COSTS IMPOSED BY CLIMATE CHANGE IN THREE ECOREGIONS OF EAST AFRICA

Study prepared for USAID East Africa
Office of Regional Economic Growth and Integration

Joy E. Hecht
Jane Kahata
Katharine Vincent

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Executive Summary

This report, prepared as an input into the design of USAID East Africa's Office for Regional Economic Growth and Integration, presents the results of an assessment of the monetary costs imposed by climate change in three ecological regions of East Africa; the Lake Victoria Basin, the Horn of Africa, and the plains of Kenya and Tanzania. It differs from other work on the impacts of climate change in that it focuses on the costs imposed by climate change rather than on the costs of adaptation; it quantifies those costs in monetary values; and the data are analyzed at the ecoregion level rather than by country. The study focuses on four major areas of climate change impact; crop production, livestock production, coastal flooding, and health. These were chosen for two reasons; because they are expected to be areas of major impact and because comparative data were available on the costs imposed. Climate change is expected to have important impacts in other areas as well, particularly extreme weather events; however comparative data were not available with which to compare the costs that these will impose on the region.

There are several reasons for the decision to quantify climate change impacts in monetary terms. First, unlike the indicators typically used in vulnerability assessments, monetary costs can be aggregated and compared across space areas of impact, which is essential for our study. This would also true if we considered the number of people affected in each region or through each area of impact. However that measure would not provide any information about the significance of the impacts, nor does it provide a way to distinguish those harmed by climate change from those who benefit. Assessing the burden imposed by climate change in monetary costs avoids these problems; they can easily be summed and compared, and they provide an indication of the magnitude and direction of impact. If desired, they can also serve as the cost side of a cost-benefit analysis of different adaptation activities.

Our analysis relies on regional or global databases and models that provide comparable data and analyses for each of the countries in our ecoregions, and on other researchers' analyses of the impacts of climate change. Since the study was designed as a rapid cost assessment to provide policy guidance to USAID, we did not have time to aggregate the results of local or national studies and reconcile differences among them in order to make reliable international comparisons. The overall process of carrying out our study, therefore, has involved locating international standard databases in the key areas, locating other analytical studies that provide the inputs we need to answer the questions of particular interest to us, and doing our own combinations and transformations of those inputs to estimate the costs that climate change will impose. Because we have relied on analytical studies carried out by other researchers, we cannot choose the SRES, climate models, or time horizons that we feel are most likely. These choices have already been made by the analysts whose work we are using; our work must adopt the SRES and climate model choices that they have made.

The overall results are show in the table below. A few points jump out. First, the costs imposed by health impacts are far bigger than those of agriculture or coastal flooding. Our work only considered malaria; the costs due to impacts on malnutrition, diarrheal diseases, or other health problems may make this even greater. Second, the impacts on agriculture are not always negative; in the Horn of Africa and the Plains the value of crops is expected to rise; the value of livestock is also expected to rise in the Plains ecoregion. The impacts on livestock are projected to be much lower than those on crops, which is consistent with its relatively smaller role in the economies of the countries in the region.

Maximum change in value due to climate change between now and 2050, in constant $US 1000s		
Horn of Africa	crops	$279,244
	livestock	-$23,173
	health	-$18,735,515
	coastal flooding	-$244,100
Lake Victoria	crops	-$1,462,686
	livestock	-$90,942
	health	-$10,291,811
	coastal flooding	not available
Plains	crops	$534,509
	livestock	$8,825
	health	-$1,302,610
	coastal flooding	-$287,100

A few recommendations for USAID action follow directly from these values:

- Variation in costs is much greater across areas of impact than across ecoregions; if AID is choosing one type of focus, it should be by area rather than location.
- The high values for health suggest that USAID's Global Health Initiative must incorporate climate change into its planning.

However there is far too much uncertainty, and there are far too many gaps in the study, to conclude that USAID's climate change work should be limited to the health arena. Comparative cost figures like these are only indicators. If costs are much greater in one area than another, they flag our attention to what may be the highest burden of climate change. If they are lower in some areas than expected, that is also a flag, telling us that we need to look more closely in order to understand what underlies our calculations, whether they are reliable, and if so why our expectations were incorrect. Like most indicators, this one alerts us to important issues, but it does *not* tell us what to do about those issues. Indicators are simplistic measures that raise a flag to draw our attention. They are not complex analyses, and therefore they neither give us insights on the driving forces behind the vulnerability, nor tell us how to resolve the problems that raised the flags in the first place.

While the focus on costs that is the basis for this study is interesting, it is not sufficient for allocating resources. Within a country, and even more within an ecoregion, summing the costs will allow benefits accruing to one group to mask harm incurred by another. While this is "correct" from a perspective of total costs, it does not give a complete understanding of who will be affected by climate change and how, or how many people are harmed and how many are better off. These equity concerns suggest that USAID may want to complement this study with analysis of how many people will be affected by climate change and who they are, looking more narrowly at which social groups will be affected in each direction, and at their ethnic identity, gender, level and source of income, education, and other socioeconomic features. USAID could carry out some of this analysis itself, but a more constructive strategy may be to work with the appropriate regional institutions to enable them to analyze and systematically track these issues.

In the area of agriculture, further investigation is needed to understand more fully what the impacts of climate change may be and how to ensure that projected increases in output actually occur. The increases in output projected by the research we have used depend on investments in agricultural

research; if these are not understood and made, then yields may drop rather than rising. Moreover, the model does not consider whether additional land is actually available for food production; issue must be explored at a more detailed scale in East Africa to determine how and where crop production actually can grow with climate change. Our analysis has also not considered the crop mix that would make up the increases in production in two of the three ecoregions; if Feed the Future wishes to rely on this work, they must examine the models further, to determine what the crop balance is expected to be with climate change. Beyond the models we have used, climate change will affect food supply through the impact of extreme events, both on the ability to grow food in the face of floods or droughts, and on the ability to market or import food if transport networks are damaged. While we recommend that the Global Climate Change Initiative take the lead in considering extreme events, Feed the Future should be involved as well, since its outcomes will be important for food security.

Several activities may be useful to respond to the health implications of climate change. One is for USAID to work with regional institutions to identify the specific places within the region that are most at risk of increased malaria, in order to determine where prevention activities must be targeted. Another useful strategy may be to develop early warning systems to predict outbreaks of malaria or other diseases based on seasonal or ten-day weather forecasts. In addition, it will be important to look into the implications for other diseases well, as research begins to shed more light on this issue. The Global Health Initiative should collaborate with the GCCI in strengthening data and analysis of all of these issues.

Although our analysis of extreme weather events was limited to coastal flooding, we expect them to impose high costs throughout the region. Addressing the lack of systematic information in this area may be a constructive use of USAID regional resources. One strategy may be to strengthen institutional structures for collecting more detailed data about disasters, so as to build a database with richer information about East Africa than that provided by EM-DAT. USAID may also wish to engage academic researchers in East Africa and elsewhere to focus on modeling the economic impact of climate-related disasters in the region. USAID should also build capacity in regional institutions to analyze the implications of extreme weather events for specific coastal cities, and perhaps more importantly, for transportation and economic activity throughout the East Africa region. The results of this analysis will be crucial for urban and regional planning for the next fifty to one hundred years, given the close links between settlement patterns, infrastructure development, and the costs imposed by sea level rise. It will also be crucial for application of the recently-completed diagnostic study of East Africa trade corridors, which does not now include any projections of the impacts of extreme weather events on traffic flow.

The approach taken in this study may offer a useful strategy for other institutions working on vulnerability assessments and adaptation. Several issues are relevant to the question of whether this approach should be considered elsewhere. First, is monetary cost a useful measure of the impacts of climate change? The answer to this question is mixed. On the one hand, monetary cost is a very useful measure because it permits comparison and aggregation and can capture the relative importance of different impacts. On the other hand, total cost can be misleading if benefits in one place balance out costs elsewhere, and more detailed analysis is needed to understand the equity impacts. Thus while cost is a useful indicator of the impacts of climate change, it should must be paired with information about how many people are affected, who they are, and how they are affected. This combination of measures can provide a much richer understanding of the impacts of climate change than any one of them alone.

Second, how adequately do global or continental studies of the impacts of climate change describe what may happen in any individual country? Our experience has been mixed in this respect. Analyses based

on sub-national spatial data, such as the malaria analysis we used, may be more reliable when aggregated to the national scale than those based on using national statistics in a global model, as is the case of the crop production analyses. On the other hand, all of these may be more reliable at the national scale than the Ricardian analyses, which are based on sample data for eleven countries extrapolated to the continent, and then disaggregated based on agroecological zone. Policy-makers interested in relying on this kind of work to inform national decisions will have to understand clearly how the studies are designed, so they can assess whether the results are in fact likely to be useful for their purposes.

The third key question is how easily the results of global or continental studies can be used by an agency with modest resources to shed light on its own decision-making. Our answer to this has to be that at present this is not easy enough. While databases distributed by the United Nations, the IMF, CIESIN and other NGOs are easy to use, and some institutions building analytical models also make an effort to make them available to potential users, accessing and using the results of analytical work is more challenging. Policy-makers like those at USAID do not have time and resources to learn about and run models themselves, or to hire someone else to do it for them. Following the model of benefits transfer in environmental valuation, they would like to be able to apply other analysts' results to their own situations, and this is not easy enough. While the authors of the studies we used clearly realize the importance of their results and the utility of their data to other analysts, none of them has made them easy enough for others to access and apply. Rather, researchers carrying out these studies seem to expect that their colleagues will consider the conclusions of published papers, but they do not expect anyone to want to use their digital results as input into other analyses.

Helping policy-makers to use the results, rather than simply the conclusions, of the extensive research now being carried out on the impacts of the climate change should be a high priority for everyone working in this field. To achieve this, it is important for both authors and publishers to think about how to present the results so that they can actually be applied to policy analysis. This is not the norm for conventional academic publications, so it will take some changes in thinking about these issues; it will not happen automatically. It may be useful for USAID to identify and support an institution that already plays a significant role in disseminating the results of climate change research, and that is already tracking new work in the field, to take on the task of helping authors and publishers to make their results more easily usable by other analysts. This would be a valuable contribution to helping policy-makers use the existing research more fully than is now the case.

On the whole, then, it seems that studies of the type we have carried out are feasible, and can make a useful contribution to decision-making about adaptation. Cost is a very useful measure of climate change impact, although it should not be used separately from complementary indicators that shed more light on how many people are affected, how, and who they are. Although not all global studies will offer meaningful results at a national or regional level, some will; the use of this work to inform national policy-making should not be ruled out. And while there are logistical challenges in actually accessing the results of other analytical work in a usable format, these should be surmountable with investment in how they are made available to the public.

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AOGCM	atmospheric and oceanic global climate model
CC	climate change
CCC	Canadian Centre for Climate Modeling and Analysis
CCSR	Centre for Climate Systems Research (Columbia University, New York)
CIESIN	Center for International Earth Science Information Network
COMESA	Common Market for Eastern and Southern Africa
CSIRO / CSI	Commonwealth Science and Industrial Research Organization (Australia)
DIVA	Dynamic Interactive Vulnerability Assessment model
EAC	East African Community
EM-DAT	Emergency Events Database
GCCI	Global Climate Change Initiative
GCM	global climate model
GHG	greenhouse gases
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
I&R	Iglesias and Rosenzweig
MIROC / MIR	medium resolution model of the Center for Climate System Research at the University of Tokyo, the National Institute for Environmental Studies, and the Frontier Research Center for Global Change, in Japan
NAPA	National Adaptation Plan of Action
PCM	Parallel Climate Model
SADC	Southern African Development Community
SEDAC	Socioeconomic Data Applications Center
SEI	Stockholm Environment Institute
SRES	Special Report on Emissions Scenarios
VA	vulnerability assessment

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Any errors in this report are our responsibility, and in no way the fault of the many people who provided their assistance.

Joy Hecht

1. Introduction

This report is an input into the design of a regional climate change adaptation program, to be carried out by USAID East Africa's Office for Regional Economic Growth and Integration. It presents the results of an assessment of the monetary costs imposed by climate change in three ecological regions of East Africa.[1]

Several features of this study distinguish it from other work on the impacts of climate change. First, it focuses on the costs imposed by climate change, and not on the costs of adaptation. Second, it quantifies those costs in monetary values, rather than using the indicators or qualitative reviews common in vulnerability assessments. Third, the data are analyzed at the ecoregion level rather than by country. The use of ecoregions reflects differences in topography, weather, and agricultural potential across East Africa, and makes it possible to capture the different impacts of climate change in each area. The assessment of impacts in monetary terms makes it possible to directly compare the impacts of climate change across the ecoregions and across areas of climate change impact.

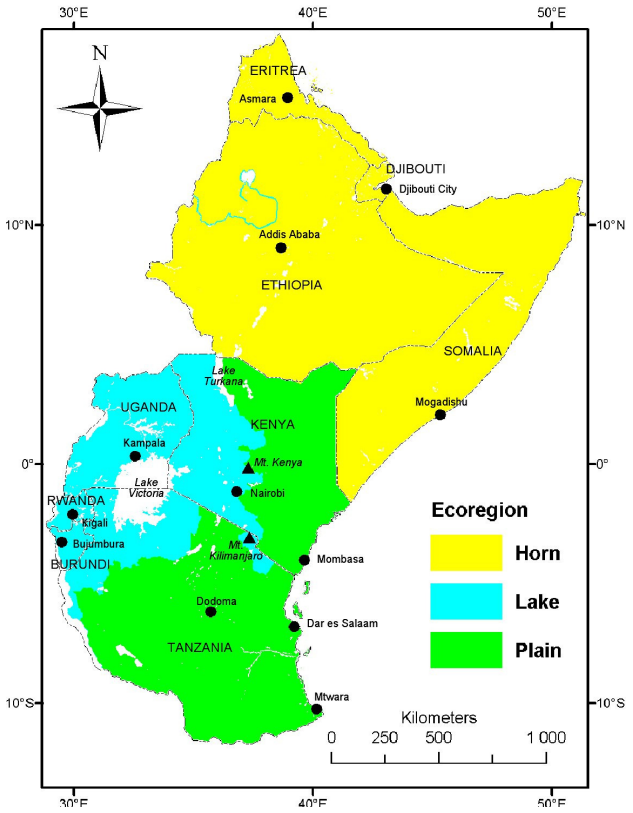

Figure 1. East Africa ecoregions used in the study

The ecoregions analyzed in this study are shown in Figure 1. The Horn of Africa region, in yellow, includes all of Eritrea, Ethiopia, Djibouti, and Somalia. This is the driest ecoregion in the study, although the Ethiopian highlands show considerable variation in rainfall levels and vegetation characteristics. The population of this region was about 99 million in 2005.[2] The Lake Victoria basin, in blue, includes all of Burundi, Rwanda, and Uganda, plus the highland areas of Kenya and Tanzania and high-elevation areas around Mounts Kenya and Kilimanjaro. It is generally characterized by mountainous areas, humid forests and savannas, and of course numerous lakes. The population of the region was about 95 million in 2005. The plains region, in green, includes eastern Kenya and Tanzania. This is an area of arid to somewhat humid savannah, without the extreme topography of the Lake region or the highlands of Ethiopia. The population of the plains ecoregion was about 36.5 million in 2005.

The study considers the impacts of climate change in a number of areas. These areas were selected using two criteria. First, the climate change literature anticipates that they will be key climate change impact areas for East Africa.

[1] This report, the spreadsheets underlying it, and most of the reports in the reference list are available at http://www.joyhecht.net/East Africa Climate Change/eacc.html.

[2] All population data used in this study come from the CIESIN Socioeconomic Data Applications Center (SEDAC) Gridded Population of the World dataset, version 3, for 2005, available at http://sedac.ciesin.columbia.edu/gpw.

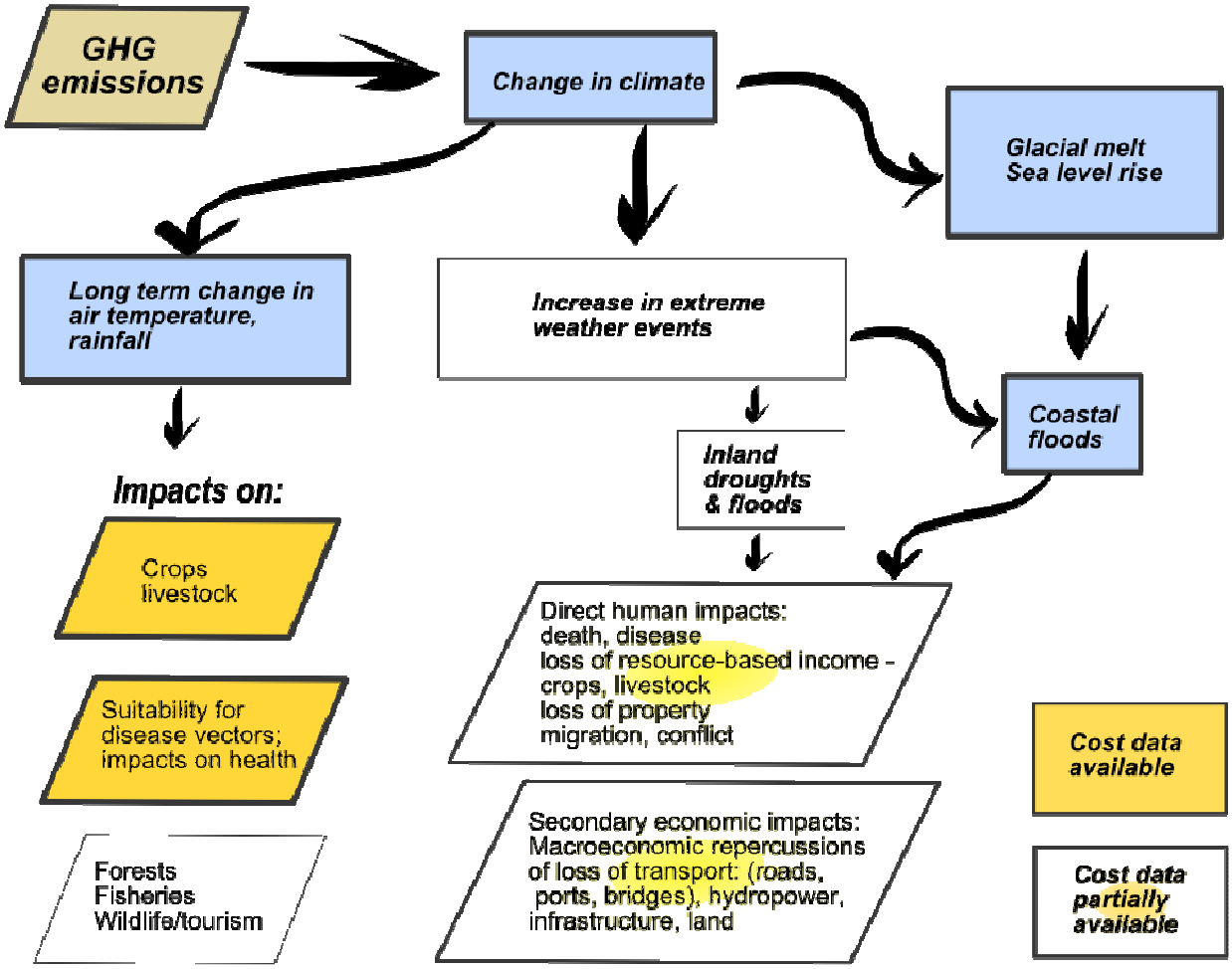

Figure 2. Impacts of climate change on human societies

Gray shading: Inputs into the environment
Light blue shading: Physical impacts on the environment about which we have data
Yellow shading: Impacts for which we have cost data
Yellow burst: Impacts for which we have partial data
Unshaded: No data available

Secondly, quantitative empirical data on them is already available. We use the term "areas of climate change impact" because, although some of them are economic sectors, others are not. These areas are depicted in Figure 2, which presents a simplified chain of links between the increase in greenhouse gas emissions, various parameters of the physical environment, and the resulting costs imposed on humans.

The starting point in this flow chart is the greenhouse gas (GHG) emissions, shown in the parallelogram in the upper left. These cause changes in the earth's climate system, which are modeled by climate scientists to estimate changes in physical parameters that in turn bring about specific changes that will affect humans. The changes shaded in light blue – long term change in air temperature, rainfall, glacial melt, sea level rise, and coastal floods – are those changes in physical parameters that we have been able to quantify in this study. The changes in the unshaded box –increases in extreme weather events,

causing inland droughts and floods – are more difficult to model accurately, and thus, while important, are excluded on the grounds that we have not been able to locate data on the costs they impose.

Our flow chart does not include impacts on hydrology and the availability of surface or ground water. If, as the Intergovernmental Panel on Climate Change (IPCC) predicts (see discussion in section 2.3 below), climate change will lead to an increase in rainfall in East Africa, this will not be a matter for concern. Moreover, given the IPCC predictions, water availability has not been the focus of other analysts' work in the region, which means that systematic data are not available on the issue for our use.

