectrum of Africa. Countries from each region of the continent are included. Countries with different racial, religious, and language backgrounds are represented. A short description of the regions and their distribution over the continent are provided in the following two tables:

Farming systems and agro-ecological zones in Sub-Saharan Africa

Agro-ecological zone	Farming sytem	% of land area	Agricultural Pop (%) of total in the region)
Various	Irrigated	1	2

Humid	Tree crop Forest based Rice-tree crop Highland perennial	3 11 1 1	76 7 2 8
Humid/temperate	Highland temperate mixed	2	7
Moist sub-humid	Root crop	12	12
Dry sub-humid	Cereal-root crop mixed Maize mixed Large commercial and small holder	13 10 5	15 16 5
Semi-arid	Agro-pastoral millet	8	9
Arid	Pastoral Sparse (arid)	14 18	7 2
Various	Coastal artisanal fish-ing Urban based	2 Little	3 Little

Source: FAO (2001)

Although we don't have a precise measure of the share of these agro-ecological zones in our sample countries, the next table suggests that they are accurately represented in the sample.

Farming systems Characteristics of Selected Countries

Country	Agro-Ecological system
Burkina Faso	8, 11
Cameroon	2, 3, 7
Egypt	8, 11, 12
Ethiopia	5, 6, 9, 12
Ghana	2, 7, 8
Kenya	9, 11, 12
Níger	12, 13
Nigeria	2, 7, 8, 11
Senegal	1, 11
South Africa	9, 10, 13
Zambia	1, 7, 8, 9, 11
Zimbabwe	9, 11, 12, 13

Legend:

(1) Irrigated (2) Tree crops; (3) Forest based, (5) Highland perennial, (6) Highland temperate mixed, (7) Root crop, (8) Cereal root crop mixed, (9) Maize mixed, (10)Large commercial and small holder, (11) Agro-pastoral millet/sorghum (12) Pastoral, (13) arid.

Source: FAO (2001)

The Cross Sectional and the Crop Modeling Approaches

Adaptation to climate involves a change in agricultural practices in response to a change in climate conditions. It often involves a combination of various individual responses at

the farm level, as was suggested in the main text of the proposal. Of course, adaptation assumes that farmers have access to alternative practices and technologies that are already available in their region. Thus, government policies should support R&D that prepares the appropriate technologies. We will apply two approaches, documented in the literature—the FAO crop modeling approach and the Ricardian (Cross Sectional Approach). A third approach, experimental crop simulations, will not be explored in this study because of insufficient funds. However, this is a promising approach as well and so we review it in this section.

Experimental Crop Simulation

The experimental crop simulation literature begins with controlled experiments that measure the effect of climate and carbon fertilization on crops. The results of these experiments are then introduced into crop simulation models. This literature (e.g., El-Shaer et al., 1997; Kapetanaki and Rosenzweig, 1997; Iglesias and Minguez, 1997, Jin et al., 1994) addresses impacts by simulating changes in growing parameters of various crops according to the latest scientific advances. This approach does not take into account economic considerations and human capital limitations, both of which affect actual farm-level decisions. Therefore, it is hard to interpret the adaptation scenarios explored by agronomists.

While El-Shaer et al. (1997) identify possible climate-related adaptation strategies for Egyptian agriculture (changes in water, land, and crop management), they do not provide quantitative estimates of the changes in crop performance associated with these adaptation strategies. Kapetanaki and Rosenzweig (1997) identify several adaptation strategies for maize in Greece. These strategies include adjusted planting dates and introduction of new maize varieties. Simulations for 3 sites suggest that earlier planting dates of maize (10-30 days) increase yield by nearly 10% in all sites. Introduction of new varieties fully mitigate negative climate change impacts on yield in one site but only partially at the two southern sites. A combination of earlier planting dates and new varieties completely counter balance the negative impact of climate change in all sites. Iglesias and Minguez (1997) evaluated several adaptation strategies for wheat and maize in various climatological regions in Spain. The adaptation strategies tested include combinations of new hybrids and changes in sowing dates, and double cropping, with short-cycle maize varieties as a second crop. This strategy not only reduces the impact of increased temperature on yield, but it also allows intensification of water and land use. The additional crops to be grown with maize were lentils and a vetch-forage barley mixture. Incorporating CO_2 effects suggest that, depending on the region, water use efficiency also improves with the adaptation strategies. Water efficiency improves by 0-10% in southern regions and 40-80% in northern regions of Spain. Jin et al., 1994 examines adaptation strategies in Southern China for growing rice. They find that creating a new cultivar created a higher yield in five out of seven sites. Changing the planting dates of the currently used cultivars caused increased rice yields in the northern sites, but not in the southern sites. Combining the changing of both the cultivars and the planting dates significantly increased the rice yields at six of the seven site locations.

The Cross Sectional Approach

The most important advantage of the (Cross sectional) Ricardian approach is its ability to incorporate efficient private adaptation to climate. Private adaptation involves changes

that farmers would make to tailor their operations to the environment in order to increase profits. Because private adaptation benefits the farmer, there is every reason to expect that it will occur. One of the most important adaptations that farmers will make is crop choice. Depending on what climate a farmer finds himself in; there is a particular crop that will be the optimal choice. For example, Figure 1 shows three potential grains that could be grown from wheat, to corn, to rice. Each crop is best suited for a specific temperature (and precipitation). For example, a farmer in a cool temperate site might find that wheat is the optimal choice. If the temperature warms, however, the wheat yields for the farmer in Figure 1 will fall and his net revenue will fall as well. If this farmer, however, switches to corn, his net revenues will rise. It is very important to model optimal crop switching in order to avoid overestimating climate change impacts.

One of the drawbacks of the cross-sectional Ricardian method is that the experiment is difficult to control across farms. Farms may vary for many reasons in addition to the variables of interest. In order to control for this problem, the studies try to include other important variables such as soil quality, market access, and solar radiation. However, it is often not possible to get perfect measures of these variables so that one cannot guarantee that all of these factors have been taken into account. Further, some important variables may not be measured at all. This serious weakness of the cross-sectional approach is paradoxically a strength of the agronomic model. The agronomic model, by relying on carefully controlled experiments, does not fall prey to this problem of extraneous variables.

Another valid criticism of the cross-sectional approach is that it rarely considers price effects. Because the existing studies rely on a cross-section within a country, there is no price variation across farms. All the farms face the same prices. The studies have consequently been forced to assume that prices are constant. This leads to a bias in the welfare calculations (Cline, 1996). The cross-sectional approach only measures the loss to producers from the climate change. By ignoring the price change that would occur if supply changed, a loss in consumer surplus is omitted. The Ricardian studies consequently underestimate damages and overestimate benefits.

Although it is easy to criticize the Ricardian studies for assuming prices are constant; it is quite difficult to include price effects carefully using any method. First, for most crops, prices are determined in a global market. In order to predict what would happen to each crop, one would need a global model. Unfortunately, global crop models are poorly calibrated so that it is difficult to predict what will happen to the global supply of any single crop in a new world climate. Second, the few global analyses completed to date predict that the range of warming expected for the next century should have only a small effect on aggregate supply (Reilly et al., 1994; 1996). Third, if aggregate supply changes by only a small amount, the bias from assuming prices are constant is also small. For example, even if aggregate supply changed by 25%, the bias from assuming constant prices would be less than 7% (Mendelsohn and Nordhaus, 1996).

The application of a cross-sectional approach to agriculture in developing countries raises some additional difficulties that the Brazilian and Indian studies had to address. Although many prices are constant throughout the sample, some are not. Not only are these prices endogenous but many times they are not measured well either. It is consequently difficult to control for their influence. For example, household members form a large fraction of the labor pool used in developing country farms. Agricultural surveys

have difficulty measuring the wages paid to household members and often do not even collect the number of hours that family members work. This can be especially troublesome with subsistence farms (Grepperud, 1997; Bennholdt-Thomsen, 1982). A good measure for household labor was not available in either Brazil or India. The study was forced to control for this factor using just a dummy variable that identified farms relying heavily on household labor. This dummy variable is difficult to interpret because it signifies unpaid labor, which implies a positive sign on net revenue, but it also signifies a smaller and more marginal farm, which implies a negative sign. Another input which is difficult to price is animal work. Although there are official prices for bullocks, for example, in India, these costs reflect the price of buying one. Bullocks would also have to be fed and managed. Farms that naturally grow feed may find it cheaper to maintain a bullock than a farm that would have to purchase food for its animals. In order to try to control for the price of animal power, the study includes the number of bullocks per hectare as a control variable. Although this is an imperfect solution because the number of animals is endogenous, it hopefully reduces the potential bias animal power may have on the climate coefficients.