The parallelograms in the lower portion of the flow chart show the outputs, i.e. the impacts on human beings. Those shaded in solid yellow – crops, livestock, suitability for disease vectors, impacts on health – are those for which we have data for our region. The ones with a burst of yellow are those for which we have some but not all data; specifically, we have data on the costs imposed by sea level rise and coastal flooding, but not the costs imposed by extreme weather events inland. The unshaded parallelogram in the lower left includes areas for which cost data were not available, essentially because in economic terms these areas of impact are of relatively low importance compared to agriculture and health, so they have received less attention from analysts of the costs imposed by climate change.

This report is in nine sections. The second describes the methodology used for the assessment. Sections three through seven describe the quantitative analysis of agriculture (crops), livestock, a combination of crops and livestock, health, and sea level rise. Section eight discusses climate impacts related to extreme weather events, which could not be quantified but are nevertheless very important. Section nine discusses the implications of our findings for USAID programming and for future work of this type.

2. Methodology

2.1 Choosing a metric for the assessment

There are several reasons for the decision to quantify climate change impacts in monetary terms. Vulnerability assessments (VA) are typically conducted at a detailed scale in a fairly small geographic area, rather than at the ecoregion scale of our analysis. To obtain results for an ecoregion, it would be necessary to aggregate the results of a number of VAs, and draw conclusions about the larger area of which they are a part. However, VAs can use a number of different methods, with the results expressed in terms of indicators that are particular to the individual study. As a result, it is not possible to aggregate the results of several VAs conducted in the same geographic area, because they do not use the same measures to express their findings. For the same reason, it is not possible rigorously to compare the results of a group of VAs, as we wish to do in comparing the impacts of climate change across both ecoregions and areas of impact.[3]

Another possible metric for our assessment could be the number of people affected in each region or through each area of impact. This has the advantage that it can be quantified and the results of individual studies can be compared with each other. However it does not provide any information about the significance of the impacts, nor does it provide a way to distinguish those harmed by climate change from those who benefit.

Assessing the burden imposed by climate change in monetary costs avoids these problems. Costs can be summed across countries or other geographic areas, and they can easily be compared across areas of impact. If the valuation is complete, including non-marketed as well as marketed costs, they capture the significance of impacts, since less significant ones will impose lower costs. Even where it is only possible to capture market values (as opposed to the estimated monetary value of non-marketed impacts), they still provide more insight into the magnitude of the burden imposed than would be obtained by counting the number of people affected. Thus monetary measures can provide a fairly straightforward way to prioritize the problems created by climate change. If desired, they can also serve as the cost side of a cost-benefit analysis of different adaptation activities.

For all of these reasons, monetary costs offer the most practical way to compare the burdens imposed by climate change across ecoregions and areas of impact.

2.2 Costs imposed vs. costs of adaptation

This study is focusing on the costs imposed by climate change, not the costs of adaptation. This is an important distinction. Climate change will affect people, making their lives more difficult by reducing incomes, causing disease, and in some cases causing humanitarian disasters. These are the costs imposed by climate change. If societies anticipate these challenges, they will take steps in advance to reduce or prevent them; the cost of these steps is the cost of adaptation. Our study focuses on the first part of that process, calculating the costs that climate change will impose in the absence of any adaptation to minimize those harms.

[3] Annex A outlines a number of key vulnerability assessments which have been conducted at various scales and for different impact areas in East Africa.

This is an innovative approach. The majority of existing climate change cost studies have been conducted as inputs into the United Nations Framework Convention on Climate Change policy process. Consequently, they have focused on the cost of adaptation as an input into discussion of who pays for climate change. Calculating the costs imposed by climate change in this study gives an indication of the relative impacts by area, which is useful for prioritizing needs for interventions.

Although the distinction between costs imposed by climate change and costs of adaptation may seem obvious, in practice it is not always clear. In some situations, particularly with respect to long-term gradual change rather than extreme events, people will adapt to climate change without any investment in adaptation programs. In the case of livestock, for example, research shows that some animals do better in warmer climates than others. Where pastoralists now have a mix of animals, they are likely to shift towards those that remain healthier as temperatures rise, and a public sector program to encourage them to adapt may be unnecessary. Or, to take a more extreme case, if sea level rises slowly over time, people will not stay where they are and drown, they will move away from the water. Migration could be understood as a form of adaptation, and the cost imposed would be the death of people who stayed to drown instead of migrating – but this is clearly foolish. In cases like these, there may not really be a cost imposed in the "no adaptation" scenario, because not adapting at all is inconceivable.

2.3 About Climate Models and Socioeconomic Scenarios

The links between greenhouse gas emissions and the changes in weather and sea levels that will impose costs in East Africa are modeled in global climate models, depicted by the light blue boxes in the upper part of the flow chart in Figure 2. These are highly complex, three-dimensional models of the physical, biological, and chemical processes that drive the global climate system, covering the atmosphere, the oceans, or the coupled atmospheric-ocean system.

In order to run these models, analysts must make some assumptions about the level of greenhouse gases that will be emitted, which in turn determine the concentrations of CO_2 in the atmosphere. The level of GHG emissions is itself dependent on population growth and the growth and structure of the global economy; how many people are there, what kind of energy sources do they use, how much do they consume? Moreover, the impact of climate change on society depends on how many people there are, where they live, and their needs for food and consumer goods. For example, the impacts of sea level rise depend on how many people live near the coast as well as how much the water rises; the extent of global food shortages with climate change (if there are shortages) depend on how many mouths must be fed as well as how much food can be grown.

In order to organize the analysis of climate change, the members of the IPCC developed a set of commonly used scenarios to describe global population and economic growth. These were published in the *Special Report on Emissions Scenarios*[4], and they are commonly referred to as the "SRES scenarios" or simply "SRES." The SRES, of which there are about forty in all, are grouped into four "families" or "storylines," A1, A2, B1 and B2. Each explores a different development pathway, incorporating a wide range of demographic, economic and technological driving forces, and resulting in different levels of GHG emissions:[5]

[4] Nakicenovic and Swart, 2000.

[5] A summary description of the SRES may be found at http://www.ipcc.ch/ipccreports/sres/emission/index.php?idp=3.

- The A1 storyline assumes a world of very rapid economic growth, a global population that peaks in mid-century, and rapid introduction of new and more efficient technologies. A1 is divided into three groups, in which different sources of energy predominate. The A1F1 scenario is fossil-fuel intensive, A1T relies on non-fossil energy sources, and A1B relies on a balance of fossil and non-fossil sources of energy.
- The A2 storyline depicts a world characterized by regional self-reliance and the preservation of local identities. Population growth rates, per capita incomes, and technological change diverge significantly among regions, so the global population continues to grow rapidly while the global income distribution is inequitable.
- In the B1 storyline, different regions of the world converge rather than diverging in their development patterns. The global economy is increasingly based on services and information, becoming less material intensive, and emphasizing the introduction of clean and resource-efficient technologies. Consequently greenhouse gas emissions will tend to be lower in the B1 family of scenarios than elsewhere.
- The B2 storyline is characterized by population growth between the levels of A1 and A2, and by less rapid but more diverse technological change than in A1 or B1. Economic development in this world occurs at an intermediate pace. While there is some emphasis on environmental protection and social equity, solutions to these problems are sought at the local and regional levels rather than globally.

Projections of the change in global temperature due to GHG emissions are always based on assumptions about which of these scenarios will prevail over the coming century. Table 1 shows what the IPCC considers the best estimates of global average temperature change and sea level rise at the end of the 21st century. As we might expect from the description of the SRES, the lowest changes in temperature and sea level arise under the B1 scenario, while the highest occur under A1F1.

Table 1. Projected global average surface warming and sea level rise at the end of the 21st century.

	Temperature Change		Sea Level Rise
	(in °C at 2090-2099 relative to 1980-1999)		(in m at 2090-2099 relative to 1980-1999)
Case	Best estimate	Likely range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59
Source: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-projections-of.html			

Globally there is less agreement on the changes expected in rainfall levels. Most climate models suggest that precipitation is expected to increase by as much as 20% in extreme latitudes. Around the equator, precipitation is also expected to increase, though there is less certainty about this projection. In temperate latitudes, on the other hand, many models show decreasing precipitation, particularly in the Sahara and Mediterranean. Figure 3, from the IPCC, shows the expected changes between the period from 1980-1999 and 2090-2099. The map on the left is for the period from December to February, while that on the right is for June through August, and all projections are for the A1B SRES. Checked areas are those for which 90% of models agree on the direction of change, while solid areas are those where less than 66% are in agreement.

Global climate models are downscaled to the national level, making it possible for us to look at the predictions for our ecoregions. Table 2 shows predictions of temperature and precipitation change for three SRES scenarios, for each of the three ecoregions. In all three regions, rainfall is expected to increase, which is in keeping with the global predictions depicted above. The greatest impacts are predicted in the Horn, and the smallest in the Lake Victoria Basin; again, as expected, the A2 scenario is expected to lead to the most change and the B1 scenario to the least.

Table 2. Temperature and Precipitation Predictions for East Africa

Region	SRES	Temperature Change (degC)		Precipitation Change (%)	
		2050s	2080s	Mid Century	End Century
Horn of Africa	High A2	2.0-2.5	3.0-3.5	40%-50%	40%-50%
Horn of Africa	Medium A1B	1.5-2.0	2.5-3.0	40%-50%	30%-40%
Horn of Africa	Low B1	1.0-1.5	1.5-2.0	40%-50%	20%-30%
Lake Victoria Basin	High A2	1.5-2.0	2.5-3.0	0%-10%	10%-20%
Lake Victoria Basin	Medium A1B	1.0-1.5	2.0-2.5	10%-20%	10%-20%
Lake Victoria Basin	Low B1	1.0-1.5	1.0-1.5	0%-10%	0%-10%
Plains	High A2	1.5-2.0	2.5-3.0	10%-20%	10%-20%
Plains	Medium A1B	1.0-1.5	2.0-2.5	10%-20%	10%-20%
Plains	Low B1	1.0-1.5	1.0-1.5	10%-20%	0%-10%

Source: Compiled from data at www.climatewizard.org.

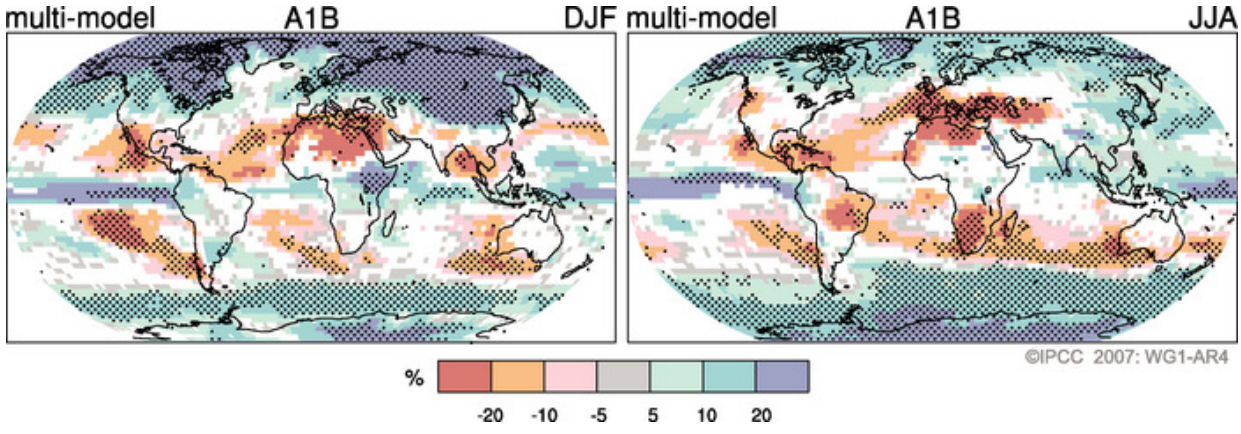

Figure 3. Percent changes in precipitation for 2090–2099 relative to 1980–1999
Source: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/figure-spm-7.html

The predictions in Table 2 are based on the IPCC Fourth Assessment Report. However there is great uncertainty in this work. While models predict long term trends, they are unable to project variability within those trends; thus a long term increase in average rainfall might still present itself with an increasing frequency of drought, interspersed with shorter periods of heavy rainfall. The uncertainty of climate science is further highlighted by more recent research finding that East Africa has experienced more severe drought in recent years, which is likely to continue and be exacerbated in the future.[6] All of the research on which this paper relies assumed that the IPCC predictions are correct, and therefore that precipitation will rise in our region with climate change.

2.4 How do we estimate costs?

Many studies look at the costs imposed by climate change within a community, in one country, or within one sector; the Stockholm Environment Institute, for example, has carried out detailed analyses of the costs of climate change in Tanzania, Rwanda, and Kenya.[7] Other studies calculate parameters that could be included in analyses of the costs of climate change in specific places. While in some cases it may be possible to take a bottom-up approach to calculating costs at the ecoregion scale, aggregating the results of these studies is often difficult, because the methods used for one analysis are not comparable with those used elsewhere. Moreover, there would inevitably be major geographic gaps, since not all areas would be covered by the different studies. Extrapolating results from studies conducted for small spatial areas to estimate the costs across a country or ecoregion would introduce a large margin of error in their work.

For these reasons, our analysis relies on regional or global databases and models that provide comparable data and analyses for each of the countries in our ecoregions, rather than aggregation of the results of local or national studies. This approach has been applied in all of the data we have collected for the study. Thus the baseline population data for the study come from the CIESIN Socioeconomic Data Applications Center (http://sedac.ciesin.columbia.edu/gpw), rather than from the national statistical offices of the nine countries covered by the study. Our agricultural statistics come from FAOSTAT (faostat.fao.org) rather than from the agriculture or statistical departments of the nine countries. In some cases this may mean that for individual countries we are not using the most detailed or complete data. However this disadvantage is balanced against the fact that this approach ensures that the data we are using mean the same thing across countries, because respected institutions have dealt with standardizing them in order to create internationally compatible databases, a task which we could not take on ourselves.

Our study is relying, as well, on other researchers' analyses of the impacts of climate change, when these can be applied at the scale of our ecoregions and used as inputs into our cost estimates. The overall process of carrying out our study, therefore, has involved locating international standard databases on the issues of interest, locating other analytical studies that provide the inputs we need to answer the questions of interest to us, and doing our own combinations and transformations of those inputs to estimate the costs that climate change will impose. The details of how we did those calculations for each area of impact are presented in the chapters describing our analysis.[8]

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[6] Williams and Funk 2011.

[7] Stockholm Environment Institute 2009a and 2009b; also see http://economics-of-cc-in-tanzania.org/reportsandpublications.html, http://rw.cceconomics.org, and http://kenya.cceconomics.org.

[8] The spreadsheets containing our data and calculations are also available at http://www.joyhecht.net/East Africa Climate Change/eacc.html.

The data we have gathered measure a variety of different kinds of costs. The agriculture data estimate the change in the market value, in current prices, of crops or livestock that will be sold in 2050 with climate change. Thus they do not represent farmers' income, since they are not net of the expenses incurred in producing those products. The health data are estimates of the costs imposed on the society by death and illness, valued using GDP per capita. This could be understood in a variety of ways; as a proxy for the financial and emotional costs imposed on the families affected by health problems, as a proxy for the income lost by the economy of the country, as a combination of household costs, decreased GDP, and direct expenditures across the economy related to disease, or in other ways. The costs imposed by sea level rise are a mix of costs. They include GDP-related values that may be interpreted in ways similar to the health costs, lost value of submerged assets, decreased incomes due to assets degraded by the sea, and estimates of the economic value of lost non-marketed environmental services. Although we compare these costs with projections of GDP, as discussed below, none of them actually represents a change in GDP due to climate change. In some cases they represent direct financial losses to households harmed by climate change, but this is not always the case.

Because our study is based on analytical studies carried out by other researchers, we cannot choose the SRES or climate models that we feel are most likely. These choices have already been made by the analysts whose work we are relying on; our work must adopt the SRES and climate model choices that they have made. Similarly, we cannot change the time projections. Some of the models we have used project to 2050, while others go to 2100; we can only look at our ecoregions over the same time periods.

The impacts of climate change are typically expressed in a particular year, e.g. change in temperature from 1990 to 2090, or additional disease that will occur in 2050 because of climate change. We have estimated costs in the same way, in terms of the additional cost in a given year in the future because of climate change. Our cost estimates are not cumulative; we are not estimating all the costs from now until that year, but only the cost that will be borne in a specified year in the future. This is how the studies on which we have relied calculate their costs, so we will do the same.

2.5 Scaling the costs: GDP projections

The costs imposed by climate change are hard to evaluate without putting them into a context that may suggest the magnitude of the impact. Although the costs we have estimated do not measure how GDP will be affected by climate change, we have used the ratio of climate change costs to GDP as an indicator of the significance of different areas of harm, and of the economic impact of each area of climate change.

To do this, we sought baseline projections of GDP into the future to provide a basis of comparison. We did not find them, however. This was no surprise; 50- or 100-year projections of GDP would necessarily be so inexact that no economic organization is likely to publish them. We therefore did projections ourselves, not because we believe they are accurate, but simply to have some basis for comparing the importance of climate change costs across ecoregions and areas of impact.

Our projections are straightforward linear extrapolations of IMF GDP figures for 2006 through 2013[9]; obviously these figures include IMF projections for a few years into the future. The IMF provided growth rates in constant dollars, which we averaged for 2006-2013. We then applied those rates to

[9] Downloaded from http://www.imf.org/external/pubs/ft/weo/2008/02/weodata/index.aspx.

actual 2005 GDP in current dollars to project each country's GDP to 2100.[10] (Because there are no national accounts data for Somalia, our projections do not include that country.)

Obviously, the resulting figures should not be taken as reasonable estimates of GDP for any of these countries, nor for the region as a whole, since they do not in any way attempt to factor in expected changes in the region or in individual countries within it. However, they do provide a useful way to get a rough sense of the potential importance of the different impacts of climate change. They certainly should not be used for any other purpose.

2.6 Converting national data to ecoregion level

Most of the data used in this study are national level data. Seven of our nine countries fall entirely within one ecoregion; only for Kenya and Tanzania are data allocated between ecoregions. Those two countries have been divided into ecoregions along the boundaries of political jurisdictions.[11] In most cases (except for livestock), data on Kenya and Tanzania have been allocated to ecoregions based on the share of population living in each. This is the basis for calculation of GDP at ecoregion level and for allocating crop yields and health costs. Sea level rise is entirely allocated to the plains region of Kenya and Tanzania. The livestock calculations are more complex, and are explained in that section of the report.

[10] The projections are available in the spreadsheet entitled "economic and population data March 2011."
[11] The list of which jurisdictions are assigned to which ecoregion is in the spreadsheet entitled "economic and population data March 2011."

3. Agriculture: Crop Growth and Trade Models

The impact of climate change on food production is obviously a major concern, both at the global scale and for East Africa. Quantitative analyses of this issue are designed to address the question of whether the world will be able to grow enough food to meet the needs of its population with climate change.

Two major modeling efforts addressing this issue have provided data at the country level that could be used in our study. One of these was carried out by the International Food Policy Research Institute (IFPRI)[12], and the other by Ana Iglesias and Cynthia Rosenzweig (I&R).[13] Both of these studies begin by projecting the production of major cereals and other food crops at the national level under a range of SRES scenarios and climate models. In making these projections, both models assume that the land is available to increase agricultural output; neither builds spatial data on land use into the model, nor do they estimate the opportunity costs of land that might be reallocated from other uses to agriculture. The IFPRI model builds in exogenous assumptions about changes in agricultural technology that lead to increased yields; it is not explicitly stated whether the I&R work does the same.[14] The predicted changes in crop production are then fed into models of world food trade, which are used to estimate price changes and the imports or exports of food crops from each country.

From our perspective, there was one important difference between these two studies. The I&R work predicts total crop production under a number of different SRES scenarios, but does not predict it under a "no climate change" scenario. The IFPRI study, in contrast, predicts output under two SRES scenarios and using two climate models, plus they predict agricultural output with no climate change. By calculating the difference between the projections under the four climate options (2 SRES x 2 climate models) and the no climate change scenario, we have an estimate of the change in output due specifically to climate change, which can be used to estimate the economic costs of climate change. This is not possible with the I&R results. We have, however, worked with both sets of data, in order to compare the overall output trends predicted by the two models.