Technology is another important issue which must be addressed in climate change studies. For example, both India and Brazil have had large and successful drives to enhance farming technology. These drives tended to be concentrated on the more temperate farmlands in both countries. In Brazil, farm technology centers were originally concentrated around Sao Paulo and in India around the Ganges River delta. There consequently was a possibility that technology was facilitating improvement in temperate versus tropical climate zones and would affect climate sensitivity. This hypothesis was examined for India (McKinsey and Evenson, 1998). The study reveals that technology has increased farm performance over the last two decades but technological change has not affected climate sensitivity to date. Because technological development has not specifically been designed to overcome heat tolerance, the historic interaction between technology and climate appears to be minimal.

Technology is nonetheless an important component of climate sensitivity. Although new technologies have not pushed agriculture towards more temperate climates, modern technologies appear to reduce the sensitivity of agriculture to temperature. The chronic concern in development of improving technological adoption consequently has climate change implications (Antle, 1995). As more modern farming techniques get adopted, farmers in developing countries are likely to be able to cope with warming more easily. The adoption of new technologies can free farmers from previous environmental constraints, through new varieties, irrigation technologies, and other methods (Dinar and Zilberman, 1991; Dinar et al., 1992). Warming may still be harmful in developing countries but the adoption of new technologies may reduce some of the potential damages.

In addition to the Ricardian approach which explores how net revenues change across climate zones, cross sectional evidence can also be used to explore a more detailed farm decision model. This approach was first developed by FAO (1992). The method begins with agro-ecological zones. There are both advantages and disadvantages to using agro-ecological zones for climate predictions. The biggest advantage associated with the agro-ecological zones is that they have been carefully studied. The geographic distribution of the zones has been published for developing countries (FAO 1992). The current model using the zonal approach, however, has many problems. The climate zones repre-

sent large categories so that subtle shifts within a zone have no effect but a small shift from one zone to another has a dramatic consequence. The key measures of productivity have not yet blended soils and climate together; the effect of each is computed independently. It is not clear how tightly climate zones can predict either which crops are grown or what their yields will be. The approach is subject to the same limitations as the agro-economic models in that adaptation must be explicitly accounted for to be included. Finally, the existing application of the method predicts large price changes along with small changes in aggregate supply suggesting that there may be problems with the calibration of the underlying economic model (Darwin et al., 1995; Darwin, 1999). Although the technique has potential, the available model is currently in too crude a form to examine the climate change results carefully.

The FAO version of crop modeling explores how micro decisions by each farmer vary across agro-ecological zones. For example, the model explores how the timing of planting and harvesting, the method or technology applied, and crop choice might all vary with climate zone. In each case, the farmer decision in each region could be regressed upon climate, soil data, and economic data to construct an empirical model. We wish to adapt this approach to this project.

Institutional Framework and Responsibilities in Project Implementation

The study team will include 2-3 experts from each of the participating countries. Each team will work as an independent unit that will be guided by one of the implementing agencies (U of Pretoria, Dept pf Ag Economics) in the short-run and by the Bank's team (staff from AFTE1, RDV, WBIEN), and by consultants (A climate change expert and a water modeler), and will be supported via the electronic communication platform and during the workshops by experts involved in similar work in Europe, the Mediterranean countries of Morocco, Spain, and Tunisia (David Madison - University College, London, Rachid Doukkali - Insitute Hassan II, Rabat, Alberto Gariddo - Politechnic Agricultural University of Madrid, and Slim Zekri - School of Agriculture, Tunis).

The work in Morocco and Tunisia was funded by the WB (Morocco and Tunisia) and IAMZ (Tunisia). It yielded one dissertation of a graduate student in each country (A student from Burkina Faso benefited from the Moroccan study, and is now a team member in the Institute of Climate Change in Burkina Faso. He will participate in the work on Burkina Faso under the African study). The Tunisian student is now completing his research (in IAMZ) on Tunisia and expanding it to Spain. The Mediterranean-Europe study plans to combine the information from Morocco, Tunisia, Spain, and England to estimate a regional climate surface. The lessons learned from this regional study will be implemented in the African Study. Moreover, the data collected in the study on Morocco and Tunisia, in Northern Africa, will be added to the data set to be used for the regional analysis.

WBIEN has been involved in the identification of the team members in the various countries, and will assist with the coordination of the periodical meetings of the various countries, and preparation of learning material. The country analyses will be coordinated by the World Bank's RDV and by a consultant, to be responsible for the methodologies and for the regional analysis. The project will be managed by staff from AFTE1 and RDV, which will provide logistical support, once the regular GEF preparation and supervision SWs are in place. Scientific advice will be provided by ENV.

Several additional International agencies will be involved in the project. FAO has already expressed interest in the project and will make its data sources available for project use, in addition to making its staff available for consultation. UNDP and WMO will be consulted throughout all project stages and involved in preparation of all three workshops. UNEP may play a major role in the final conference, and may be involved with the interim workshops during the 3 years of the project. The USA NOAA, Office of Global Programs has expressed interest in the project. They may provide support for one workshop and also access to their climatic data.

The regional institutes:

IAMZ, a leading regional institute in work on climate change, has agreed to provide overall administration of the Project. IAMZ will coordinate the work of The University of Pretoria and of ACMAD/AGRYMET, will do the contracting and will manage the project funds. IAMZ may host the first regional workshop, if necessary.

ACMAD/AGRYMET, a well known regional weather forecasting and educational institute, will coordinate all regional educational programs associated with the project. This will include the preparation of the regional workshops and the compilation of the material for the workshops. ACMAD/AGRYMET will work in close relationship with the project national teams and with the project regional team, to guarantee harmonized outputs that fit into the educational material it prepares.

The Department of Agricultural Economics at the University of Pretoria, South Africa had already developed capacity in regional climate change work. South Africa is also one of the countries participating in the project. A senior researcher from this institute (not part of the national team) will advise all national teams on issues related to the data specifications and the analysis. The advise will e provided via Email, phone calls, and if necessary in actual visits to the countries. Being familiar with the work in each country, this expert could mobilize team members in one country to respond to the issues raised by the team in another country.

ANNEX A-2: INVENTORY OF CLIMATE, WATER AND AGRO-ECOLOGY DATA BASES

For a detailed description see Background paper "Climate, water and agro-ecology data-bases on project countries" by Reddy (2001).

A2.1 Agro-ecology Databases

Agricultural Statistics (AGMAN)
http://edcintl.cr.usgs.gov/adds/toolsdata.php?tool=am

Food Supply Situation and Crop Prospects in Sub-Saharan Africa
http://www.fao.org/WAICENT/faoinfo/economic/giews/english/eaf/eaftoc.htm

The LUCC/Miombo CD-ROM Set
http://www.start.org/Archive/Panafrica/Miombo_CD.html

Database on Food and Agriculture for Eastern Africa
http://www.fao.org/WAICENT/faoinfo/economic/giews/english/basedocs/eafrbase.htm

Database on Food and Agriculture for Southern Africa
http://www.fao.org/WAICENT/faoinfo/economic/giews/english/basedocs/safrbase.htm

Data on Crop Use Intensity
http://edcintl.cr.usgs.gov/adds/mapdatas1.php?type=cuil

West African Spatial Analysis Project
http://edcintl.cr.usgs.gov/adds/mapdatas1.php?type=wasa

Sahel Weather and Crop Situation
http://www.fao.org/waicent/faoinfo/economic/giews/english/esahel/sahtoc.htm

Food Supply Situation and Crop Prospects in Sub-Saharan Africa
http://www.fao.org/waicent/faoinfo/economic/giews/english/giewse.htm

Market Price Data (PRICEMAN)
http://edcintl.cr.usgs.gov/adds/toolsdata.php?tool=pm

FAO(1984) Agro-climatological data: Africa, Vol 1 &2, Food and Agricultural Organization, Rome

Consolidated Information System for Famine Management in Africa
http://www.cred.be/centre/publi/075e/ch01.htm#TopOfPage

ECOCROP 1 and ECOCROP-2
The FAO crop environmental requirements database
http://www.fao.org/ag/agl/agll/ecocrop.htm

Soils and Crop Use Intensity in Greater Horn of Africa
http://edcsnw3.cr.usgs.gov/ip/gha/natural.html

Food Supply Situation and Crop Prospects in Sub-Saharan Africa
http://www.fao.org/waicent/faoinfo/economic/giews/english/giewse.htm