3.1 Applying the Iglesias and Rosenzweig results

The I&R study projected growth of three crops; maize, rice and wheat. They provide data for the average production of these crops from 2000 to 2006 for each country, and percent changes from the baseline to 2020, 2050, and 2080.[15] We have applied these growth rates to data on the top twenty

[12] Nelson et al, 2010.
[13] Iglesias & Rosenzweig 2010
[14] The full data from the I&R work is available on the web (at http://sedac.ciesin.columbia.edu/ mva/cropclimate/); however documentation on how the study was carried out is not available at that site. A request to the authors for detail on their methodology received no reply; hence it is not possible to specify exactly how their work was carried out.
[15] The Data Dictionary worksheet of the I&R spreadsheet, cells A4-C6, explains that the baseline production levels for rice, wheat and maize (labeled RI_2000, WH_2000, and MZ_2000) are an average of values from 2000-2006. In subsequent entries in the dictionary, they explain that their values for change in value between the baseline and 2020, 2050, and 2080 apply their growth rates to 1990 production figures. It is not clear whether in fact their baseline is for 1990 or 2000-2006, although the calculated changes do equal the given baseline times the given rates of change. We have assumed that in fact the baseline is an average of 2000-2006 values.

crops by value for each of our nine countries, available from the FAO.[16] This was done in a series of steps:[17]

Table 3. Simplification of SRES

A1FI	A1FI
A2a	A2
A2b	
A2c	
B1a	B1a
B2a	B2
B2b	

- Average the 2000-2006 production and value of each crop for each country.
- Average the I&R growth rates to reduce their seven SRES down to four, in order to simplify our results, as shown in Table 3. We do not know what precipitation and temperature levels underlie the I&R work; however the authors also averaged SRES in this way, so it should be acceptable.[18]
- For each I&R crop that is part of the country's top twenty, apply the I&R growth rates to the average values for 2000-2006, to calculate the value of output in 2020, 2050, and 2080.
- Sum the values just calculated, and use them to calculate overall growth rates to 2020, 2050, and 2080.
- Apply the overall growth rates to each of the other crops in the country's top twenty plant products (not to animal products) to estimate their value in 2020, 2050, and 2080.
- Sum all of the 2020, 2050, and 2080 values across crops to calculate the total value of agricultural output in those years.

This methodology implicitly assumes that the growth rates estimated by I&R for rice, wheat and maize can be averaged to project growth of other crops, i.e. that other crops will be affected by climate change and world trade patterns in the same way as the major cereals that are the focus of the I&R work. This assumption is obviously open to question; different plants will certainly respond in different ways to changes in climate conditions. As discussed below, we have made the same assumption when working with the IFPRI data. While we were not able to contact Iglesias and Rosenzweig to get their view of whether this result was within acceptable ranges of error, the authors of the IFPRI work did feel it was an acceptable assumption to make when using their results.[19]

Although the production figures used to project changes in overall crop values are the output of a trade model, the values we estimate do not capture changes in prices resulting from shifts in production and trade. We are applying the calculated total growth rates to FAO data on the value of output in the baseline time period, which implicitly assumes that prices remain unchanged over time. Of course this will not actually be the case; however we have no basis for predicting the changes in crop prices without running our own models on agricultural trade, which we cannot do.

The results of these calculations are summarized in Tables 5 and 6 below, along with results using the IFPRI data.

[16] Country data on the top twenty crops by either quantity or by value, for any year from 1961 to 2008, are available at http://faostat.fao.org/site/339/default.aspx. We downloaded data on the top twenty by value for 2000-2006 for our analysis. We would have preferred to use data for more agricultural products than simply the top twenty, especially as for some countries many of those were animal rather than plant products. However, while the FAO website provides quantity data for many other products, it does not provide value data for any other than the top twenty, so this was not possible.

[17] The full detail of the calculations can be followed in the spreadsheet entitled "Crops March 2011."

[18] Iglesias and Rosenzweig 2010, worksheet labeled "CO2 level and avg yield change"

[19] Email from Gerald Nelson, IFPRI, 24 December 2010.

3.2 Applying the IFPRI results

The IFPRI study covers six crops (cassava, groundnut, maize, rice, soybean, and wheat) using 2000 values as a baseline, and projects output of each crop in each country at five-year increments from 2010 to 2050. They present results for two SRES, A1B and B1, and simulate impacts on climate conditions using two climate models, termed CSIRO or CSI[20] and MIROC 3.2 or MIR.[21] Nelson et al (2010) provides figures for the changes in temperature and rainfall predicted by the two climate models in East Africa for the A2 SRES, though not for A1B and B1; these are shown in Table 4. Since we do not have the corresponding numbers for the A1B and B1 SRES, we don't know exactly what projected changes in climate underlie the results we are using; however this table does show several things. First, the changes in temperature are about at the average of the regional temperature changes presented in Table 2. Second, the rainfall change is at the low end of the projections in Table 2. Third, the MIROC model projects somewhat more moderate temperature change but greater change in precipitation than the CSI model.

Table 4. Changes in East Africa precipitation and temperature underlying IFPRI work

	Change in Precipitation		Change in Temperature	
Model	%	Millimeters	Average Min °C	Average Max °C
CSIRO	0.9	7.7	1.68	1.63
MIROC 3.2	14.0	120.5	1.89	1.28
Source: Nelson et al Table A2.3, pp. 85-6				

The IFPRI work presents results for the two SRES and climate models, and for a "perfect mitigation" scenario that is equivalent to one with no climate change. For each scenario, they have calculated an optimistic projection (lowest levels of population growth and highest levels of income growth), a pessimistic projection (highest population and lowest income), and a middle-of-the-road projection that they term the baseline. To simplify our results, we have averaged their optimistic, pessimistic, and baseline projections, so we have five scenarios rather than fifteen.[22]

Our steps for applying the IFPRI results are similar to those used for the I&R data:[23]

- For each IFPRI crop that is part of the country's top twenty, apply the average growth rates for the five scenarios to the value of production in 2000 from the FAO data, to estimate the value of production from 2010 through 2050.
- Sum the value of production for the IFPRI crops and calculate overall growth rates for each five-year period.
- Apply those overall growth rates to each of the other top twenty crops (again, not to animal products).
- Sum the values of all crops to obtain the value of production between 2010 and 2050 for each of the five scenarios.

[20] Commonwealth Science and Industrial Research Organization, in Australia

[21] The medium resolution model of the Center for Climate System Research at the University of Tokyo, the National Institute for Environmental Studies, and the Frontier Research Center for Global Change, in Japan.

[22] For reasons that are not clear, the IFPRI production projections are consistently highest for the pessimistic projections and lowest for the optimistic ones. Their projections by SRES are more in line with our expectations.

[23] These calculations are also available in the spreadsheet entitled "Crops March 2011."

The IFPRI model assumes that changes in agricultural technology will lead to increased crop yields over time. This assumption is embedded in their model through the use of exogenous coefficients of increased yield. Their report does not detail the basis for those coefficients; in an email the study's authors explained that they are based on modeling, historical experience, and expert opinion, and that their results are very sensitive to the level of these coefficients.[24] These coefficients will therefore also be an important determinant of our estimates of the impact of climate change over the three ecoregions. This must be taken into account in any use of our results.

The caveats about these results described for the I&R model – that they assume the growth rates of major cereals will be applicable to all crops, and that they do not capture changes in crop prices – apply to the IFPRI results as well.

3.3 Findings

Tables 5 and 6 show the results of this work. Table 5 is a summary table showing agricultural output and the impacts of climate change in 2020 and 2050, at the ecoregion scale. The different among the results from the different climate scenarios was relatively modest, so to simplify the presentation in these tables, we have averaged them together.[25] As mentioned above, only the IFPRI study lets us actually see the impacts of climate change, distinct from the overall projections of agricultural output. The most striking observation, shown in the bolded rows labeled "IFPRI – impact of CC," is that climate change is expected to increase the value of crops in the Horn of Africa and the Plains ecoregion; this was an unanticipated result.

Table 5. Summary, Impacts of Climate Change on Crop Values at Ecoregion Level

		Value of Crops in $US 1000s		
		baseline	projected 2020	projected 2050
Horn	IFPRI - avg 4 climate scenarios	2,609,214	5,626,912	8,250,054
	IFPRI - without climate change		5,464,296	7,970,810
	IFPRI – impact of CC		**162,616**	**279,244**
	I&R - avg 7 climate scenarios	3,178,761	3,037,686	3,213,375
	For comparison: GDP	14,165,915	45,406,644	498,548,055
Lake	IFPRI - avg 4 climate scenarios	6,597,037	9,435,842	12,938,892
	IFPRI - without climate change		9,708,486	14,401,579
	IFPRI – impact of CC		**-272,645**	**-1,462,686**
	I&R - avg 7 climate scenarios	7,369,269	7,322,993	7,104,396
	For comparison: GDP	31,328,363	86,507,100	706,148,368
Plains	IFPRI - avg 4 climate scenarios	1,547,854	2,322,211	2,503,604
	IFPRI - without climate change		1,941,225	1,969,096
	IFPRI – impact of CC		**380,986**	**534,509**
	I&R - avg 7 climate scenarios	2,081,608	2,013,265	2,064,980
	For comparison: GDP	13,736,871	38,501,225	310,860,006

[24] Email from Gerald Nelson, IFPRI, 24 December 2010.

[25] Full detail with the climate change scenarios distinguished from each other is available in the spreadsheet entitled "Crops March 2011."

Another striking result comes from the comparisons with estimated GDP in 2020 and 2050. Although, as mentioned above, our GDP estimates should not be considered reliable on their own, they are nevertheless useful for showing at least the orders of magnitude of the impacts of climate change. A quick look at these figures shows that the impact of climate change on crop values is very low compared to GDP. In all three ecoregions, and in both projected time periods, the impact of climate change is under 1% of GDP, and in most cases it is well under 0.5%.

Another observation that can be made from the data in Table 5 is that the Iglesias and Rosenzweig projections are much more pessimistic than the IFPRI ones. In the Lake and Plain regions, I&R project slight decreases in total output with climate change, whereas the IFPRI model predicts significant increases in total output with climate change even where the marginal impact of climate change is negative. As mentioned above, the IFPRI model incorporates exogenous assumptions about improvements in agricultural technology; because it is not well documented, we cannot tell whether the I&R model does anything equivalent, although it is possible, given their lower projected output, that they do not.

Table 6 provides more detailed data on the results from the two models, showing how each country will change (including the division of Kenya and Tanzania into the Lake and Plain ecoregions), and showing values for more time points. One observation that is clear from the additional time points is that the IFPRI model suggests that the impacts of climate change on output will be greater earlier in the century than in the period between 2035 and 2050. (The impacts between the baseline and 2020 are less consistent than for later projections, because our work used the FAO data for the 2000 baseline, and those values differ from the IFPRI baseline data.) This pattern could occur for a number of reasons; the timing of the actual climate changes under the different scenarios, the responses of particular crops to changes in climate, or the timing of the exogenous changes in agricultural technology that IFPRI assumes will occur in each country.

Table 6. Impacts of Climate Change at Country Level

		baseline	**2020**	**2035**	**2050**	**2080**
Burundi	IFPRI output with CC	540,117	597,345	641,232	606,227	
	IFPRI change in output due to CC		126,150	267,876	422,620	
	I&R output with CC	607,022	586,064		574,139	536,618
	GDP	795,883	1,627,317	3,327,326	6,803,282	28,442
Djibouti	IFPRI output with CC (a)					
	IFPRI change in output due to CC					
	I&R output with CC	7,284	7,088		7,710	7,366
	GDP	708,844	1,851,808	4,837,729	12,638,253	86,253,773
Eritrea	IFPRI output with CC	48,647	45,758	62,344	75,642	
	IFPRI change in output due to CC		3,489	8,367	15,039	
	I&R output with CC	113,566	56,921		56,493	53,191
	GDP	1,171,435	1,823,630	2,838,933	4,419,504	10,710,514
Ethiopia	IFPRI output with CC	2,442,660	5,465,283	6,708,620	7,965,534	
	IFPRI change in output due to CC		-152,500	-119,585	-289,689	
	I&R output with CC	2,932,496	2,853,570		3,033,876	2,886,729
	GDP	12,285,636	41,731,206	141,750,382	481,490,298	5,555,384,782

Kenya	IFPRI output with CC	1,587,203	3,047,698	3,751,697	4,106,257	
	IFPRI change in output due to CC		-159,535	-337,712	-544,275	
	I&R output with CC	1,869,141	1,831,578		1,692,460	1,528,512
	GDP	18,737,923	45,590,494	110,924,419	269,885,794	1,597,665,102
Kenya lake	IFPRI output with CC	1,177,301	2,260,617	2,782,806	3,045,799	
	IFPRI change in output due to CC		-118,334	-250,496	-403,713	
	I&R output with CC	1,386,427	1,358,565		1,255,375	1,133,767
	GDP	13,898,776	33,816,560	82,277,728	200,186,668	1,185,061,463
Kenya plain	IFPRI output with CC	409,902	787,081	968,891	1,060,458	
	IFPRI change in output due to CC		-41,201	-87,215	-140,561	
	I&R output with CC	482,713	473,013		437,085	394,744
	GDP	4,839,146	11,773,934	28,646,691	69,699,126	412,603,639
Rwanda	IFPRI output with CC	1,005,866	1,441,753	1,942,955	2,364,059	
	IFPRI change in output due to CC		-171,138	-388,319	-651,657	
	I&R output with CC	1,119,345	1,081,766		1,061,457	992,389
	GDP	2,389,503	5,452,031	12,439,671	28,383,080	147,761,323
Somalia	IFPRI output with CC	117,907	115,871	172,526	208,878	
	IFPRI change in output due to CC		-13,605	-27,036	-4,594	
	I&R output with CC	125,416	120,107		115,296	107,340
	GDP (b)					
Tanzania	IFPRI output with CC	1,808,646	2,439,915	2,474,048	2,293,717	
	IFPRI change in output due to CC		-540,050	-608,472	-626,134	
	I&R output with CC	2,541,262	2,448,056		2,587,354	2,500,672
	GDP	14,141,921	42,479,988	127,602,842	383,297,785	3,458,503,621
Tanzania lake	IFPRI output with CC	670,694	904,785	917,442	850,571	
	IFPRI change in output due to CC		-200,265	-225,638	-232,187	
	I&R output with CC	942,367	907,804		959,459	927,315
	GDP	5,244,197	15,752,697	47,318,492	142,136,905	1,282,504,151
Tanzania plain	IFPRI output with CC	1,137,952	1,535,130	1,556,606	1,443,147	
	IFPRI change in output due to CC		-339,786	-382,835	-393,947	
	I&R output with CC	1,598,895	1,540,253		1,627,895	1,573,357
	GDP	8,897,725	26,727,291	80,284,350	241,160,880	2,175,999,470
Uganda	IFPRI output with CC	3,203,059	4,231,342	5,287,917	6,072,237	
	IFPRI change in output due to CC		636,232	1,407,905	2,327,624	
	I&R output with CC	3,314,109	3,388,795		3,253,965	3,101,473
	GDP	9,000,004	29,858,494	99,058,815	328,638,432	3,617,168,981

(a) The IFPRI study does not include results for Djibouti.
(b) National accounts data, including GDP, are not available for Somalia.

Another observation about Table 6 is that in the Horn and Lake ecoregions the impacts of climate change vary from country to country. In Burundi and Uganda, climate change is expected to increase the value of crop output, whereas in the rest of the Lake ecoregion it is expected to decrease the value of crops. In the Horn ecoregion, the modest increases in Eritrea are overwhelmed by much greater decreases in Ethiopia and Somalia. (The IFPRI study does not include data on Djibouti.) This suggests that if USAID wishes to use these results in program design, it will be important to drill further down in the IFPRI data and model, to learn more about what explains the variation across countries.

Several other issues will also call for investigation, if these results are to inform program design. To estimate the costs imposed by climate change, we have simply aggregated the value of different crops. In practice, however, the IFPRI data show results for six different cereals, distinguish between irrigated and rainfed production, and embody exogenous assumptions about changes in crop yields due to agricultural research. If USAID wishes to use the IFPRI results to design Feed the Future activities, it will be essential to understand all the detail in the study, rather than analyzing only the total value of agricultural output, as we did in order to estimate the costs imposed by climate change.

4. Agriculture: the Ricardian Approach to Livestock

The crop and trade model approaches of I&R and IFPRI cover major cereal crops, but do not factor in any animal products. We had to look elsewhere, therefore, to find projections of the impacts of climate change on livestock. Because animal products are not as crucial as grains from a global food security perspective, not as much effort has been made systematically to analyze them from a global or continental perspective.

One set of studies has, however, addressed the impacts of climate change on livestock choices in Africa.[26] These studies all take the so-called Ricardian approach, which is based on cross-sectional data about the behavior of farmers faced with a variety of different conditions, including differences in weather. Many such studies have been carried out based on the results of a survey of about ten thousand farmers in eleven African countries conducted in 2002-3 in the context of the GEF funded project "Climate Change Impacts and Adaptation of Agroecological Systems in Africa." The database includes a wide range of information about each farm, including crop and animal choices, net revenue, costs, prices faced in markets, soil information, temperature, rainfall, and so on. (Some of the information, such as weather data, did not come from the farmers themselves.)

The general approach taken in all of these studies is to run regressions on the data to determine how variations in temperature and rainfall affect farmers' net revenues, crop choices, livestock choices, or other independent variables. The spatial variation identified in this way is assumed to be a proxy for the changes that will be observed over time with climate change.

A number of criticisms have been leveled at this approach. Since it is based on variation across space among farmers, it cannot capture changes that do not vary across space. In particular, it will not capture the impacts of carbon fertilization (which is factored into the I&R and IFPRI models), although this is less of an issue for animal products than for crops.[27] It also does not capture any changes in global food trade, since it does not include a trade model. However, this is our only source of consistent estimates of the impact of climate change on livestock practices that can be applied at the country level, so we had no alternative but to make use of it.

The Ricardian studies of livestock have taken a number of different approaches. Seo and Mendelsohn (2006a) looks at the impact of climate on revenue per farm, the value of animals owned, and the revenue per unit of animal value. Seo and Mendelsohn (2006b) compares three different analytical approaches to determining how climate change will affect decisions about whether to hold livestock and choice of species. Seo and Mendelsohn (2006c) refines the Ricardian approach to analyze which species are selected, the number of animals per farm, and the net revenue per animal. Seo et al (2009a) adds a new element to the analysis, considering the impact of climate change on choice of animal species by farmers within sixteen different agroecological zones.

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[26] Seo and Mendelsohn 2006a, 2006b, and 2006c; Seo et al 2009a, 2009b.

[27] Carbon fertilization is the positive effect that increased carbon in the environment is expected to have on crop yields, both because CO_2 is an input into photosynthesis, and because increased atmospheric concentration of CO2 reduces water lost to respiration. Studies carried out in laboratory conditions where the atmosphere is fully controlled by the researcher have estimated possible increases in crop yields of 30 to 40% with increased CO_2 in the atmosphere. However studies conducted in farm fields suggest that yield changes due to increased CO_2 are between 7% an 11%. (Cline 2007, p. 24) The magnitude of the carbon fertilization effect is still open to considerable question.

Our analysis relied on the results of Seo et al (2009a), because the availability of different coefficients for the impacts of change in temperature and rainfall in each of the sixteen agroecological zones fits well with the ecoregion comparisons that are the focus of our work. Seo et al provides data for five types of livestock; dairy cattle, beef cattle, sheep, goats and chickens.[28] They assign each farmer to a single primary animal, rather than identifying the share of each species in each farmer's herd. For each agroecological zone, they then provide several key values:

- The probability of each animal being the primary one for a given farmer; this is equivalent to the percent of farmers in each zone specializing in each animal.
- For each of three climate scenarios, the changes in probability of each animal being the primary one for a given farmer in 2100.

Table 7 provides an example of these coefficients, to make this clear. In the high elevation semi-arid agroecological zone, 1.8% of farmers are primarily owners of beef cattle, 30.27% have dairy cattle, and so on. The temperature and rainfall changes that will result from one of the climate change scenarios will lead ownership of beef cattle to increase by 3.23% (so the new ownership share will be 1.86%), ownership of dairy cattle to decrease by 4.2% (to 29%), and so on. The shares of farmers with each animal add up to 100% within each zone; the changes in share to not add up to anything in particular.

Table 7. Example of livestock coefficients

Species	Share of farmers for whom this is primary: high elevation semi-arid zone	% Change in share due to CC
Beef	1.8	3.23
Dairy	30.27	-4.2
Goats	9.54	3.34
Sheep	27.05	-9.26
Chickens	31.33	6.89
Total	100.00	

We applied these coefficients through several steps:[29]

- Overlaying spatial data on the location of the agroecological zones[30] with the CIESIN maps of population density used throughout this study, we calculated the population of each agroecological zone within each country and ecoregion in our study.
- Since the World Bank survey was carried out in 2002-3, we extracted the 2002 FAOSTAT data on the value of animal products[31] that are among the top twenty agricultural products in value for each country.
- The total value for each livestock product within each country was divided among the agroecological zones based on the population of that zone and the share of population for whom that is the primary animal. This gives the baseline value to which the percent changes due to climate change must be applied, to calculate the value of each livestock product with climate change.

[28] For our purposes it is unfortunate that the World Bank data did not track camels as well; however we have to live with this limitation.
[29] The full calculations may be seen in the spreadsheet titled YYYYYY.
[30] The spatial data on location of the agroecological zones was provided by Pradeep Kurukulasuriya, for which we are greatly appreciative.
[31] Downloaded from http://faostat.fao.org/site/339/default.aspx; see footnote 16 for more details on these data.

- The calculations are made, applying the percent change in share for each zone and animal to the value of that animal's products for that zone, to determine the value of each product in 2100 with the given climate change scenario.
- These values are summed across agroecological zones to calculate the value of each livestock product in each country and ecoregion in 2100 under the given climate change scenario.