Tropical Soil Cover and Organic Resource Exchange (TropSCORE)
http://trouble.mannlib.cornell.edu:9700/

FAO Agro-ecological zones data sets

http://www.fao.org/ag/AGL/agll/gaez/index.htm

A2.2 Climate Databases

Nicholson's African Rainfall Data
ftp://ncardata.ucar.edu/datasets/ds571.0

National Center for Environmental Prediction, NOAA – Africa Desk
http://www.cpc.noaa.gov/products/african_desk/

Rainfall data (RAINMAN)
http://edcintl.cr.usgs.gov/adds/toolsdata.php?tool=rm

Climate Prediction Center, National Centers for Environmental Prediction, NOAA/National Weather Service
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/current_impacts/global_precip_accum.html

Famine Early Warning System Network
http://geoweb.fao.org/GBR/GeoWEB.exe$CtryDefault

Digital Elevation Model of Africa, DEM
http://miombo.gecp.virginia.edu/cd/Miombocd/Docs/database/dem30s/index.html

A2.3 Water Databases

AQUA STAT
http://www.fao.org/waicent/FaoInfo/Agricult/AGL/AGLW/aquastat/afric.htm

African Water Issues Research Unit, Pretoria University, South Africa
http://www.up.ac.za/academic/libarts/polsci/awiru/

Revised FAO Methodology for Crop Water Requirements: *Martin Smith*
http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGL/aglw/webpub/REVPUB.htm

CROPWAT

http://www.fao.org/ag/AGL/AGLW/climwat.htm

SADC Water Resource Database
http://www.fao.org/fi/alcom/wrd.htm

Scheme Irrigation Management Information System (SIMIS)
http://www.fao.org/ag/agl/aglw/simis.htm

Soil Water Balance in West Africa
http://civil.ce.utexas.edu/prof/maidment/gishydro/africa/ex3af/ex3af.htm

Water Networks in Africa

Name of network	Country	Nature of network	Topic focus	Status
CEDARE Water information network	Egypt	Worldwide web information network	environment and development	Active
Africa water network	Kenya	Information exchange among African NGOs in water sector	Water resources research	Active

Source: Brooks, David B., Eglal Rached and Maurice Saad (eds.) (1997) Management of Water Demand in Africa and the Middle East: Current Practices and Future Needs, International Development Center, Ottawa, Canada.

A2.4 Country Specific Databases

South Africa Climate and Crop Information
http://www.usda.gov/oce/waob/jawf/profiles/html/saf/safpage.htm

Egypt Climate and Crop Information
http://www.usda.gov/agency/oce/waob/jawf/profiles/html/mid/midpage.htm

Zimbabwe Meteorological climatological and hydrometeorological data base
http://weather.utande.co.zw/dbase-search/index.htm

Burkina Faso Agro-climatic Zones Database
http://edcintl.cr.usgs.gov/adds/mapdatas1.php?type=clzn

Special Report Crop And Food Supply Assessment Mission To Ethiopia
http://www.fao.org/waicent/faoinfo/economic/giews/english/alertes/1998/Sreth982.htm#E61E1

FAO/WFP Crop and Food Supply Assessment Mission to Zambia
http://www.fao.org/waicent/faoinfo/economic/giews/english/alertes/1998/Srzam986.htm#E11E1

OTHER BIBLIOGRAPHIES
http://africagcc.gecp.virginia.edu/Publications/

ANNEX A-3: THE PROPOSED TEAMS FOR THE TARGETED RESEARCH

IAMZ team: Mr. Dunixi Gabina, Zaragoza, Spain.

ACMAD/AGRYMET team: Dr. Abdelkrim Ben Mohamed, Abdou Moumouni University Niamey, Niger

CEEPA ,Univ of Pretoria Team: Prof. Rashid Hassan, Prof. Johanne Kirsten, Prof. Ravine Poonyth, Pretoria, South Africa.

Burkina Faso team: Prof. Leopold Some, National Center for science and Technology Research, Ouagadougou, Burkina Faso.

Cameroon team: Ms. Catherine Okotiko, team leader for climate change research projects; Ernest Lytia Molua, Department of Agricultural Economics, Georg-August University Goettingen, Germany.

Egypt team: Dr. Helmy Eid Soil, Water and Environment Resource Institute, Cairo, Egypt.

Ethiopia team: Dr. Abebe Tadege, National Meteorological Services Agency, Addis Ababa, Ethiopia.