The results of this analysis are shown in Tables 8 and 10. Table 8 provides a summary of the results at the ecoregion scale, averaging across the three different climate change scenarios included in the underlying study. The values are shown up to 2050 rather than 2100 (halving the changes in value), in order to be comparable with the summary data showed for crops. One interesting observation is the different impacts on different animals. In all three regions, the values of beef cattle and sheep are projected to rise, while those of dairy cattle and chickens are expected to decline. Goats will rise in the Horn and Lake regions, but they will decline slightly in the Plains region.

Table 8. Average impacts of climate change on livestock at ecoregion scale

		Change in value of Livestock due to Climate Change, 2000 - 2050, in $US 1000s					
	Value in 2002	Beef cattle	Dairy cattle	Goats	Sheep	Chickens	Total
Horn	$1,715,018	$7,186	-$34,424	$1,259	$2,924	-$119	-$23,173
GDP:	$14,165,915						$498,548,055
Lake	$1,915,605	$12,688	-$110,854	$7,322	$1,175	-$1,273	-$90,942
GDP:	$31,328,363						$706,148,368
Plain	$1,109,561	$14,698	-$3,591	-$487	$1,329	-$3,124	$8,825
GDP:	$13,736,871						$310,860,006

Another interesting observation is the low value of climate change impacts on livestock relative to GDP, considerably lower than the impact on crops. The highest value relative to GDP is in the Lake region, and there is it only slight above 0.01%. While both the livestock and the GDP figures are subject to many caveats as to their precision, the values are so small as to suggest that from a cost perspective, livestock will not be a major matter for concern. This is, of course, due in part to the fact that the decreases in value of some animals are balanced out by the increases in value of other animals. If our data included camels, the balancing increases might be even greater, since camels are likely to be more viable with increased temperatures in the region.

Table 10 shows the changes in value to the year 2100, providing detail at the country level and maintaining the distinction among the three different climate scenarios used by Seo et al. Those three scenarios all assume the A1 SRES, applying the climate change predictions of three atmospheric and oceanic global climate models (AOGCM); one from the Canadian Climate Centre (CCC), one from the Centre for Climate Systems Research (CCSR), and the Parallel Climate Model (PCM). Table 9 shows the temperature and rainfall predictions of those three models in winter and summer. These predictions are for all of Africa, so they may not be accurate for our regions. In particular, all three climate models project significant drops in rainfall in the summer and only modest increases in the winter, whereas the IPCC projections for East Africa summarized in Table 2 are for modest to significant increases in rainfall over the year as a whole. This suggests that PCM may in fact be more accurate for East Africa than the other two models, since it suggests a net increase in rainfall over the year.

Table 9. AOGCM Climate Scenarios by 2100				
	Temperature		Rainfall	
Scenario	Summer (°C)	Change	Summer (mm/month)	Change
CCC	25.7	6	149.8	-33.7
CCSR	25.7	4.4	149.8	-45.8
PCM	25.7	2.2	149.8	-4.7
	Winter (°C)	Change	Winter (mm/month)	Change
CCC	22.4	7.3	12.8	3.5
CCSR	22.4	3.7	12.8	10.1
PCM	22.4	3.1	12.8	21.6
Source: Seo et al 2009a, Table 6 p. 18				

Table 10 provides detailed results by country and climate scenario. Some patterns are fairly consistent across countries and climate models, such as the decrease in value of dairy cattle and chickens. Within the Plain and Lake ecoregions the results are also quite consistent from one country to another. Within the Horn, though, they are less so; the impacts on livestock in Ethiopia are frequently in the opposite direction from the impacts on other countries in the region. This is probably due to the dominance of the Ethiopian highlands, which differ significantly from coastal parts of this ecoregion. The fact that the Seo et al study does not include camels is presumably more important in the Horn than in the other ecoregions, since this area will be most suited to raising camels.

Table 10. Change in the value of livestock 2002-2100, in $US thousands, by country and ecoregion.

	Burundi	Djibouti	Eritrea	Ethiopia	Kenya	Kenya lake	Kenya plain	Rwanda	Somalia	Tanzania	Tanzania lake	Tanzania plain	Uganda
CCC Climate Model													
Beef cattle	$998	-$591	-$1,141	$475	$14,067	$5,923	$8,144	$1,444	-$5,057	$24,704	$1,683	$23,020	$10,925
Dairy cattle	-$1,001	-$70	-$1,245	-$66,007	-$135,313	-$125,482	-$9,831	-$5,925	-$6,788	-$12,604	-$2,782	-$9,822	-$30,478
Goats	-$44	$37	$0	$0	-$667	$475	-$1,142	$71	$1,480	-$3,825	-$327	-$3,498	$101
Sheep	$0	$432	$2,857	$21,261	$16,003	$8,526	$7,477	$0	$20,985	$0	$0	$0	$0
Chickens	-$425	$0	-$162	-$2,224	$0	$0	$0	$0	-$241	-$9,574	-$1,027	-$8,547	-$2,852
Total	-$472	-$191	$310	-$46,496	-$105,910	-$110,558	$4,648	-$4,410	$10,379	-$1,299	-$2,452	$1,153	-$22,304
CCSR Climate Model													
Beef cattle	$1,082	-$443	-$291	$21,833	$20,090	$13,778	$6,312	$1,923	-$2,344	$19,561	$1,970	$17,590	$9,974
Dairy cattle	-$1,482	$71	$403	-$66,511	-$189,518	-$185,844	-$3,675	-$9,779	$2,521	$19,478	$710	$18,769	-$54,145
Goats	$799	$42	$71	$0	$5,152	$4,836	$316	$830	$2,211	-$343	$17	-$359	$5,829
Sheep	$0	-$388	-$1,302	-$2,842	$1,097	$1,580	-$482	$0	-$8,375	$0	$0	$0	$0
Chickens	$156	$0	$42	$3,063	$0	$0	$0	$0	-$31	-$6,438	-$629	-$5,809	$1,902
Total	$555	-$718	-$1,077	-$44,457	-$163,179	-$165,649	$2,470	-$7,025	-$6,018	$32,259	$2,068	$30,191	-$36,440
PCM Climate Model													
Beef cattle	$937	-$234	$879	$27,836	$26,381	$15,794	$10,587	$786	$2,193	$26,609	$4,072	$22,536	$4,835
Dairy cattle	-$1,448	-$3	$122	-$68,455	-$192,018	-$181,330	-$10,688	-$9,516	-$579	-$7,900	-$1,604	-$6,296	-$55,017
Goats	$2,105	$79	$226	$0	$13,091	$11,803	$1,288	$2,109	$3,410	$568	$95	$473	$15,234
Sheep	$0	$20	-$1,129	-$6,012	-$2,080	-$3,059	$979	$0	-$7,960	$0	$0	$0	$0
Chickens	-$526	$0	$13	-$1,140	$0	$0	$0	$0	-$35	-$4,847	-$459	-$4,388	-$3,776
Total	$1,068	-$139	$111	-$47,771	-$154,626	-$156,791	$2,166	-$6,622	-$2,971	$14,429	$2,105	$12,325	-$38,723

Cells in light blue are in the Lake ecoregion; those in pale yellow are in the Horn ecoregion, and those in light green are in the Plain region. Kenya and Tanzania are in white, since they are divided between Lake and Plain.

5. Comparison of Agriculture Approaches: Ricardian Approach to Crops and Livestock Combined

One of the Ricardian studies (reported on in both Seo et al 2008 and 2009b) uses the World Bank database and the agroecological zones to evaluate the impacts of climate change on agriculture overall, combining the impacts on crops with those on livestock. The hypothesis is that the declines in one product may be compensated by increases in another, so that the impact on agriculture overall will be more moderate than that on one subsector.

The dependent variable in this study is farmers' net revenue. Seo et al (2009b) provides, for each ecoregion, farmers' average net income per hectare in $US and the percent change and amount of change in net income per hectare for each ecoregion and for each of two climate change scenarios (the CC and PCM models used in the livestock calculations). We used these values in much the same way as we did the livestock calculations, but our baseline was the total value of the top twenty agricultural products for each country in 2002 rather than the individual values for different animal products. Thus we applied the percent changes in net income to the total value of agricultural output, to obtain a new value of total agricultural output in each agroecological zone and ecoregion for each climate change scenario.

Tables 11 and 12 provide the results of this analysis by ecoregion and climate change scenario. The study results are for 2100; as with livestock, our estimates for 2050 assume that the change in value of output occurs at an even pace over the whole century. The summary results in Table 11 suggest that the modest weather changes associated with the PCM climate model will consistently increase overall agricultural output, but the more substantial changes associated with the CCC model will lead to larger decreases. This result is largely the same when looking at the country-level data shown in Table 12. It is, however, very different from the IFPRI results, in which the choice of climate model and SRES had only modest impacts on the results, and never changed the direction of the impacts.

Table 11. Ricardian analysis of the impacts of climate change on agriculture, in $US 1000s

	Climate change model	**Value in 2002**	**Change due to CC 2002-2050**	**Change due to CC 2002-2100**
Horn	CCC	$5,278,264	-$899,440	-$1,798,879
	PCM	$5,278,264	$1,562,590	$3,125,179
For comparison:	Horn GDP	$14,165,915	$498,548,055	$28,695,694,275
Lake	CCC	$9,693,784	-$750,858	-$1,501,715
	PCM	$9,693,784	$2,972,550	$5,945,100
For comparison:	Lake GDP	$31,328,363	$706,148,368	$27,852,131,820
Plain	CCC	$3,013,399	-$144,232	-$288,464
	PCM	$3,013,399	$230,329	$460,658
For Comparison:	Plain GDP	$13,736,871	$310,860,006	$10,781,267,353

Table 12. Change due to climate change, 2002-2100, under two different climate change scenarios, by country; values in $US 1000s

	Burundi	Djibouti	Eritrea	Ethiopia	Kenya	Kenya lake	Kenya plain	Rwanda	Somalia	Tanzania	Tanzania lake	Tanzania plain	Uganda
CCC	-$94,142	-$9,227	-$33,270	-$1,411,086	-$602,775	-$490,797	-$111,978	-$173,027	n/a	-$1,331,693	-$176,486	-$1,155,207	-$567,262
PCM	$503,321	-$5,083	$45,432	$2,814,312	$2,255,511	$1,946,590	$308,921	$1,102,133	$270,519	$944,963	$151,737	$793,226	$2,241,318
Value in 2002	$662,627	$40,834	$108,790	$3,943,467	$3,243,669	$2,405,978	$837,691	$1,314,904	$1,185,173	$3,458,041	$1,282,333	$2,175,708	$4,027,942

Cells in light blue are in the Lake ecoregion; those in pale yellow are in the Horn ecoregion, and those in light green are in the Plain region. Kenya and Tanzania are in white, since they are divided between Lake and Plain.

Table 13. Change in value of agricultural products due to Climate Change, 2002-2050, in $US 1000s

		Value in 2002	Climate model	Change due to CC
Horn	Crops & Livestock: Ricardian	$5,278,264	CCC	-$899,440
			PCM	$1,562,590
	Crops: IFPRI		Average	$279,244
	Livestock: Ricardian	$1,715,018	Average	-$23,173
	GDP:	$14,165,915		$498,548,055
Lake	Crops & Livestock: Ricardian	$9,693,784	CCC	-$750,858
			PCM	$2,972,550
	Crops: IFPRI		Average	-$1,462,686
	Livestock: Ricardian	$1,915,605	Average	-$90,942
	GDP:	$31,328,363		$706,148,368
Plain	Crops & Livestock: Ricardian	$3,013,399	CCC	-$144,232
			PCM	$230,329
	Crops: IFPRI		Average	$534,509
	Livestock: Ricardian	$1,109,561	Average	$8,825
	GDP:	$13,736,871		$310,860,006

Table 13 compares the impacts of climate change on agricultural output calculated using the IFPRI crop and trade-based model, the Ricardian work on livestock, and the Ricardian work on livestock plus crops. Several observations can be made from the comparison. First, the Ricardian analysis of crops plus livestock does not really suggest, as hypothesized, that declines in livestock values will be offset by gains in crops, or vice versa. The two different climate models project widely divergent impacts on overall agricultural output, with consistent losses with the CCC projections, and much larger consistent gains under the PCM scenario. In comparison, the total impacts on livestock alone are small. In the Lake region, the impact of climate change on livestock is just over 12% of the CCC projection for the impact of crops plus livestock. In the Plain region it is just over 6% of the CCC value, and has the opposite sign. In the Horn is it less than 3%. These figures suggest that crops and livestock are not offsetting each other. Rather, using the Ricardian approach the impacts of climate change on livestock are minor or insignificant as a share of the overall impact of climate change on the agriculture sector.

The comparison of the IFPRI model with Ricardian results is even less conclusive, since both the magnitude and the direction of the impacts differ in inconsistent ways. If the different models converged on similar projections for similar climate scenarios, we might feel reasonably comfortable that those projections were a plausible estimation of what the impacts of climate change actually will be on the value of agricultural output over the next forty years. Given that they do not, we are left concluding that there are too many different source of uncertainty in the factors that may determine how climate change influences agriculture for us to be sure that we know even the direction of the impacts.

The only observation that we can make, which will be interesting when we compare these figures with the analysis of health and sea level rise, is that the impacts of climate change on agriculture appear to be modest as a share of GDP; in all cases the impact in 2050 is less than .5% of GDP.

6. Health

Changes in climate can affect human health both directly and indirectly, via changes in biological and ecological processes that influence the transmission of infectious diseases. The changes in temperature and precipitation projected for East Africa are expected to change the endemic ranges of diseases themselves and of the animals that transmit those diseases to humans. Diseases expected to increase in scope include malaria, cholera, meningitis, Rift Valley fever, and dengue fever. In addition, the disruption of extreme climate events and the possible negative impacts of climate change on agricultural output are likely to combine to increase rates of malnutrition in East Africa.

Most of the systematic cross-country analytical work on health impacts of climate change in Africa has focused on malaria. Given the high share of global malaria accounted for by cases in Africa and the high costs it already imposes, this is not surprising. Our analysis therefore also focuses on malaria, although attention to other diseases and health conditions, such as cholera and malnutrition, would also have been of great interest had data been available.

Our work depends on a study conducted by Tanser et al (2003), which analyzes the spatial extension of habitat suitable for both the malaria parasite itself, the *Plasmodium falciparum* bacteria, and the vector for its transmission to humans, mosquitoes of the Anopheles genus. They used three SRES scenarios, A1F1, A2a, and B1. For each, they overlaid the projected distribution of habitat with population projections to obtain, for each country in Africa, the percent change in person-months of exposure to malaria and the percent change in number of people exposed to the disease. These are shown in Table 14 for East Africa. They did not project population changes, so the application of their percent change to the baseline levels of exposure (in 1995) would not reflect the actual number of person-months of exposure or people exposed in the future. The impacts of the three SRES scenarios are, on the whole, fairly consistent (except in Somalia); the impact of B1 on malaria is the lowest, the impact of A1F1 is the highest, and the impact of A2a is between them. The rate of change varies considerably from country to country, with the change in exposure in Ethiopia and Rwanda being the most marked.

Table 14. Changes in exposure to malaria under three climate change scenarios

	Person-months exposure (millions)	Percent change, current to 2070-2099			Population exposure (millions)	Percent change, current to 2070-2099		
Country	Current (1995)	B1	A2a	A1F1	Current (1995)	B1	A2a	A1F1
Burundi	24.19	93.60	97.30	117.50	3.74	51.30	56.50	62.00
Eritrea	5.46	53.00	59.30	64.00	1.92	22.70	23.10	26.20
Ethiopia	85.81	149.30	231.10	349.30	22.51	78.10	92.10	122.30
Kenya	111.21	69.70	93.60	124.10	14.50	49.10	58.80	73.10
Rwanda	18.33	103.80	122.50	171.30	2.44	70.80	86.50	107.30
Somalia	2.04	-43.30	90.20	78.60	0.55	-14.10	76.50	54.10
Tanzania	178.64	11.60	12.90	19.20	26.50	9.10	10.70	12.70
Uganda	174.17	14.20	20.10	28.80	17.30	8.10	9.40	13.00
Numbers are derived from present climate conditions and increase projected to the end of the 21st century (2070–2099), assuming a constant population.								

Assuming that in East Africa there is a direct relationship between being exposed to malaria and contracting the disease, we applied these rates of change to WHO data on malaria for the nine countries.[32] The WHO data quantify disease rates in terms of Disability Adjusted Life-Years, or DALYs. This standard measure is the sum of the number of years of life lost by those who die of the disease plus a weighted sum of the number of years that people live with the disease. The weights used to calculate DALYs for different diseases are established by the WHO, and reflect the difficulty of living with the disease.[33] Thus, for example, the weight for living with occasional bouts of malaria is .191. If each year of life is weighted equally, a man with a life expectancy of 60 years who dies of malaria at age 20 would generate 40 DALYs. If his sister (with the same life expectancy) contracted malaria at age 20 and lived with it until age 60, she would generate 40 x .191 = 7.64 DALYs. Between the two of them, they would add 47.64 DALYs to the rate for their country.[34]

The WHO provides 2004 data on the DALYs per 100,000 population by disease and by country.[35] Our first step was to multiply these figures by population data to calculate the current DALYs due to malaria in each of our countries and ecoregions.[36]

Since we are interested in tracking the increase in cost due to climate change, we then had to consider how to value a DALY in monetary terms. This issue is a difficult one, at the intersection of economics and ethics. The simplest approach, which only captures the economic impact of a life lost, is to value it at the foregone earnings due to death or illness. That implies that the life of a rich person is worth more than that of a poor person, which could be appropriate in terms of impact on the economy, but obviously has no validity in human or ethical terms. Another economic approach to valuing a life could be based on what someone is willing to pay to reduce the probability of dying, if they are fully informed about the impact of their choice. This measure also has what economists call an income effect – a rich person can afford to spend more on risk avoidance than a poor person can – so it raises the same ethical concerns. From a strictly economic perspective, the costs imposed by death and illness could also include the costs of medical care, the impacts on the ability of other family members to get an education and earn a living, and an array of other costs in addition to foregone earnings on the part of the person with the disease.

We searched for other studies that had estimated the value of a DALY or of a life for East Africa, but we did not find any. We have, therefore, taken a very simplistic approach to valuing a DALY, and used GDP per capita. (For Somalia, for which national accounts data are not available, we used average GDP per capita for the Horn region.) This obviously does not resolve any of the ethical concerns. As a measure of economic impact, it is plausible. On the one hand, the people who suffer from malaria may

[32] This assumption may be open to question. It is possible that for people already exposed to malaria, a lengthening of the season during which the disease can be contracted will not increase the probability of becoming ill. If so, this analysis could be done applying the Tanser coefficients for number of people exposed, rather than for person-months of exposure.

[33] The weights used by WHO in calculating DALYs are set out in World Health Organization 2004. Living with bouts of malaria receives a weight of .191; neurological consequences of the disease are weighted at .471; anemia stemming from the disease is weighted at .012. For comparison, living with AIDS without anti-retrovirals is weighted at .505, while living with the disease with anti-retrovirals gets a weight of .167. Living with intermittent episodes of diarrheal disease is weighted at .105.

[34] In fact, in its 2004 Global Burden of Disease study (the source for our data), each year of life does not have equal weight. Years lost at a young age are weighted somewhat higher than years lost at an old age. Thus the DALYs for a child expected to live to 60 who dies at age 10 will be higher than the DALYs for a man expected to live to 80 who dies at age 30.

[35] From http://www.who.int/entity/healthinfo/global_burden_disease/gbddeathdalycountryestimates2004.xls, in the worksheet labeled "DALY rates."

[36] The full details of our calculations may be seen in the spreadsheet entitled "Health March 2011.

tend to have less than average income, because wealthier people may be able to protect against getting the disease. To the extent that that is the case, GDP per capita will overvalue the economic impacts. However it does not capture any of the secondary costs – medical care, impacts on other family members, and so on – which could make it too low. GDP per capita varies significantly across our countries and ecoregions, so the costs imposed in different ecoregions will be affected accordingly.

Using GDP per capita to value a DALY, we calculated the costs imposed by malaria in each country and ecoregion in 2004/5 (DALYs are for 2004, population for 2005), to serve as a cost baseline without climate change. We then extrapolated those costs into the future, based on population growth rates from the United Nations[37] and on our own calculations of GDP and GDP per capita.[38] This gave us an estimate of the costs imposed by malaria through 2050, in the absence of climate change.

Although the Tanser growth rates are for 2070-2099, we did not project costs beyond 2050. We therefore multiplied the Tanser growth rates for person-months of exposure by two thirds to calculate costs imposed by malaria in 2050 rather than in 2070-2099. Applying the adjusted growth rates for each country to the cost estimates for that country in 2050, we calculated the costs imposed by malaria due to climate change at the country and ecoregion level for the three SRES used by Tanser et al. The results are presented at the ecoregion and country levels in Table 15.

Table 15. Costs imposed by malaria, in $US 1000 (a)

	Costs 2004-5	GDP 2005	Costs 2050 W/out CC	Costs 2050 due to CC			GDP 2050
				B1	A2a	A1F1	
Horn	$324,151	$14,165,915	$12,692,889	$10,879,148	$18,257,403	$27,069,990	498,548,055
Lake	$1,375,902	$31,328,363	$21,672,484	$8,355,167	$9,638,132	$12,882,133	$706,148,368
Plain	$148,479	$13,736,871	$1,704,821	$602,370	$1,441,900	$1,863,559	$310,860,006
Burundi	$30,645	$795,883	$261,956	$163,461	$169,922	$205,199	$6,803,282
Djibouti	$2,490	$708,844	$44,388	$15,684	$37,543	$48,521	$12,638,253
Eritrea	$1,793	$1,171,435	$6,763	$2,390	$2,674	$2,885	$4,419,504
Ethiopia	$288,351	$12,285,636	$11,300,875	$11,248,137	$17,410,881	$26,315,970	$481,490,298
Kenya lake	$570,541	$13,898,776	$8,217,604	$3,864,100	$4,380,896	$5,799,802	$200,186,668
Kenya plain	$52,305	$4,839,146	$775,831	$274,127	$656,181	$848,070	$69,699,126
Rwanda	$73,147	$2,389,503	$996,200	$689,370	$813,563	$1,137,660	$28,383,080
Somalia (b)	$31,517		$1,340,863	-$387,063	$806,306	$702,612	
Tanz. Lake	$215,273	$5,244,197	$6,613,171	$3,109,660	$3,525,555	$4,667,429	$142,136,905
Tanz. Plain	$96,174	$8,897,725	$928,990	$328,243	$785,719	$1,015,489	$241,160,880
Uganda	$486,296	$9,000,004	$5,583,553	$528,576	$748,196	$1,072,042	$328,638,432

(a) All values are costs; we have not put a negative sign in front of each. The "negative" value for Somalia under B1 SRES is actually a benefit.
(b) Costs associated with a DALY for Somalia are calculated using GDP per capita for the Horn ecoregion, since there are no national accounts data for Somalia.

[37] The population projections, available for the period from 1961 to 2050, are from the UN Population Division, UN Revision 2008. We downloaded them from http://faostat.fao.org/site/550/DesktopDefault.aspx?PageID=550#ancor.
[38] Available in the spreadsheet entitled "economic and population data March 2011."

These results show that climate change-induced malaria will impose considerably higher costs than the other areas of impact we have considered so far, particularly in the Horn of Africa. Even under the B1 SRES, the costs imposed by climate-change induced malaria will have more than six times the impact of agriculture; under A1F1, they will be close to 20 times the impact of agriculture. Whereas the impact of agriculture never went above 0.5% of GDP, in the Horn ecoregion the impact of malaria will be more than 5% of GDP under the A1F1 scenario.

In the Lake region, on the other hand, the impact of climate change on malaria, while a significant cost, is relatively much smaller than in the Horn. This is because malaria is much more important in the Lake region now than elsewhere in the region, so the spatial area into which it will spread (in higher altitudes where malaria will become a problem) is much smaller. Still, however, the costs imposed by climate-change induced malaria will be between 1 and 2% of GDP, far more than the costs of agriculture. In the Plain ecoregion the costs will be about 0.5% of GDP, about the same as the costs imposed by agriculture.

The country data are fairly consistent with the summaries at the ecoregion scale. In the Horn, they show that the high costs imposed by malaria are largely due to changes in Ethiopia. This was predictable from the coefficients of change in the Tanser study; person-months of exposure to malaria in Ethiopia are expected to increase by 349% by 2070-2099. The decrease in malaria in Somalia under the B1 scenario is unexpected; presumably the climate changes anticipated will actually make some areas no longer suitable for either the bacteria that causes the disease or the mosquito that transmits it.

Studies like the Tanser one are not available to predict the impacts of climate change on other diseases, although the impacts on diarrheal diseases and malnutrition are expected to be significant. Those health problems impose significant costs on our ecoregions now, and are projected to impose considerably higher costs by 2050 in the absence of climate change, as shown in Table 16.[39]

Table 16. Costs of malnutrition and diarrheal diseases, $US 1000s

	2004/5	2050
Protein-energy malnutrition		
Horn	$232,821.96	$8,418,488.35
Lake	$351,270.36	$7,917,713.24
Plain	$119,146.19	$2,696,231.66
Diarrheal diseases		
Horn	$870,933.27	$31,491,623.42
Lake	$1,691,411.18	$38,124,789.68
Plain	$614,724.70	$13,910,978.81

The high costs of these diseases at present, especially in the Lake region, suggest that it will be important to determine how they may be affected by climate change as well. Encouraging this kind of research, or seeking it out as it becomes available, may be a useful activity for the Global Health Initiative in addition to work to specifically target the increases in malaria expected from climate change.

[39] These costs are calculated in the same way as the cost per DALY for malaria. Data on DALYs for malnutrition and diarrheal diseases are from http://www.who.int/entity/healthinfo/global_burden_disease/gbddeathdalycountryestimates2004.xls, in the worksheet labeled "DALY rates."

7. Sea Level Rise

Coastal communities will be affected by climate change in several specific ways. The expansion of ocean waters as their temperatures increase, combined with the melting of the major land-based ice sheets of Greenland and Antarctica, will cause sea levels to rise worldwide. The increase in air and ocean temperatures will also cause increased storminess, resulting in higher storm surges than have occurred in the past. These effects will combine both to submerge coastal areas and to increase the frequency and severity of intermittent coastal flooding due to storms. The extent of these effects is very much up to question. Estimates for sea level rise between 2000 and 2100 range from about 14 meters to almost 35 meters, depending on the climate models used and the expectations about the extent of melting of the Greenland and Antarctic ice sheets.[40]

The impact of these climatic changes on coastal communities will take many forms:

- Some coastal land will simply disappear due to long-term sea level rise or erosion caused by higher storm surges. Residents of that land will be forced to migrate inland, and infrastructure or buildings on that land will be lost to the rising waters.
- Other coastal land will be flooded more often than in the past, causing migration inland to avoid the water, even if the land has not disappeared. Infrastructure and buildings on that land may be damaged, destroyed, or may lose economic value due to frequent flooding.
- Buildings and public infrastructure constructed on land that is permanently under water or intermittently flooded will be damaged or lost.
- The loss of infrastructure can have repercussions for the economy (in the loss of roads or port facilities), for public health (especially in the loss of drinking water systems), and of course direct negative impacts on those whose homes are flooded. Effects on transport infrastructure will extend the impacts of sea level rise beyond coastal communities to people inland who rely on the supply of commercial goods through the ports and road systems.

The cost imposed by sea level rise will depend not only how high the waters flow, but also on the number of people and the value of physical investments at risk. This in turn will depend on population and economic growth over the course of the 21st century. As coastal populations increase with population growth and migration, the number of people directly at risk will increase. They will invest in new buildings and infrastructure, which will also be directly at risk. Independently, economic growth may increase the value of those investments, further increasing the economic losses. If, as is common, coastal wetlands are converted to agriculture or to human settlements, that will also reduce natural protection against storm surges and flooding.

Our analysis of these costs is based on a study by Brown et al (2009) that estimates the costs imposed by country for all of Africa. This is certainly not the only study considering impacts of sea level rise in Africa – in particular, Dasgupta and others at the World Bank and the Center for Global Development have done a number of studies of these issues (Dasgupta et al 2007, 2009) – but this is the only one we located that includes comparable cost data by country for all of the coastal countries in our study area.

The Brown et al study uses the Dynamic Interactive Vulnerability Assessment model (DIVA) to predict the coastal impacts and costs of sea level rise. DIVA is an integrated biophysical and socioeconomic

[40] Based on data in Table 10.7 of chapter 10 of the IPCC Fourth Assessment Report, p. 820. (Solomon et al 2007 or Meehl et al 2007)

model for predicting coastal impacts of climate change.[41] Brown et al ran the model for fourteen different climate scenarios, summarized in Table 17. Unlike the other studies we have worked with, this one uses different scenarios to model greenhouse gas emissions (and thus sea level rise) and population changes (and thus the impacts of that sea level rise), as shown in Table 17. They estimate the impacts and costs of sea level rise both with and without adaptation for each climate scenario. For each population change scenario, they also estimate the costs imposed by coastal flooding with and without sea level rise. This makes it easy for us to calculate the costs imposed by sea level rise under each scenario, by calculating the difference between the costs for a given set of climate and population scenarios without adaptation and the same population scenario without sea level rise. Thus in terms of the cases in the table below, we have compared case 4 with case 12, case 6 with case 10, and case 8 with case 14.

Table 17. Climate scenarios analyzed by Brown et al in considering sea level rise

Case	Sea Level Rise Assumption	Population and Economic Growth Scenario	Adaptation Assumption
1	Rahmstorf[42]	A1B	With adaptation
2	Rahmstorf	A1B	Without adaptation
3	A1FI high-range (fossil fuel intensive)	A1FI	With adaptation
4	A1FI high-range	A1FI	Without adaptation
5	A1B mid-range (high growth)	A1B	With adaptation
6	A1B mid-range	A1B	Without adaptation
7	B1 low-range (less energy use)	B1	With adaptation
8	B1 low-range	B1	Without adaptation
9	No SLR	A1B	With adaptation
10	No SLR	A1B	Without adaptation
11	No SLR	A1FI	With adaptation
12	No SLR	A1FI	Without adaptation
13	No SLR	B1	With adaptation
14	No SLR	B1	Without adaptation

The Brown et al study provides detailed results for each of the fourteen scenarios, for each of six time periods from 2000 to 2100. Among the values in their results are:

- Total cost of adaptation - since we are comparing "no adaptation" scenarios with "no sea level" scenarios, this is always zero
- Total costs imposed by sea level rise after adaptation - since we are only considering "no adaptation" scenarios, this will be the total cost imposed by coastal flooding. It is equal to the sum of the costs of forced migration, land loss due to submergence or erosion, salinization, sea floods, and river floods. Brown et al only provide detail on three of these - the costs of forced migration, salinization, and sea floods - so instead of calculating total costs from the underlying components, we must use the totals they provide in the tables in their paper.
- Number of people who are forced to migrate due to coastal flooding.
- Costs of forced migration – this is estimated, rather simplistically, as three times GDP per capita for each person forced to migrate.

[41] More information about DIVA is available at http://www.pik-potsdam.de/DINAS-COAST/Overview/overview_index.

[42] "Rahmstorf" is a sea level and socioeconomic growth scenario based on work by Rahmstorf (2007), which predicted higher sea level rise than the IPCC Fourth Assessment Report (Solomon et al, 2007 or Meehl et al 2007).

- Number of people actually flooded - this is greater than forced migration, since not all people who are flooded actually have to move. If a person is actually flooded more than once per year, or if they actually lose their land to erosion, then DIVA assumes that they will be forced to migrate.
- Costs imposed by the loss of the non-marketed ecosystem services of wetlands, including coastal forests, freshwater marshes, high and low unvegetated wetlands, mangroves, and salt marshes.

Table 18 presents the results of this analysis, at the ecoregion and country levels, for three SRES. The most striking observation is the huge jump in costs in 2075, in both the A1B and B1 climate scenarios. This is explained by the interaction between the timing of sea level rise and the timing of population growth in coastal areas. The settlement patterns projected by DIVA anticipate a major increase in coastal populations between 2050 and 2075, just before that land becomes subject to flooding as sea level rises. The consequent forced migration leads to very high costs in 2075. By 2100, however, the land areas that will be newly flooded will not have high population, so the costs imposed by sea level rise in that year will drop back down from the 2075 high.

Table 18. Costs due to sea level rise at ecoregion scale, in $US 1000s

Location	SRES	2000	2025	2050	2075	2100
Horn	A1FI	$0	$3,700	$244,100	$161,800	$458,600
	A1B	$0	$2,000	$60,100	$2,149,800	$249,500
	B1	$0	$1,300	$5,900	$55,900	$114,600
GDP		$14,165,915	$54,399,610	$498,548,055	$3,767,537,390	$28,695,694,275
Plains	A1FI	$130	$19,400	$287,100	$160,800	$445,000
	A1B	$100	$14,700	$76,800	$2,626,800	$378,400
	B1	$200	$14,900	$194,600	$1,710,800	$729,200
GDP		$13,736,871	$67,394,927	$310,860,006	$1,814,883,343	$10,781,267,353
Djibouti	A1FI	$0	$1,100	$227,600	$68,600	$173,700
	A1B	$0	$400	$37,900	$2,100,100	$111,200
	B1	$0	$400	$1,200	$21,400	$48,100
Eritrea	A1FI	$0	$400	$1,500	$11,800	$43,700
	A1B	$0	$100	$900	$4,800	$15,100
	B1	$0	$400	$1,000	$7,300	$10,900
Kenya	A1FI	$130	$19,400	$287,100	$160,800	$445,000
	A1B	$100	$600	$75,200	$2,703,200	$291,300
	B1	$100	$600	$4,000	$49,000	$622,000
Somalia	A1FI	-$30	$2,200	$15,000	$81,400	$241,200
	A1B	$0	$1,500	$21,300	$44,900	$123,200
	B1	$0	$500	$3,700	$27,200	$55,600
Tanzania	A1FI	$100	$22,400	$76,100	-$47,500	$143,000
	A1B	$0	$14,100	$1,600	-$76,400	$87,100
	B1	$100	$14,300	$190,600	$1,661,800	$107,200

The second striking observation is how low these costs are relative to GDP. Even the highest estimates for the A1F1 scenario total less than 0.1% of GDP in both ecoregions. It is, however, plausible that

costs would be higher relative to GDP in the Plains ecoregion than in the Horn, given the presence of the two major port cities of Dar Es-Salaam and Mombasa.

For the most part, the country level data are consistent with the regional summaries. However, a number of elements are open to question, and appear to indicate that there are errors in the underlying data, particularly for Tanzania. As described above, the total costs of climate change should be the sum of five underlying components, and the paper only provides the data for three of those underlying components. However in some cases, the sum of the three components for which we have data is more than $1 million higher than the totals given in the paper, which cannot be correct.[43]

In addition, as described above the costs of forced migration are supposed to be calculated as three times GDP per capita. Thus it would not make sense for the cost of forced migration divided by the number of forced migrants to be constant from one country to another. However, for Tables 31-36 in Brown et al – the tables for the AIB climate change scenario with no adaptation – the total cost of forced migration divided by the total number of forced migrants is always $6,000, for all countries and for all years. Again, something appears to be incorrect with these values. Yet another discrepancy appears to emerge from the values for Djibouti in 2075.[44] With the total population of Djibouti less than 2% of that of Kenya or Tanzania, even with most of Djibouti's population living in Djibouti City on the coast, it seems unlikely that the costs imposed by climate change in Djibouti would be almost as high as those imposed on Kenya and higher than the costs in Tanzania.

All of these apparent discrepancies suggest that it may be useful to look further into the costs imposed by sea level rise. This is reinforced by several aspects of the methods used in the DIVA model that would tend to underestimate the total costs predicted by the model. First, DIVA values all land lost to sea level based on its value as agricultural land. The logic for this is that

> [a]gricultural land has the lowest value and it is assumed that if land used for other, higher-valued purposes (e.g., industry or housing) is lost, then those uses would move and occupy agricultural land. (Hinkel and Klein, p. 390)

This assumption overlooks the transactions costs and replacement costs for infrastructure that would be lost to sea level rise, especially in areas such as Dar Es-Salaam and Mombasa. Beyond that, DIVA does not estimate the macroeconomic impacts of infrastructure loss. Clearly damage to the ports in Kenya and Tanzania due to sea level rise will have significant impacts on the region on a whole, as trade flows are interrupted and use of transport corridors impeded. This will affect all three of our ecoregions, not only the two that actually are on the coast. For all of these reasons, we expect that the costs estimated by Brown et al will understate the actual impacts of climate change on our ecoregions.

Kebede and Nicholls, two of the authors on the Brown et al paper, have carried out a more detailed assessment of the costs of sea level rise in Dar Es-Salaam (Kebede and Nicholls 2011). This study does factor in the value of the infrastructure and buildings lost to flooding, although it does not include macroeconomic impacts of those losses in Tanzania or elsewhere. It projects the population exposed to sea level rise and the value of assets threatened, under several climate scenarios plus a no sea level rise scenario, and with three different patterns of population distribution within the metropolitan area. This analytical structure adds a dimension to the analysis that is not part of the Africa-wide study, in that it makes it possible to separate the impact of climate-change induced sea level rise from the impact of the distribution of population within the urban area. This study looks not only at average long-term trends, but also at the impact of extreme events, which also adds a dimension to the Africa-wide study.

[43] These errors are found in Tables 35 and 35 of Brown et al.
[44] Table 35 of Brown et al.

Table 19. Population and assets exposed to the 100-year water level in Dar es Salaam

Year	Extreme water level	Population Exposed (1000s)			Assets Exposed ($US 1,000,000)		
		Population Growth Distribution Scenarios			Population Growth Distribution Scenarios		
		Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
No climate-induced SLR Scenario							
2005	3.06	30.1	30.1	30.1	35.4	35.4	35.4
2030	3.02	105.7	59.6	29.7	388.1	218.8	34.9
2050	2.99	140.6	79.1	28.7	1996.8	1123.3	33.7
2070	2.96	182.4	102.7	28.5	8434.4	4748.7	33.5
B1 low-range SLR Scenario							
2005	3.08	30.4	30.4	30.4	35.8	35.8	35.8
2030	3.07	106.8	60.8	30.3	392.4	223.1	35.6
2050	3.08	147.3	83.9	30.4	2092.4	1192.3	35.8
2070	3.09	193.1	110.5	30.7	8929.5	5112	36.1
A1B med-range SLR Scenario							
2005	3.09	30.7	30.7	30.7	36.1	36.1	36.1
2030	3.13	108	62.3	31.1	396.7	228.8	36.5
2050	3.19	150.2	87.7	31.8	2132.9	1245.7	37.4
2070	3.26	198.9	116.4	32.3	9197.7	5380.6	38
A1FI high-range SLR Scenario							
2005	3.12	31.1	31.1	31.1	36.5	36.5	36.5
2030	3.23	110	64.3	32	404.1	236	37.7
2050	3.38	155.7	91.5	33.2	2212.2	1299.9	39
2070	3.58	208.8	122	34.6	9658	5643.7	40.6
Rahmstorf SLR Scenario							
2005	3.11	31	31	31	36.5	36.5	36.5
2030	3.21	109.7	63.9	31.9	402.8	234.8	37.5
2050	3.37	155.5	91.3	33.1	2208.9	1297.1	39
2070	3.62	212.6	126.1	35	9831.1	5832.3	41.2
Source: Kebede and Nicholls, 2011, Table 7, p. 18.							

Table 19 shows the additional number of people and value of assets exposed to a one-hundred-year flood event, under four climate scenarios plus no sea level rise, and with three different spatial distributions of population. The interesting observation from this table is that the impacts of spatial distribution of population are a much more important determinant of the numbers of people or value of assets threatened than are the impacts of climate change. This is seen by comparing the difference, say, between the value of assets threatened under population distribution scenario 1 in 2070 across the five climate scenarios (the column of shaded cells) with the value assets threatened in 2070 with no climate change (the row of shaded cells). From one climate scenario to another the values range from $8,434 million to $9,831 million. In contrast, from one population distribution scenario to another they range from $8,434 million to $33 million. This suggests that the uncertainty in the model over where

population will actually settle is much important to the outcome than how much sea level will actually rise with climate change.

While these results are not comparable to the results of the Africa-wide analysis, they do suggest that the impact of climate change, all else being equal, may in fact not be high relative to GDP, especially as these results pertain to the hundred-year flood rather than to the long-term trends analyzed in the Africa-wide study. The uncertainties in the Brown et al data also suggest that more detailed investigation of the impacts of climate change on the key ports of the region, including consideration of the impacts on trade throughout the region, may also be important. If trade is disrupted, this will have repercussions for USAID's economic growth activities in general and to access to food in particular. This issue warrants additional attention in the context of the design of other USAID activities.

8. Extreme Events

The analytical studies that we have considered so far in this paper identify the impacts of long-term gradual change in the climate of East Africa on agriculture, health, and sea level rise. While these trends are clearly important, they are for the most part not how people in the region will experience climate change, and they may not be responsible for imposing the most significant costs. Climate change will be experienced as a combination of two kinds of events; gradual long term evolution of the average levels of temperature, rainfall, sea level, and other parameters, and increasingly wide and more frequent fluctuations around the gradually changing means. It is those fluctuations that will be experienced by the population as the impact of climate change, through more frequent and more extreme storms, floods, droughts, drought-induced fires, and all of the consequences of those weather events. Certainly, over time farmers will need to shift to crops that can survive better in heat, and pastoralists will shift from cattle towards goats or perhaps camels – but there is time to respond to changes in average conditions, and the response can be planned in advance. It is the extremes that will have immediate and devastating consequences - the floods that destroy the year's harvest or the droughts that kill entire herds and send families on the move in search of water and food - and these disasters are harder to plan for and head off.

Moreover, the costs of extreme events will have repercussions throughout USAID activities in the region. While climate change may be the cause of an increase in droughts or floods, the results will be an increase in incidence of disease, reduced access to nutritious food, and even greater delays in the already-compromised movement of freight along major transport corridors in the region. These impacts should be integrated into all USAID activities in the region; they do not fall within the purview of the Global Climate Change Initiative alone.