Ghana team: Dr. Mensah Bonsu, Faculty of Agriculture, University of Cape Coast(UCC),Cape Coast, Ghana; Dr.J. K. Adu, Animal Research Institute, Centre for Scientific and Industrial Research (CSIR); Prof. Edward Ofori-Sarpong, Dept of geography and resource Development; Prof. Elizabeth Ardayfio-Schandorf, Dept of geography and resource Development, Ghana.

Kenya team: F. Karanja, Meteorology dept, Richard Odingo, dept of geography,.Dr. Silvery Oteng'i, Dept of meteorology, Univ. of Nairobi, Kenya

Niger team: Dr. Abdelkrim Ben Mohamed, Abdou Moumouni University Niamey, Niger

Senegal team: Prof. Madiagne Diagne, ISRA/IRD, Dakar, Senegal

South Africa team: Daneswar Poonyth(Ravine), Dept. of Economics, University of Pretoria.

Zambia team: Prof. Suman Jain, Department of Mathematics and Statistics, University of Zambia, Lusaka.

Zimbabwe team: Prof. Renneth Mano, Dept of Economics, University of Zimbabwe, Harare.

The regional team: Robert Mendelsohn – Yale School of Forestry and Environmental Studies; A water modeler – TBD, FAO expert – Renne Gommes.

Panel of experts team: David Madison - University College, London; Rachid Doukkali - Insitute Hassan II, Rabat; Alberto Gariddo - Politechnic Agricultural University of Madrid; Slim Zekri - School of Agriculture, Tunis.

ANNEX B: EXPLAIN HOW THE RESULTS CONTRIBUTE TO THE OBJECTIVES OF EXISTING OPERATIONAL PROGRAMS, OR THE ASSESSMENT OF POTENTIAL NEED FOR NEW OPERATIONAL PROGRAMS

Agriculture for grazing or crops is the primary cause of permanent land use change across the world. As human demands continued to steadily grow with population expansions bringing more and more natural habitat and other resources under managed cultivation of food and fiber and animal feeding systems, the consequences for ecosystems functioning and impacts on biodiversity reached serious levels. Conversion of natural forest, wetland and grassland into crop or livestock grazing lands is the major cause of habitat destruction and extinction of animal and plant species. Habitat alteration and conversion through removal of forest cover, draining of wetlands or damming of fresh surface water courses are the main causes of biodiversity loss. Some economic activities such as urbanization and the building of mines, dams, and factories, consume vast amounts of resources but generally little land. Other activities such as forestry change natural landscapes by harvesting old growth and replacing natural forests with plantations. But in Africa, forestry has done little to change land use. Only agriculture converts vast amounts of natural landscape into a completely different land use- farms. More over, introduction of new and exotic species of plants and animals in pursuit of higher productivity is another important factor leading to biodiversity loss and extinction. On top of that, the use of inputs such as chemical fertilizers, pesticides, irrigation and heavy mechanization are also important causes of water quality degradation, species loss and disruption of the natural functioning of ecosystems. This in addition to various national development strategies geared towards increased agricultural production and food security policies that distorted the structure of economic incentives in favor of environmentally degrading farming methods and technologies.

The primary link between this project and biological diversity is that the project will shed light on which land is being used for farms and how much will be used in the future. By understanding the expansion of agriculture, conservation managers will get a better sense of what land will be left for wildlife habitat and which wildlife are particularly at risk.

For example, in semi-arid East Africa, vast amounts of wildlife depend on large open ranges that permit great herds to migrate across countries. If certain components of that landscape become farmland, the wild herds may have trouble moving from habitat to habitat. In wetter regions of Africa, habitat may be more threatened by conversion of forests to farmland. By modeling the behavior of farms, conservation managers can get a better sense of what natural wild lands are at risk.

A second link between agriculture and biodiversity concerns the preservation of historic farm species. Throughout Africa, farmers have carefully husbanded local breeds that are well adapted to the rigors of the local environment. As traditional breeding and genetically modification continue to develop new breeds, however, farmers have been shifting from these old stocks to new breeds at a rapid rate. Many farm diversity specialists are concerned that the old breeds could well be lost from this modernization. They fear that important genetic features of these old breeds might also disappear, reducing important diversity. Although this study is not intended to be a careful genetic analysis, information about breeds will be collected to study animal husbandry. It is possible that

this component of the analysis can provide new insights about shifts in breed composition identifying which areas are most vulnerable to possible losses.

The pressure on natural habitat and biological resources from agricultural practices is expected to increase with climate change as a result of the predicted decline in agricultural yields due to global warming. This is particularly of high concern in the developing world and especially Africa (worse starting conditions, weak adaptability and limited adaptation options for African farmers and agricultural production systems, as will be elaborated later). Basically, reduced yields will place more pressure and higher demand for more conversion of lands, extraction of water supply sources for irrigation, introduction of more new exotic plant and animal species, more intensive use of chemical inputs and hence pollution and environmental damage, erosion, etc. seriously accelerating biodiversity loss and extinction. Also, particularly in Africa, where property rights are still to a large extend, either absent or weakly defined and most natural habitats under forest, grasslands and wetlands and water supply sources are exploited under open access regimes, climate change will lead to faster and more excessive rates of harvesting of wild species and natural products and ecosystems goods and services.

This Targeted Research project relates to impact of climate change on agro-ecological systems, cross cutting Window for OP12 on Integrated Ecosystem Management Conservation and OP13 on Sustainable Use of Biological Diversity Important to Agriculture.

The project will assist Burkina Faso, Egypt, Ethiopia, Ghana, Kenya, Niger, Senegal, South Africa, Zambia, and Zimbabwe establish their current assessment of the economic impact of climate change on their agriculture sectors and determine the economic value of various adaptation interventions. In addition, The research project will allow extrapolation of similar assessment to countries not included in the sample. In doing so the targeted research will develop a generic tool which can be applied to countries in other continents.

The methodology developed in the targeted research project will allow at the country level to:

(i) improve national assessment methodologies of impact of climate change and effectiveness of adaptation in agriculture.

(ii) help policy makers and government agencies evaluate intervention policies in the agriculture sector.

From an operational point of view the methodology will :

(i) provide with tools for quantitative, predictive assessment of potential impact on the agricultural sector.

(ii) complement and amend the IPCC process by providing a more country /sector focused assessment of both the impact and the effectiveness of adaptation, which is currently insufficiently developed, and

(iii) Establish regional capacity at both scientific and policy levels for further extension of the methodology into other sub-sectors in the sample countries and other countries that are not included in the sample. Further more, use the capacity that will result from the targeted research project to develop similar work in other continents (e.g., Latin America).

ANNEX C: ESTABLISH THE INSTRUMENTALITY BY DESCRIBING THE BASE-LINE FOR RELEVANT RESEARCH

Although there are well-established concerns about climate change effects on various sectors in Africa, there is little quantitative information concerning how serious these effects will be. Existing agricultural studies cover only a small fraction of Africa, and few of the African studies include data of actual farmer behavior (adaptation includes responses such as planting dates, harvest dates, use of fertilizer, and crop choice). Existing studies (see preliminary review by Rosenthal, 2000 attached to this proposal) mostly examine how individual crops behave in controlled experiments, addressing largely grain crops. Only one study known to address regional impacts in Zambia (Munalula et al., 1999) suggests decrease in net revenue per hectare in various regions in Zambia between 60 and 100%, depending on the region and the climate scenario. There have been numerous programs and projects in various African countries, funded by various donors (See Background document by Rama, 2001 and Annex A-2 for more information). Projects and programs address water supply variability, drought implications and technology transfer. Because many of these projects and programs are done at a country level, or at a sub-regional level, results are not replicable, and in many cases, information produced is not used.

The targeted research will introduce several innovations in the increment. **First**, this study will attempt to include water supply in the analysis. **Second**, this study will attempt to conduct cross-national analyses for the first time. **Third**, the data generated by the project (part of which will be used from base line data collection activities) will be used for a national-level as well as regional analyses that will be extrapolated to surrounding countries not included in the sample. **Fourth**, develop intra-country exchange among various levels of decision makers, and inter-country exchanges between all the country teams participating in the project.

The methodology to be developed in this targeted research will be fully replicable to other countries and regions, and will assist policy makers in the countries and GEF in evaluating various intervention policies. The importance of the proposed project to GEF is in its ability to prioritize, on a global/regional scale, among adaptation measures that may reduce vulnerability of global environmental benefits in certain regions of the African Continent non the first place, and in other continents thereafter.