Systematic data are not available to project changes in frequency and level of extreme events, nor are data available to analyze historic costs or project them into the future. This is the case for a number of reasons. From the perspective of climate scientists, while all projections are difficult and uncertain, those concerning the frequency and strength of extreme events are even more difficult and uncertain than those concerning long-term trends. As we have seen, the IPCC and the many global climate research centers have published projections of future temperature, precipitation and sea level; they have not published analogous projections for extreme events. This is because modeling extreme events (and climate variability within a longer term trend) is technically more difficult than modeling longer term trends. Therefore we do not have the basic scientific results needed to assess what the probability of those events might be in our ecoregions.

In addition, systematic data on the costs now imposed by extreme events are not available for East Africa. Broadly speaking, those costs may be of several types:

- Direct humanitarian impacts on human life; death, illness, displacement, separation of family members, migration, conflict, loss of homes.
- Cost of public sector response to disasters; food aid, emergency shelter, medical care, etc.
- Direct loss of income sources; crops, livestock, sources of other resource-based income, businesses and other capital investments
- Direct costs of damage to infrastructure; e.g. replacement costs for electric power generation facilities, ports, water, roads, bridges, train lines, water supply and sewer systems, educational facilities, and so on.
- Economic repercussions of the loss of infrastructure.

Scattered cost estimates are certainly available for individual disasters, or for certain types of impacts. For example, the Stockholm Environment Institute (SEI) has estimated the costs imposed by major flooding in Rwanda in 2007, based on the best data available about the impacts of that event.[45] Their cost summary, shown in Table 20, is revealing. While they list many of the types of cost that we mentioned above, they are not able to find any estimates for most of them. They estimated of the value of lives lost; however in light of the difficulties of placing a value on a life (discussed in the health section above), these estimates fall within a very wide range depending on valuation method chosen. They estimate the cost of replacing houses destroyed, and put a value on individuals displaced. They value lost crops. They allude to infrastructure loss, but do not place a value either on its replacement or on the economic repercussions of its loss. They allude to damage to the water and educational systems, but do not quantify or place a value on them. They do not mention losses of other income, the costs of public sector response, or any other costs.

Table 20. SEI data on costs of 2007 flooding in Rwanda

Sector	Physical Impacts	Estimated economic cost (2007$mn)
Health (mortality)	18-20 deaths	1.67 to 18.8 (depending on valuation estimates used)
Property	342-706 houses destroyed 678 houses damaged 2188 to 2369 individuals displaced	0.50 to 0.85 (replacement) 0.16 (displacement)
Infrastructure	Damage to roads, bridges, other	Not estimated
Agriculture	2500 hectares flooded	1.72
Water	Water system damage, contamination	Not estimated
Other	Education - loss of school materials	Not estimated
TOTAL		**$ 4.1 to 21.5 million**

(Source: SEI 2009a, p. 15)

The SEI assessment does place a value on one social consequence of particular concern to USAID, migration resulting from disasters. Their study does not explain how they came up with the figure of $160,000 as the monetary value of displacement of 2,188 to 2,369 individuals, but it does suggest that there may be ways to value migration. Similarly the DIVA model places a value on displacement of three times GDP per capita. The logic for either of these values is not clear, although presumably the displacement in the SEI case is only temporary whereas the much higher value in the case of sea level rise is permanent.

Predicting or placing a monetary value on the conflict that often accompanies displacement is also difficult. There is an extensive literature on the economic impacts of civil conflict (see, for example, Collier 1999, Imai and Weinstein 2000), which focuses not only on the value of lives lost, but on the macroeconomic and fiscal consequences of conflict. This literature suggests that war causes economic harm by reducing investment in the country. On the other hand, Voors et al (2010) and Nillesen and Verwimp (2010), carrying out detailed studies in Burundi, find that there is actually increased financial risk-taking after episodes of civil conflict, and that farmers are more likely to plant cash crops, rather than reverting to subsistence activities, results that seem to run counter to the conventional wisdom of Collier and Imai and Weinstein.

There is also a considerable literature on the impact of shocks on household wellbeing, and the ability of households to insure against sudden changes in their situations. This literature addresses questions such as how household consumption is affected by what are termed "idiosyncratic" and "covariate" shocks.

[45] Stockholm Environment Institute 2009b, p. 15.

(Günther and Harttgen 2006a, 2006b). The former are shocks that occur randomly to a single household, such as an accident, while the latter are shocks that affect the entire community, such as the extreme weather events that will be caused by climate change. Other work looks at the impacts of conflict on children's health (Bundervoet et al, 2007) or school enrollment (Jensen 2000). One of the major challenges to this kind of work, however, is the lack of systematic data with which to analyze the impact of shocks, particularly in the developing world (Günther and Harttgen 2006a, p. 3). As explained with regard to vulnerability assessments, such studies also typically take place at the small (community) scale, and thus cannot be accurately upscaled through aggregation.

The primary global database on disasters is the Emergency Events Database (EM-DAT), maintained at the Catholic University of Louvain in Belgium.[46] While rigorous procedures are in place for accepting entries to the database, and several sources of verification are required before data are made public, the information this database stores about each event is limited to location, date, type of disaster, number of deaths, number of people affected, and a single field for cost (left blank for virtually all of the East Africa records). It is, therefore, not sufficient to enable us to analyze the current costs imposed by extreme events, quite aside from whether climate models would enable us to determine how much those costs will increase due to climate change.

Investing in more complete data on the impacts and costs – both direct and indirect – of extreme events may be an effective way for USAID to address these problems across the region. With better information on the costs imposed by disasters, complemented with an understanding of the effectiveness of strategies to reduce the different risks, policy makers will be able to make more informed choices about where to invest the resources available for reducing risk. As the climate science community improves its understanding of extreme weather events, we will know more about the probability that disasters will occur; this information will also feed into the analysis of how to allocate resources for risk reduction.

None of this is meant to imply that USAID should take an economic approach to deciding whether to respond to the humanitarian crises caused by extreme weather events. Once the crisis has occurred, intervention is unavoidable. The goal of improved information is to improve disaster risk reduction, thereby preventing the crises that can most easily be prevented, so as to minimize the need for humanitarian response once the crisis is unavoidable.

[46] www.emdat.be

9. Implications for USAID Activity

This study has focused on the costs imposed by climate change in three ecoregions of East Africa and across four areas of climate change impact. Its primary direct output is a set of cost numbers at that scale. When considering implications of the study for USAID, we must understand what these cost calculations tell us – and what they do not tell us.

Comparative cost figures like the ones we have constructed are indicators. If costs are much greater in one place or area of impact than another, they serve as a flag to attract our attention, so we can focus on places or areas where the projected burden of climate change may be highest. If they are lower in some areas than expected, that is also a flag, telling us that we need to look more closely in order to understand what underlies our calculations, whether they are reliable, and if so why our expectations were incorrect. Like most indicators, this one alerts us to issues that we must consider – but it does *not* tell us what to do about those issues. Indicators are simplistic measures that raise a flag to draw our attention. They are not complex analyses, and therefore they neither give us insights on the driving forces behind the vulnerability, nor tell us how to resolve the problems that raised the flags in the first place.

Given that key aspect of the nature of indicators, the recommendations from this study fall at several different levels. Some recommendations are a direct outcome of the cost figures themselves. More, however, flow from the need to investigate what underlies those cost figures, in order to determine whether they are correct or to decide how to respond to them. Yet others are a response to the lack of information with which to estimate the impacts of climate change. In addition to these recommendations for USAID action, we have also learned about the limitations of doing this kind of analysis, which may be useful for future work of this type.

9.1 Direct Implications of the Costs

Several observations flow directly from the cost data we have gathered. First, the impacts of climate change vary more and more reliably across areas of impact than across ecoregions. If USAID is to use this study to orient its regional adaptation programs in a single direction, the choice should be by area of impact rather than by location.

Second, the costs imposed by malaria are considerably higher than those in other areas of impact. Even given the considerable uncertainty in all of these estimates, it does appear that the costs imposed through increased malaria will be higher than those imposed through agriculture or perhaps sea level rise. For the Global Health Initiative, building climate change impacts into the design of their programs seems to be essential, particularly in Ethiopia.

The observation that the costs imposed by climate change on health are greater than costs imposed in other areas of impact does not mean that the regional activities of the Global Climate Change Initiative should focus on health entirely or even partially. Climate change is a cross-cutting problem with implications for everything that happens in the region, and the activities of the GCCI may best be devoted to addressing issues that will not fall clearly within the purview of another USAID initiative. Moreover, there are far too many gaps in this study, far too many unresolved questions, and far too many considerations other than cost that should go into decisions about adaptation priorities, for adaptation funds to be allocated based on these cost calculations alone. The sections below detail some

of the other conclusions and learning from this study, which must also inform use of adaptation resources.

9.2 Indirect Implications: Cost and other measures

While the focus on costs that is the basis for this study is interesting, it is not sufficient for allocating resources. Within a country, and even more within an ecoregion, summing the costs will allow benefits accruing to one group to mask harm incurred by another. While this is "correct" from a perspective of overall economic impacts, it does not give a complete understanding of who will be affected by climate change and how, or how many people are harmed and how many are better off. Hidden within an analysis of total costs, a large benefit to a small group of rich people could balance out harm to a much larger group of poor people that may, in fact, totally eliminate their income. Given the low incomes of most people in East Africa, and the large share of the population dependent on agriculture, we cannot focus solely on total cost figures without looking at the number of people harmed and benefited, which people are harmed and benefited, and their income levels.

These equity issues suggest that USAID may want to complement this study by building capacity in the region for further analysis into how many people will be affected by climate change and who they are. Carrying out an analysis parallel to this one that estimates the total number of people harmed (or affected positively or negatively) by climate change in each ecoregion probably is not useful, because like this analysis it will be too general. However, looking more narrowly at which social groups will be affected in each direction, and at characteristics such as ethnic group, gender, level and source of income, education, and other socioeconomic features may provide a richer understanding of how climate change will really affect East Africans. USAID could carry out some of this analysis itself, but a more constructive strategy may be to work with the appropriate regional institutions to enable them to analyze and systematically track these issues.

9.3 Agriculture and Implications for Feed the Future

This study has not led to clear conclusions about how climate change will affect East African agriculture. The different analyses we have considered show impacts in different directions and of different magnitudes. The IFPRI study is certainly the most sophisticated and ambitious, although this may not necessarily mean it is the most likely to be correct. It does, however, suggest several useful implications for Feed the Future.

First, the fact that the IFPRI model predicts increases in agricultural production in two out of three ecoregions does not mean that leaders in those countries can relax and assume that they will not have food supply problems in the future. The IFPRI results incorporate exogenous assumptions about increases in agricultural productivity, which presumably assume that productive investments will be made in agricultural research. To achieve the IFPRI results, we need to know exactly what those assumptions are, and countries will have to ensure that the anticipated investments are actually made.

Second, it is important to determine whether the IFPRI results stem only from changes in yield, or whether they also depend on extensification of agriculture onto land that is not now under cultivation. This can be determined from the IFPRI data, by looking at the coefficients of increase in yield and the production data, to see whether the increased yields account for all or only some of the increases in production.

Assuming that at least some of the increase is due to extensification, USAID will want to enable East African countries to go beyond the IFPRI data to consider whether agricultural extensification is in fact feasible; which land could be used to increase food production, how it is being used now, and what the opportunity cost would be of putting it in to agriculture. This would require a spatial analysis that considers the suitability of different places for different crops under anticipated future climate conditions, to determine what will grow where, how much can be produced, and which land would actually have to switch from other uses to agriculture. It is entirely plausible that such an analysis would lead to results quite different from the IFPRI study, for several reasons. The IFPRI work focuses on the world's major cereal crops, and not on the major crops grown in East Africa. Moreover, the IFPRI production estimates are in part the result of feeding the crop production data into global trade models, and predicting trends for the world as a whole. A more detailed analysis of East Africa would not be linked to a global trade model. Instead, it would presumably assume that the region is small enough to be able to buy or sell in global markets with out affecting world food prices, so future net imports or exports would be determined by the balance between domestic production and domestic demand.

Our analysis has calculated the total changes in value of agricultural production due to climate change, but we have not considered which crops would make up that production, and how that would change from current crop mixes. The IFPRI data shed some light on that question, within the scope of the six crops included in their model (only some of which are grown in East Africa). This is not incorporated into our analysis, since it was not necessary in order to estimate total impacts on output. However if Feed the Future wishes to rely on the IFPRI results, they will want to examine those results further, to determine what the crop balance is expected to be with climate change. Since the IFPRI work only includes some of the crops that are important in East Africa, this will not present a full picture of how crop mixes are expected to evolve, but it will provide somewhat more insight than we have from total production alone.

Beyond the changes in agricultural production modeled by the IFPRI work, climate change will affect food supply through the impact of extreme events, both on the ability to grow food in the face of floods or droughts, and on the ability to market or import food if transport networks are damaged. The work on impacts of extreme weather events recommended below will be important for Feed the Future through both of these channels. While the Global Climate Change Initiative may take the lead in that work, Feed the Future should be involved as well, since its outcomes will be important for food security.

9.4 Health and Implications for the Global Health Initiative

The high costs of malaria identified in our study do seem to argue for actions to head off these impacts insofar as possible. Of course these estimates are a function of our methodology, and are in large measure the outcome of the decision to value a DALY at GDP per capita. If users of the results feel that a different valuation method would be more appropriate, it would be easy to apply, and could significantly change the total cost estimates.

Several activities may be useful to respond to the anticipated increases in malaria. One is for USAID to work with regional institutions to identify the specific places within the region that are most at risk, in order to determine where prevention activities must be targeted. Within those countries, it will be important to work with national institutions to strengthen existing malaria control programs or create such programs where they do not yet exist.

Another useful approach may be to develop early warning systems to predict outbreaks of malaria or other diseases based on seasonal or ten-day weather forecasts. Outbreaks of malaria, cholera, and

many other diseases can at least in part be predicted using routine weather data. Those data are available to East African governments; what is needed is to create the institutional communication mechanisms to ensure that the link is made from weather departments to analysts who can use weather data to predict disease, and then from the analysts to those in a position actually to target disease prevention activities towards affected communities.

Our study has only considered the impacts of climate change on malaria. It will be important to look into the implications for other diseases well, as research begins to shed more light on this issue. The IFPRI work provides estimates of the impacts of climate change on malnutrition among children aged 0-5; investigating these data may shed additional light on this issue. Extreme events are also likely to affect malnutrition, through direct loss of crops to drought or floods and through threats to the transportation of food. The Global Health Initiative should collaborate with the GCCI in strengthening data and analysis of these issues, as described below.

9.5 Extreme Weather Events and Sea Level Rise

USAID may want to work with regional institutions to develop systematic data on extreme weather events, and insofar as possible to analyze cost-effectiveness of alternate mechanisms for reducing disaster risk. The information needs in this area are of several types. One strategy may be to strengthen institutional structures for collecting more detailed data about disasters, so as to build a database with richer information about East Africa than that provided by EM-DAT. Such a database could track some elements of the costs imposed by disaster, and could provide underlying data with which to estimate others. Analyzing the broader economic impacts of disasters will require complementary modeling work. USAID may wish to engage the global community of scholars who work in this field both to focus their work on East Africa and to build capacity in East African institutions to participate in the analysis of economic impacts of disasters. This combination of direct data collection and economic modeling will enable regional institutions to understand better the costs imposed by climate change, and contribute to more informed decisions about how to head off those costs.

The impacts of sea level rise also need more analysis in order to understand how to reduce the regional costs of climate change. More detailed analyses of the impacts on the ports of Dar Es-Salaam and Mombasa and on Djibouti City will be important from local, national, and regional perspectives. (Although Djibouti City does not have the regional economic importance of the other two cities, it houses about three fourths of the entire population of Djibouti. Flooding there will not have significant regional consequences, but could be devastating for the country.[47]) This analysis should estimate costs in ways that make more sense for urban areas, particularly with respect to valuing infrastructure and buildings lost to flooding. Following the example of Kebede and Nicholls (2011), it should consider the implications of local population distribution in the estimation of costs, since these assumptions appear to be considerably more important than the choice of climate scenarios in determining what will actually come to pass. It should also be broadened to consider the implications of damage to ports for regional trade, looking not only at coastal countries but at the whole East Africa region.

As with the recommendations on extreme weather events, this analytical work should be done by bringing outside experts to work with regional institutions, so as to build capacity within East Africa. The results of this analysis will be crucial for urban and regional planning for the next fifty to one hundred years, given the close links between settlement patterns, infrastructure development, and the

[47] UN-Habitat 2008, pp. 144, 150.

costs imposed by sea level rise. It must, therefore, involve not only regional institutions and academics, but also local authorities in the metropolitan areas involved. Similarly, while this work could be led by USAID's regional office in East Africa, it will necessarily also involve the bilateral missions in the countries involved.

These issues are also tied to broader transportation concerns. USAID, through its global Trade Capacity Building Project, has recently completed a detailed study of trade corridors through the East Africa region, in order to identify the costs of shipping and determine the best ways to reduce those costs.[48] This corridors study does not take into account the implications of climate change in general, or extreme weather events in particular, for the condition of the roads and the costs of land transport. It was carried out to meet the needs of three regional organizations, COMESA, EAC, and SADC,[49] in response to their concerns about the costs of transport in the region. Given the broad regional interest in these issues and their implications for virtually all activities in East Africa, integrating the implications of climate change into the many projects proposed to improve transport in the region will be essential. This activity would fall within the purview of the GCCI, working with regional organizations and with the USAID projects and contractors responsible for the corridors diagnostic study.

9.6 Meta Level Conclusions: On Methodology

The approach taken in this study raises questions that go beyond the immediate results and implications for USAID programming. If this approach is effective, regional comparative assessments based on the modeling work of specialized research organizations could be a useful strategy for other institutions working on vulnerability assessments and adaptation. Several issues are relevant to the question of whether this approach should be considered elsewhere.

First, is monetary cost a useful measure of the impacts of climate change? The answer to this question is, perhaps, already embedded in our paper. As we explained in the introduction, monetary cost is a very useful measure, because it permits comparisons and aggregation, and incorporates a measure of the significance of different impacts. It is particularly useful for study at this scale, assessing ecoregions that cut across countries as well as varying areas of potential climate change impact. On the other hand, as detailed in the conclusions, it is limited because it can mask all manner of problems. The benefits in one part of the country (or ecoregion, or area of impact) may cancel out the harm elsewhere, giving an impression that no one is hurt when in fact some people are hurt very badly. Moreover, monetary values do not capture the equity issues that are more visible if we look at how many people are affected and who they are. A change that wipes out the livelihoods of many very poor people may add up to a very small monetary impact from a national perspective; however it may actually represent a very significant harm to a large proportion of the population.

The overall conclusion on this question is therefore fairly straightforward. Cost is a very interesting and useful indicator of the impacts of climate change, but it cannot be used alone. It must be paired with information about how many people are affected, who they are, and how they are affected. This combination of measures can provide a much richer understanding of the impacts of climate change than any one of them alone.

Second, how adequately do global or continental studies of the impacts of climate change describe what may happen in any individual country? For countries or regions to be able to use the results of global or

[48] Nathan Associates, 2011

[49] Respectively, the Common Market for Eastern and Southern Africa, the East African Community, and the South African Development Community

continental studies to address more local issues, the broader studies have to have enough detail to be reasonably accurate at the country level.

The adequacy of the studies we have relied on is mixed. The crop modeling studies – those of IFPRI and Iglesias and Rosenzweig – are probably on the whole more accurate at the country level than the Ricardian work, because they do at least work with country-level agricultural data and climate predictions downscaled to the country level. In contrast, it is not clear how adequately the World Bank survey underlying the Ricardian work describes individual countries not covered by that survey. The Ricardian studies we used say nothing about how the data were extrapolated to apply to all of Africa; while the results may be considered representative at the continental scale, they may not be as accurate at the country level. The disaggregation of the results to the agroecological zone scale may make the application at the country scale more accurate, however. On the other hand, the particular data collected by the World Bank survey clearly has some limitations for our purposes, particularly in that there are no data about camels, and we cannot identify, for each farmer, the distribution of animals in his herd and the balance between livestock and crops in his income.

The IFPRI data raise different questions, mostly about whether national climate change predictions and agricultural data aggregated to the national level are sufficiently detailed to provide useful information for national or regional policy-making. With no information about sub-national variation in climate or crop choices, it is hard to be sure that national predictions of output can be convincing. Summing to a regional scale may somewhat reduce the margins of error, but regional sums may not be adequate for policy purposes.

The malaria data may be more accurate at a national level, because the results are based on more detailed spatial analysis of the spread of habitat rather than on national parameters. Although this is not detailed enough to determine precisely where exposure will increase and which communities will be at risk, it probably is sufficient to know in which countries the risks will be greatest.

For similar reasons, despite the questions about assumptions in the DIVA model, the analysis of sea level rise may also be more convincing at the national scale than the agricultural studies. The analysis of where flooding will occur is based on spatial data at a much higher resolution than the numerical data used in the agricultural studies. Although we have raised a number of questions about the DIVA model and about the study we relied on, in principle the results should be meaningful at the national or sub-national level. The main questions here pertain to the assumptions about where exactly the increased coastal population will settle, since, as shown in the Dar Es-Salaam analysis, the results are very sensitive to those assumptions.

Thus there is considerable variation across studies in how accurate their results are at the national scale. Policy-makers interested in relying on this kind of work to inform national decisions will have to understand clearly how the studies are designed, so they can assess whether the results are in fact likely to be useful for their purposes.

The third key question is how easily the results of global or continental studies can be used. Can an agency which only has a modest level of resources to put into policy analysis make sensible use of them in order to shed light on its own decision-making?

Our answer to this has to be that at present this is not easy enough. Some data sources are very easily accessible. These are primarily the data distributed by the United Nations and the IMF, and by CIESIN and other NGOs. Some institutions building analytical models also make an effort to make them available to potential users; for example, the models of crop suitability used to define the agroecological

zones used by the Ricardian studies are readily accessible from the International Institute for Applied Systems Research (IIASA) in Austria.

Accessing the results of analytical work is more challenging, however. Policy-makers like those at USAID do not have time and resources to learn about and run models themselves, or to hire someone else to do it for them. Following the model of benefits transfer in environmental valuation, they would like to be able to apply other analysts' results to their own situations, and this is not easy enough. While the authors of the studies we used clearly realize the importance of their results and the utility of their data to other analysts, none of them has made them easy enough for others to access and apply.

IFPRI has made a significant investment in a user interface through which their findings can be consulted, but in fact it is not easy to do what should be very simple, i.e. to download all of the information pertaining to a single country. Their report provides a summary of their conclusions and a general description of their methodology, but they do not provide sufficient technical documentation to enable other analysts to use their work with full understanding of how it was carried out. For example, there is no explanation of the exogenous coefficients used to estimate changes in yield by crop, although the an understanding of the logic for those parameters is clearly crucial to use of the results.

Iglesias and Rosenzweig have made the spreadsheets with their full results available to the public through the CIESIN website in an easily usable format, which is promising. However they have not provided any documentation to explain them. A report is available from CIESIN that documents an earlier version of this work, but there is no equivalent for the most recent data. Clearly, this limits the use that can be made of the data that they generously make available.

The results of the Ricardian studies were a challenge to use for a different reason. We focused on the studies analyzing the data by agroecological zone. In order to apply the resulting coefficients, we had to have a digital map of the zones to overlay with other digital data about our ecoregions. Although the coefficients were published at the agroecological zone level, the digital map of the zones was difficult to obtain. After a number of exchanges, one of the authors very kindly provided us with that map[50]; however this is clearly not an efficient way to enable policy-makers to make use of this work.

The challenges with the sea level study were more mundane. The authors published their findings along with an annex containing 184 tables of table providing country-level data on about two dozen variables, one for each of the many permutations of climate change scenario, year, adaptation, and other factors. Clearly they wished to make their detailed results available to other analysts. However, the tables were published in a pdf file, and after several email exchanges no one could tell us where to find the data in digital format. Fortunately, we were able to convert pdfs to excel without too much trouble; however again, the researchers do not seem to actually expect other analysts to use their results.

The health data were easier to use. We relied on two data sources; WHO tables on DALYs and country coefficients provided by the Tanser study. The WHO data are available in digital format on the web, and can easy be downloaded to spreadsheets. The Tanser data were in a pdf, and were in fact more difficult to transfer to a spreadsheet for trivial reasons related to typefaces; however we needed only a few values for our work, so this was not a serious problem.

Researchers carrying out these studies seem to expect that their colleagues will consider the conclusions of published papers, but they do not expect anyone to want to use their digital results as

[50] Pradeep Kurukulasuriya, to whom we are very grateful.

input into other analyses.[51] All of these constraints are relatively simple to resolve, however; they are challenges of presentation rather than concept.

Helping policy-makers to use the results, rather than simply the conclusions, of the extensive research now being carried out on the impacts of the climate change should be a high priority for everyone working in this field. To achieve this, it is important for both authors and publishers to think about how to present the results so that they can actually be applied to policy analysis. This is not the norm for conventional academic publications, so it will take some changes in thinking about these issues; it will not happen automatically.

It may be useful for USAID to identify and support an institution that already plays a significant role in disseminating the results of climate change research, and that is already tracking new work in the field, to take on the task of helping authors and publishers to make their results more easily usable by other analysts. This would be a valuable contribution to helping policy-makers use the existing research more fully than is now the case.

On the whole, then, it seems that studies of the type we have carried out are feasible, and can make a useful contribution to decision-making about adaptation. Cost is a very useful measure of climate change impact, although it should not be used separately from complementary indicators that shed more light on how many people are affected, how, and who they are. Although not all global studies will offer meaningful results at a national or regional level, some will; the use of this work to inform national policy-making should not be ruled out. And while there are logistical challenges in actually accessing the results of other analytical work in a usable format, these should be surmountable with investment in how they are made available to the public.

[51] Lest we be accused of the same behavior, the full spreadsheets containing our analysis are available on the web at www.joyhecht.net/East Africa Climate Change/eacc.html.

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Seo S. Niggol and Robert Mendelsohn, 2006a. Climate change impacts on animal husbandry in Africa: a Ricardian analysis. CEEPA Discussion Paper No. 9, Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Seo S. Niggol and Robert Mendelsohn, 2006b. Climate change adaptation in Africa: a microeconomic analysis of livestock choice. CEEPA Discussion Paper No. 19, Centre for Environmental Economics and Policy in Africa, University of Pretoria.

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Seo, S. Niggol, Robert Mendelsohn, Ariel Dinar, and Pradeep Kurukulasuriya, 2009a "Adapting to Climate Change Mosaically: An Analysis of African Livestock Management by Agro-Ecological Zones," The B.E. Journal of Economic Analysis & Policy: Vol. 9: Iss. 2 (Contributions), Article 4. Available at: http://www.bepress.com/bejeap/vol9/iss2/art4

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ANNEX A.

ANNOTATED BIBLIOGRAPHY OF VULNERABILITY ASSESSMENTS IN EAST AFRICA

Katharine Vincent
Consultant to International Resources Group

Introduction

This annex presents an annotated bibliography of vulnerability assessments (VA) in East Africa. As outlined in the methodology, there have been various approaches to VA. Traditional assessments look at model projections of climate change as related to particular areas of impact. In these cases vulnerability is typically the impact – what is left after climate change has occurred and any adaptation has taken place. This is also known as "end point" vulnerability, and is the approach typically taken with large scale assessments (at regional or national level). In contrast, smaller scale vulnerability assessments have typically assessed "starting point" vulnerability, i.e. the social and economic conditions that affect how well a community/household is likely to be able to withstand exposure to a climate hazard. These varying approaches are the reason that simply aggregating of existing research outputs was not possible for this study. However, various other vulnerability and impact assessments have been produced at various geographical levels and with differing areas of focus for the East Africa region, and some of the key ones are presented here, divided into different (but often overlapping) sections.

Table A-1: Sectoral priorities for interventions, based on NAPAs

Country	Ecoregion	Sector					
		Land and land use	Agriculture and forestry	Water resources	Health	Coasts	Energy
Kenya	Plains/Lakes	No NAPA					
Tanzania	Plains/Lakes		1	2	4		3
Rwanda	Lakes		1	2			3
Burundi	Lakes	4	2	1	5		3
Uganda	Lakes	1	2	3	4	7	
Ethiopia	Horn		1	2	3		
Eritrea	Horn		1	2	4	3	
Somalia	Horn	No NAPA					
Note: The purpose of NAPAs is not to prioritize the sectors, but to prioritize response interventions in the form of projects. These are not necessarily explicit ranks, but mentioned in the order they appear in the report.							

The first section outlines the National Communications and, where appropriate, National Adaptation Programs of Action. The former are obligatory for all signatories to the UNFCCC; the latter are required of all Least Developed Countries. Both of these documents contain vulnerability assessments by sector and rank the sectors of most national importance for interventions (see Table A-1). These sectors have been used to organize the list of other vulnerability assessments. Subsequent emphasis has been placed on regional/cross-country assessments, in keeping with the focus of the study. This is structured as follows:

Section 2. Continent wide vulnerability assessments

Section 3. Cross-country vulnerability assessments

Section 4. Sectoral vulnerability assessments:

a. Agriculture
b. Livestock
c. Health
d. Energy
e. Coasts

f. Water
g. Forestry

Section 5. Small-scale vulnerability assessments (to give an indication of sub-national assessments, which typically take a more qualitative and/or social-science based approach).

This annotated bibliography is not intended to be an exhaustive list. It includes key reports and papers but not presentations, and focuses particularly on those from reputable organizations. It also only includes those with explicit references to vulnerability and how it differs across space and time, excluding the many more studies that assume vulnerability and focus on adaptation options. In keeping with the regional focus of the study, national level assessments have been excluded (with the exception of the National Communications and NAPAs). URLs are provided for all resources; many of these reports are also available on line at http://www.joyhecht.net/East Africa Climate Change/eacc.html

1. National Communications and NAPAs

Federal Democratic Republic of Ethiopia. 2007. Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. Addis Ababa: Ministry of Water Resources, National Meteorological Agency. Available online at http://unfccc.int/resource/docs/napa/eth01.pdf

Federal Democratic Republic of Ethiopia. 2001. Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change. Addis Ababa: Ministry of Water Resources, National Meteorological Agency. Available online at http://unfccc.int/resource/docs/natc/ethnc1.pdf

Republic of Kenya. 2002. First National Communication of Kenya to the Conference of Parties to the United Nations Framework Convention on Climate Change. Nairobi: Ministry of Environment and Natural Resources. Available online at http://unfccc.int/resource/docs/natc/kennc1.pdf

Republic of Rwanda. 2006. NAPA Rwanda: National Adaptation Programmes of Action to Climate Change. Kigali: Ministry of Lands, Water, Forestry, Environment and Mines. Available online at http://unfccc.int/resource/docs/napa/rwa01e.pdf

Republic of Rwanda. 2005. Initial National Communication Under the United Nations Framework Convention on Climate Change. Kigali: Ministry of Lands, Water, Forestry, Environment and Mines. Available online at http://unfccc.int/resource/docs/natc/rwanc1.pdf

Republic of Uganda. 2007. Climate Change Uganda National Adaptation Programmes of Action. Kampala: Ministry of Water, Lands and Environment. Available online at http://unfccc.int/ resource/docs/napa/uga01.pdf

Republic of Uganda. 2002. Uganda Initial National Communication to the United Nations Framework Convention on Climate Change. Kampala: Ministry of Water, Lands and Environment. Available online at http://unfccc.int/resource/docs/natc/uganc1.pdf

République de Djibouti. 2001. Communication nationale initiale de la République de Djibouti à la Convention Cadre des Nations Unies sur les Changements Climatiques. Djibouti: Ministère de l'Habitat, de l'Urbanisme, de l'Environnement et de l'Aménagement du Territoire. Available online at http://unfccc.int/resource/docs/natc/djinc1.pdf (in French)

République du Burundi. 2001. Deuxième Communication Nationale sur les Changements Climatiques. Bujumbura: Ministère de l'Aménagement du Territoire, du Tourisme, et de l'Environnement. Available online at http://unfccc.int/resource/docs/natc/burnc2.pdf (in French)

République du Burundi. 2007. National Adaptation Plan of Action to Climate Change. Bujumbura: Ministère de l'Aménagement du Territoire, du Tourisme, et de l'Environnement. Available online at http://unfccc.int/resource/docs/napa/bdi01e.pdf

République du Burundi. 2001. Convention Cadre des Nations Unies sur les Changements Climatiques: Première Communication Nationale. Bujumbura: Ministère de l'Aménagement du Territoire, du Tourisme, et de l'Environnement. Available online at http://unfccc.int/resource/docs/natc/burnc1.pdf (in French)

State of Eritrea. 2007. National Adaptation Programme of Action. Asmara: Ministry of Land, Water and Environment. Available online at http://unfccc.int/resource/docs/napa/eri01.pdf

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United Republic of Tanzania. 2007. National Adaptation Programme of Action. Dar es Salaam: Vice President's Office, Division of Environment. Available online at http://unfccc.int/resource/docs/napa/tza01.pdf

United Republic of Tanzania. 2003. Initial National Communication under the United Nations Framework Convention on Climate Change. Dar es Salaam: Ministry for Environment, Centre for Energy, Environment, Science and Technology. Available online at http://unfccc.int/resource/docs/natc/tannc1.pdf

2. Continent-wide vulnerability assessments

Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, 2007: Africa. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, (eds) Cambridge: Cambridge University Press, 433-467. Available online at www.ipcc.ch/publications_and_data/ar4/wg2/en/ch9.html

The Africa chapter of the IPCC Fourth Assessment Report contains a comprehensive review of literature relating to adaptation, impacts and vulnerability to climate change across the continent, by sector. Among key findings of relevance to East Africa are the threat of coastal flooding due to sea level rise, changes in ecosystems, changed disease distribution, impacts on food security, and water stress.

Elasha, B.O., Medany, M., Diop, I.N., Nyong, T., Tabo, R., and C. Vogel. 2006. Background paper on impacts, vulnerability and adaptation to climate change in Africa for the African Workshop on Adaptation, Accra, Ghana, 21-23 September 2006. Available online at http://unfccc.int/files/adaptation/adverse_effects_and_response_measures_art_48/application/pdf/200609_background_african_wkshp.pdf

This paper, almost a precursor to the IPCC Fourth Assessment Report (and written by many of the same authors), includes a review of key impacts and vulnerabilities to future climate change by sector (water resources, health, agriculture and food security, biodiversity, coastal zone and marine areas, and Millennium Development Goals), as well as of adaptation.

3. Cross-country vulnerability assessments

Adger, W. N., Brooks, S., Bentham, G., Agnew, M. and Eriksen, S. 2004. New indicators of vulnerability and adaptive capacity. Tyndall Centre for Climate Change Research, Technical Report Number 7, Norwich. Available online at http://www.tyndall.ac.uk/content/new-indicators-vulnerability-and-adaptive-capacity

This report outlines a number of diagnostic and predictive vulnerability and adaptive capacity indicators useful for cross-country comparison. The diagnostic ones were measured in terms of the outcome of climate-related disasters over a decadal time period (using data from the EM-DAT database). The predictive ones were based on publicly available data relating to social, economic, political and environmental factors, with candidate proxy variables likely to represent elements of vulnerability determined from a literature review and expert judgment. In terms of mortality related to discrete extreme events, health, education, and particularly governance indicators provide a reasonable assessment of vulnerability. The paper also discusses the options for combining and aggregating indices, and recommends dividing countries into groups and then summing, in order to avoid the false degree of confidence that comes from averaging.

Brooks N and Adger W N. 2003. Country level risk measures of climate-related natural disasters and implications for adaptation to climate change. Tyndall Centre Working Paper 26. Norwich: Tyndall Centre for Climate Change Research. Available online at http://www.tyndall.ac.uk/content/country-level-risk-measures-climate-related-natural-disasters-and-implications-adaptation-cl

Using data for the number of people killed and otherwise affected by discrete climate-related natural disasters over the final decades of the 20th century as a proxy for climatic risk, this paper develops several proxies for risk and vulnerability from available data. Recognizing that disasters result from the intersection of hazard (the likelihood of occurrence and potential severity of events) and vulnerability (social, economic, political and physical factors that determine the amount of damage an event will cause), this paper shows the countries most at risk of climate change impacts. In East Africa, Kenya and Djibouti feature in the list.

Case, Michael. 2006. Climate change impacts on East Africa: A review of the scientific literature. Washington DC: WWF. Available online at http://assets.panda.org/downloads/east_africa_climate_change_impacts_final_2.pdf

This cross-sectoral paper summarizes literature to date (2006) of the impacts of climate change by sector, including water availability, desertification, food security, human health and extreme weather events.

Eriksen, S., O'Brien, K. and Lynn Rosentrater. 2008. Climate change in eastern and southern Africa: Impacts, vulnerability and adaptation. GECHS Report 2008:2, Department of Sociology and Human Geography, University of Oslo. Available online at www.gechs.org/publications/reports/

This paper presents the multiple stresses at work in eastern and southern Africa that interact to create situations of vulnerability. These stresses include the HIV/AIDS pandemic, trade liberalization, competing pressures for land, agricultural policy changes, insecurity of land tenure, conflict (and migration); all of which are affected by global environmental change, urbanization and deagrarianization. All of these stresses affect people in different ways, depending on their age, gender, ethnicity, religion, and other social factors. The paper is very descriptive, with few case studies elaborated.

Füssel, H-M. 2009. Review and quantitative analysis of indices of climate change exposure, adaptive capacity, sensitivity, and impacts. Background paper to the World Development Report 2010. Available online at http://siteresources.worldbank.org/INTWDR2010/Resources/5287678-1255547194560/WDR2010_BG_Note_Fussel.pdf

This comprehensive paper reviews theoretical approaches to vulnerability, and their implications for methods of vulnerability assessment, as well as discussing some of the major national level indicators/indices of vulnerability to climate change that have been constructed. It also presents a conceptual framework of vulnerability with the purpose of prioritizing adaptation assistance, distinguishing 5 groups of vulnerability factors and 2 groups of adaptability factors. Highly recommended.

Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC). 2007. Climate change and human development in Africa: Assessing the risks and vulnerability of climate change in Kenya, Malawi and Ethiopia. Human Development Report Office Occasional Paper. New York: UNDP. Available online at http://hdr.undp.org/en/reports/global/hdr2007-8/papers/IGAD.pdf

Summarizes vulnerabilities to/impacts of climate change across major domains (energy, water, agriculture/livestock/food security/health, coastal and marine resources, environment and biodiversity, human settlements) in Kenya, Malawi and Ethiopia; then outlines downscaled regional climate projections for 2030 and 2050; and discusses options for mainstreaming climate information in development.

Seitz, J. and W. Nyangena. 2009. Economic impact of climate change in the East African Community. Report prepared by Global 21 with funding from GTZ for the East African Community, Arusha. Available online at http://www.eacgermany.org/index.php/documents-and-studies/doc_download/2-economic-impact-of-climate-change-in-the-east-african-community

This paper gives an assessment of various sectors of the East African community to climate change: lake level volatility in the East African lakes (Edward, Albert, Kivu, Victoria, Tanganyika and Malawi); glacial and ice retreat on Kilimanjaro and in the Rwenzori mountains and Mount Kenya; pressures on forest biomes; the threat of sea level rise in Kenya and Tanzania (and warmer temperatures causing coral bleaching) and its impact on various economic sectors, including tourism, mining and fisheries; and the resurgence of malaria, particular in previously malaria-free highland areas, such as in Ethiopia, Kenya, Rwanda and Burundi; and the risk that climate change will hinder development progress to date, particularly given the dependence of livelihoods on natural resources. Of note, water stress is only likely in East Africa due to population increase, not due to climate change (which is actually projected to increase water availability).

Thornton, P.K., Jones, P.G., Owiyo, T., Kruska, R.L., Herrero, M., Kristjanson, P., Notenbaert, A., Bekele ,N .and A. Omolo, with contributions from Orindi, V., Otiende, B., Ochieng, A., Bhadwal, S., Anantram, K., Nair, S., Kumar, V. and Kulkar, U. 2006. Mapping climate vulnerability and

poverty in Africa. Report to the Department for International Development, Nairobi: ILRI. Available online at http://www.waterandclimateinformationcentre.org/resources/8012007_ILRI2006_mapping-climatevulnpovafrica.pdf

This report highlights vulnerability mapping for Africa in 2005/06, overlaying downscaled climate data from several GCMs under four different SRES growth scenarios with indicators of biophysical and social vulnerability. 14 indicators of biophysical and social vulnerability (three associated with natural capital, one with physical capital, two with social capital, six with human capital, and two with financial capital) were reduced to four components on the basis of statistical analysis, which were then used to construct one overall indicator of vulnerability. Among the "hotspot" areas, where high exposure to climate change intersects with high biophysical and social vulnerability, are the mixed arid-semi-arid systems in the Sahel, arid-semi-arid rangeland systems in parts of eastern Africa, the systems in the Great Lakes region of eastern Africa, the coastal regions of eastern Africa, and many of the drier zones of southern Africa. Contains nice spatial representations of various indicators. This study was undertaken to prioritize resources under DFID's commitment to addressing climate change.

Vincent, K. 2004. Creating an index of social vulnerability to climate change for Africa. Tyndall Centre for Climate Change Research, Working Paper 56. Available online at http://www.tyndall.ac.uk/content/creating-index-social-vulnerability-climate-change-africa

This paper outlines an index to empirically assess relative levels of human vulnerability to climate change-induced variations in water availability and allow cross-country comparison in Africa. The theory-driven aggregate index of human vulnerability is formed through the weighted average of five composite sub-indices: economic well-being and stability (20%), demographic structure (20%), institutional stability and strength of public infrastructure (40%), global interconnectivity (10%) and dependence on natural resources (10%). Using 2002-03 data, East African countries rank in the following positions out of 49, where 1 is the most vulnerable and 49 the least vulnerable: Burundi (3rd), Uganda (6th), Ethiopia (7th), Tanzania (10th), Rwanda (13th), Eritrea (18th), Kenya (30th), and Djibouti (49th).

Wheeler, D. 2011. Quantifying vulnerability to climate change: Implications for adaptation assistance. Center for Global Development Working Paper 240, Washington DC. Available online at www.cgdev.org/content/publications/detail/1424759/

This paper quantifies vulnerability for 233 global states, based on indicators for increasing weather-related disasters, sea-level rise, and the loss of agricultural productivity. It then looks at the implications of these for the cost-effective allocation of adaptation assistance.

4. Sector-based vulnerability assessments

a. Agriculture

Challinor, A., Wheeler, T., Garforth, C., Crauford, P. and A. Kassam. 2007. Assessing the vulnerability of food crop systems in Africa to climate change. Climatic Change 83:381–399. Available online at http://www.met.reading.ac.uk/~charlie/ccrg.d/talks.d/session1.d/ccrg_challinor.pdf

This paper looks at three aspects of the vulnerability of food crop systems to climate change in Africa are discussed: the assessment of the sensitivity of crops to variability in climate, the adaptive capacity of farmers, and the role of institutions in adapting to climate change. They also discuss the variability in

magnitude of projected impacts of climate change on food crops in Africa, whilst highlighting how most studies show a negative impact of climate change on crop productivity in Africa.

Kandji, S.T. and L.V. Verchot. Undated. Impacts of and adaptation to climate variability and climate change in the East African Community: A focus on the agricultural sector. Nairobi: World Agroforestry Centre (ICRAF). Available online at http://www.worldagroforestry.org/downloads/publications/PDFs/RP07172.pdf

This report is one of a series of ICRAF outputs aimed at discussing the vulnerability of African countries to climate hazards, with a specific focus on Kenya, Tanzania and Uganda (the East African Community countries). It presents climate trends, existing status of national and local level coping, the multiple driving forces of vulnerability, and concludes with some policy recommendations.

Mongi, H., Majule, A.E. and J.G. Lyimo. 2010. Vulnerability and adaptation of rain-fed agricultural to climate change and variability in semi-arid Tanzania. African Journal of Environmental Science and Technology 4 (6): 371-381. Available online at http://www.ajol.info/index.php/ajest/article/viewFile/56374/44809

This paper assess vulnerability of rain-fed agriculture to climate change in four village clusters in the Tabora region of Tanzania (Mbola, Mpenge and Isila from Uyui District) and one from the Tabora district (Tumbi), comparing perceptions gleaned through social science research with simple regression and t-test analyses of numeric data for rainfall and temperature collected over the last 35 growing seasons. Results indicate that the overall rainfall amount was found to decline while distribution was varying both in time and space, and temperature (both minima and maxima) has increased. Major implications on rain fed agriculture are possible shrinking of the growing season, increasing moisture and heat stress to common food and cash crops, increased insects and pests and eventually low income and food insecurity.

b. Livestock

Galvin, K.A., Thornton, P.K., Boone, R.B. and J. Sunderland. 2004. Climate variability and impacts on east African livestock herders: the Maasai of Ngorongoro Conservation Area, Tanzania. African Journal of Range and Forage Science 21 (3): 183-189. Available online at http://warnercnr.colostate.edu/~rboone/docs/Galvin_Climate_Maasai.pdf

This paper links a household model (PHEWS) with an ecosystem model (SAVANNA) to investigate the effects of drought and a series of wet years on the well-being of Maasai pastoralists. Results show that the ecosystem if quite resilient and the Maasai of the Ngorongoro Conservation Area are not very vulnerable to climate variability, but the precarious economic situation means that drought does tend to have a negative effect.

Kirkbride, M. and R. Grahn. 2008. Survival of the fittest. Pastoralism and climate change in East Africa. Oxfam Briefing paper no 116. Oxford: Oxfam. Available online at http://www.oxfam.org/policy/bp116-pastoralism-climate-change-0808

This paper explores the ways in pastoral livelihoods are affected by the interaction of multiple stresses: climate change: climate change, political and economic marginalization, inappropriate development policies, and increasing resource competition. A number of case studies are provided from East African, since significant proportions of GDP are made up by pastoralism in these countries. In keeping with the

advocacy aims of the publishing organization, the paper concludes with recommendations for East African governments in addressing these challenges through supporting sustainable livelihoods.

c. Health

MARA (Mapping Malaria Risk in Africa) (1998). Towards an Atlas of Malaria Risk in Africa. MARA/ARMA, Durban. Online at http://www.mara.org.za/trview_e.htm#Malaria Distribution Model

Hay, S.I., Tatem, A.J., Guerra, C.A., Snow, R.W. Population at malaria risk in Africa: 2005, 2015 and 2030. Paper prepared for the UK Government's Foresight project. Available online at http://users.ox.ac.uk/~hay/077.pdf

This paper outlines simulations of the combined effects of climate change, population growth and urbanization on the population at risk (PAR) of Plasmodium falciparum malaria in Africa, showing that the PAR will change from approximately 0.63 billion in 2005, to 0.87 billion in 2015 and 1.15 billion in 2030 (data are also presented sequentially by influence, as well as in combination). Includes (coarse resolution) maps to show distribution of risk within East Africa.

Hay, S.I., Guerra, C.A., Gething, P.W., Patil, A.P., Tatem, A.J., Noor, A.M., Kabaria, C.W., Manh, B.H., Elyazar, I.R.F., Brooker, S.J., Smith, D.L., Moyeed, R.A., Snow, R.W. (2009). A world malaria map: Plasmodium falciparum endemicity in 2007. PLoS Medicine, 6(3): e1000048. Available online at http://www.plosmedicine.org/article/info:doi/10.1371/journal.pmed.1000048

This paper describes the generation of a new world map of Plasmodium falciparum malaria endemicity for 2007. Population at risk estimates, adjusted for the transmission-modifying effects of urbanization in Africa, found that of the 1.38 billion people at risk of stable *P. falciparum* malaria, 0.69 billion were found in Central and South East Asia (CSE Asia), 0.66 billion in Africa, Yemen, and Saudi Arabia (Africa+), and 0.04 billion in the Americas. High endemicity was widespread in the Africa+ region, where 0.35 billion people are at this level of risk. The paper is also based on a dataset and maps made publicly available by the Malaria Atlas Project http://www.map.ox.ac.uk/.

Lindsay, S.W. and W.J. Martens. 1998. Malaria in the African highlands: past, present and future. Bulletin of the World Health Organization 76 (1): 33-45. Available online at http://www.ncbi.nlm.nih.gov/pubmed/9615495

This paper is one of many that highlight how climate change will allow the area at risk of malaria to increase, particularly at altitude, as places previously too cold for the anopheles mosquito come within its possible habitat. It outlines a mathematical model designed to identify endemic-prone regions in the African highlands and the differences expected to occur as a result of climate change.

Tonnang, H.E., Kangalawe, R.Y. and P.Z. Yanda. 2010. Predicting and mapping malaria under climate change scenarios: the potential redistribution of malaria vectors in Africa. Malaria Journal 23 (9): 111. Available online at http://www.ncbi.nlm.nih.gov/pubmed/20416059

This paper provides spatial representations of the potential geographical distribution and seasonal abundance of malaria vectors (Anopheles gambiae and Anopheles arabiensis) in relation to various climatic factors, including temperature, rainfall, and relative humidity, in combination with an ecoclimatic index under three climate change scenarios. Their results have shown that shifts in these species boundaries southward and eastward of Africa may occur rather than jumps into quite different climatic environments.

Trærup, S. L. M., R. A. Ortiz and A. Markandya (2010) *The Health Impacts of Climate Change: A Study of Cholera in Tanzania.* BC3 Working Paper Series 2010-01. Bilbao: Basque Centre for Climate Change (BC3). Available online at http://www.bc3research.org/working_papers/view.html

This paper provides empirical evidence to support the claim that the incidence of cholera is linked to environmental and socioeconomic factors. It integrates historical data on temperature and rainfall with the burden of disease from cholera in Tanzania, and uses socioeconomic data to control for impacts of general development on the risk of cholera. Based on these results, they can estimate the number and costs of additional cholera cases and deaths that can be attributed to climate change by year 2030 in Tanzania. The results show a significant relationship between cholera cases and temperature and predict an increase in the initial risk ratio for cholera in Tanzania in the range of 23 to 51 percent for a 1 degree Celsius increase in annual mean temperature. The cost of reactive adaptation to cholera attributed to climate change impacts by year 2030 in Tanzania is projected to be in the range of 0.02 to 0.09 percent of GDP for the lower and upper bounds respectively. Total costs, including loss of lives are estimated in the range of 1.4 to 7.8 percent of GDP by year 2030.

van Lieshout, M., Kovats, R.S., Livermore, M. and Martens. P. 2004. Climate change and malaria: analysis of the SRES climate and socio-economic scenarios. Global Environmental Change **14**(1): 87-99. Available online at http://www.geography.ryerson.ca/jmaurer/716art/716Climatechgmalaria.pdf

This paper presents the results of a global model of malaria transmission (MIASMA v.2.2) that was developed to estimate the potential impact of climate change on seasonal transmission and populations at risk of the disease. Using the model HadCM3 with four SRES emissions scenarios: A1FI, A2, B1 and B2, the additional population at risk was determined under each of the SRES population scenarios by downscaling national estimates to the 0.5×0.5° scale grid and re-aggregating by region. Additional population at risk due to climate change are projected in East Africa, central Asia, China and areas around the southern limit of the distribution in South America. Taking vulnerability as reflecting both socio-economic status (as a measure of adaptive capacity), and malaria control status, climate-induced changes in the potential distribution of malaria is projected in East Africa.

Wandiga, S.O., Opondo, M., Olago, D., Githeko, A., Githui, F., Marshall, M., Downs, T., Opere, A., Oludhe, C., Ouma, G.O., Yanda, P.Z., Kangalawe, R., Kabumbuli, R., Kathuri, J., Apindi, E., Olaka, L., Ogallo, L., Mugambi, P., Sigalla, R., Nanyunja, R., Baguma, T., Achola, P. 2006. Vulnerability to climate induced Highland malaria in East Africa. AIACC Working Paper no 25. Available online at http://www.aiaccproject.org/working_papers/working_papers.html

In addition to looking at the relationship between areas at risk of malaria and wet conditions, this report focuses on the socio-economic factors that drive vulnerability to malaria, including poverty, and inadequate warning mechanisms. This report was produced by the Assessment of Impacts and Adaptation to Climate Change (AIACC) project. AIACC was a global initiative of UNEP/WMO IPCC, funded by the Global Environment Facility, and implemented by UNEP, START and the Third World Academy of Sciences to advance scientific understandings of climate change vulnerabilities and adaptation options in developing countries. Although this is the most East Africa-specific output, other working papers and publications are also available on the website. Many, like this one, have subsequently been published in peer-reviewed journals (this one in *Climatic Change*, volume 99).

Yanda, P.Z., Kangalawe, R.Y.M. and R.J. Sigalla. 2005. Climatic and socio-economic influenced on malaria and cholera risks in the Lake Victoria region of Tanzania. AIACC working paper no 12. Available online at http://www.aiaccproject.org/working_papers/Working%20Papers/AIACC_WP_No012.pdf

This paper shows that the vulnerability and impact of climate change-induced malaria and cholera are influenced by the socioeconomic characteristics of the different communities, based on two case studies of Tanzania. Findings from this study show that the majority of respondents had similar perceptions regarding the causes and seriousness of malaria, factors that influence its severity, and how the disease can be controlled or treated, regardless of their levels of education or wealth. The study found that women, children, and the elderly are more vulnerable to malaria; which relates to their differential access to bed nets and, in the case of women, their exposure through weeding the bean fields.

Zhou G, Minakawa N, Githeko AK, Yan G. 2004. Association between climate variability and malaria epidemics in the East African Highlands. Proceedings of the National Academy of Sciences 101 (8): 2375-80. Available online at http://www.pnas.org/content/101/8/2375.full

While there had hitherto been some controversy over the link between climate change and the reemergence of Plasmodium falciparum malaria in the East African highlands, this paper concludes that climate variability (i.e. short term fluctuations around the mean climate state) may be more relevant than temperature change. Using a nonlinear mixed regression model to investigate the association between autoregression (number of malaria outpatients during the previous time period), seasonality and climate variability, and the number of monthly malaria outpatients of the past 10-20 years in seven highland sites in East Africa, 65-81% of the variance in the number of monthly malaria outpatients was explained.

Other data sources for health: The International Research Institute for Climate and Society (IRI) at Columbia University's Lamont Dougherty Earth Observatory has climate data that are used to illustrate models of climate suitability for seasonal endemic malaria, and recent climate conditions, such as rainfall anomalies, which may be associated with epidemic malaria in warm semi-arid regions of Africa (but for the malaria data they rely on MARA and MAP). http://iridl.ldeo.columbia.edu/maproom/.Health/.Regional/.Africa/.Malaria/

d. Energy

Byakola, T. and P. Mukheibir. Energy systems: Vulnerability-Adaptation-Resilience. Uganda. Paris: Helio International. Available online at http://www.helio-international.org/uploads/VARUganda.En.pdf

Over 80% of Ugandan households use firewood for cooking, and another 15.2% use charcoal, meaning biomass makes up 94% of the energy consumed in Uganda. Climate change will put pressure on the availability of natural resources for energy, and has already led to a substantial drop in energy generated by hydropower (due to fluctuations in the level of Lake Victoria), and led to rationing. The distribution system is also vulnerable, particularly due to the centralized nature of the dam-based facilities. The lack of diversification contributes to energy vulnerability, although there are plans to exploit oil resources in Uganda by 2013. Other options suggested to reduce energy vulnerability include promotion of small scale rural-based bioenergy technologies (biogas, cogeneration etc), installing smaller and decentralized energy schemes, and expanding investment in renewable.

Casmiri, D. 2009. Energy systems: Vulnerability-Adaptation-Resilience. Tanzania. Paris: Helio International. Available online at http://www.helio-international.org/VARTanzania.En.pdf

Biomass is the main energy source in Tanzania, whilst hydropower contributes about 60% of electricity generation. This is already insufficient to meet demands, which are projected to increase between 11-13% in the near future, and drought and insufficient rainfall have already brought about power shedding. Climate change is likely to exacerbate this problem due to reduced water flow in the Pangani River

(where three dams are situated). Suggested recommendations to address this are the promotion of renewable energy, having in place emergency repair plans, and recognizing the value of water.

Connor, H., Mqadi, L., Mukheibir, P., Thorne, S. and L.E. Williamson. 2007. A preliminary assessment of energy and ecosystem resilience in ten African countries. Paris: Helio International. Available online at http://www.helio-international.org/Report.En.Final.pdf

This paper is an overview of energy vulnerability as part of Helio International's ten country Vulnerability-Adaptation-Resilience methodology-based studies, three of which took place in east Africa (Kenya, Tanzania, and Uganda).

Energy, Environment and Development Network for Africa (AFREPREN/FWD). 2009. Large Scale Hydropower, Renewable Energy and Adaptation to Climate Change: Climate Change and Energy Security in East and Horn of Africa. Nairobi: Heinrich Boell Foundation. Available online at http://www.boell.or.ke/downloads/RenewableEnergyandAdaptationtoClimateChangePublication.pdf

This paper calls for urgent investigation into renewable energy due to high climate vulnerability of energy systems in East Africa, evidenced by the recent drought-induced shortages faced by Kenya, Tanzania, Uganda and Ethiopia.

Kirai, P. 2009. Energy systems: Vulnerability-Adaptation-Resilience. Kenya. Paris: Helio International. Available online at http://www.helio-international.org/VARKenya.En.pdf

Sixty percent of electricity comes from hydropower, and with demand growing at 7% per year (although less than 20% of the country have access), supply has been unable to meet demand. The majority of the population use biomass for energy, leading to widespread overexploitation of natural resources. Reduced rainfall has resulted in increased thermal generation and a rise in electricity costs, whilst flooding has disrupted energy transport systems. The paper recommends a number of measures to reduce energy vulnerability under climate change, including diversification of sources and improved efficiency.

e. Coasts

Kebede, A.S., Hanson, S., Nicholls, R.J. and M. Mokrech. 2010. Impacts of climate change and sea-level rise: a case study of Mombasa, Kenya. Tyndall Working Paper no 146. Available online at http://www.tyndall.ac.uk/sites/default/files/twp146.pdf

This paper presents a GIS-based quantitative estimate of the exposure and risks under climate change faced by Mombasa, East Africa's largest port. The current exposure to a 1 in 100 year extreme water level for the whole of Mombasa district is estimated at 190,000 people and US$470 million in assets. Currently about 60 percent of this exposure is concentrated in the Mombasa Island division of the city where about 117,000 people (2005 estimate) live below 10m elevation. By 2080, the exposure could grow to over 380,000 people and US$15 billion in assets assuming the well-known A1B sea-level and socioeconomic scenario.

f. Water

Arnell, N. W. 2004. Climate change and global water resources: SRES emissions and the socio-economic scenarios. Global Environmental Change 14 (1): 31-52. http://mfs.uchicago.edu/troubledwaters/readings/arnell.pdf

This seminal paper provides information on projections of water availability under the major SRES scenarios (taking into account population growth and economic trajectories) based on six models. Although this paper is global in emphasis, the maps provided give an indication of changes projected in East African watersheds.

Beekman, H.E., Abu-Zeid, K., Afouda, A., Hughes, S., Kane, A., Kulindwa, K.A., Odada, E.O., Opere, A., Oyebande, L. and I.C. Saayman. 2005. Facing the facts: assessing the vulnerability of Africa's water resources to global environmental change. Nairobi: UNEP. Available online at http://www.unep.org/dewa/assessments/EcoSystems/water/Vulnerability/Facing%20the%20Facts_Full.pdf

This report applies a particular vulnerability assessment methodology to all the international river basins in Africa, including the Lake Victoria and Rufiji river basins in East Africa.

g. Forestry

There is a notable absence of vulnerability assessments of forest ecosystems in East Africa, partly due to the small spatial extent of forests in this region relative to elsewhere (for example the tropical forest belt of central Africa).

5. Small-scale vulnerability assessments

Deressa, T.G., Hassan, R.M. and C. Ringler. 2009. Assessing household vulnerability to climate change: The case of farmers in the Nile Basin of Ethiopia. IFPRI Discussion Paper 00935, Washington DC: IFPRI. Available online at http://www.ifpri.org/sites/default/files/publications/ifpridp00935.pdf

This paper takes an economic approach, equating vulnerability with poverty and measuring it based on an estimation of the probability that a given shock or set of shocks will move household consumption below a given minimum level (such as the consumption poverty line) or force the consumption level to stay below the given minimum if it is already below this level. Using a household survey of farmers during the 2004-05 production year, results show that the farmers' vulnerability is highly sensitive to their minimum daily requirement (poverty line). The results further indicate that farmers in kola agro-ecological zones (which are warm and semi-arid) are the most vulnerable to extreme climatic events.

Deressa, T. D., Hassan, R.M. and C. Ringler. 2008. Measuring Ethiopian Farmers' Vulnerability to Climate Change Across Regional States, IFPRI Discussion Paper No. 806, Washington DC. Available online at http://www.ifpri.org/pubs/dp/ifpridp00806.asp

This paper analyses the vulnerability of farmers to climate change in Ethiopia through the development of a vulnerability index that is then used to compare regions within the country. The results indicate that the semi-arid and arid regions, and those characterized by recurrent drought, are most vulnerable, namely Afar, Somali, Oromia and Tigray.

Eriksen, S. H., Brown, K. and P.M Kelly. 2005. The dynamics of vulnerability: locating coping strategies in Kenya and Tanzania. The Geographical Journal **171**(4): 287-305. Available online at http://www.uea.ac.uk/~f030/papers/gj2005.pdf

This paper outlines differences in vulnerability between smallholders farmers at two locations in Kenya and Tanzania; finding that where one individual can specialize in an economic activity within the context

of diversification within the household, they are less likely to be vulnerable. This shows a gendered element, as typically women are less able to specialize due to a combination of time pressures and lack of skills.

Riché, B., Hachileka, E., Awuor, C.B. and A. Hammill. 2009. Climate related vulnerability and adaptive capacity in Ethiopia's Borana and Somali Communities. Final Assessment Report. Save the Children UK, CARE, IUCN and IISD. Available online at http://www.iisd.org/pdf/2010/climate_ethiopia_communities.pdf

This study uses CARE's Community Vulnerability and Capacity Assessment Tool to determine the level of vulnerability of two pastoral communities in the Borana and Shinile zones of Ethiopia, which are exposed to recurrent droughts. The magnitude and rate of climate change, combined with environmental, social and political issues, means that many coping strategies are now unsustainable and new adaptation options must be embraced to ensure sustainability of livelihoods in this area.

ANNEX B.

INSTITUTIONAL ASSESSMENT

Robin Mason, Consultant to USAID

With Katharine Vincent and Elizabeth Elliott,
Consultants to International Resources Group

List of Acronyms

ACT	The African Conservation Tillage Network
AfDB	African Development Bank
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
USDA	United States Department of Agriculture
AU	African Union
AWN	Africa Water Network
CAADP	Comprehensive Africa Agriculture Development Program
CCAA	Climate Change Adaptation in Africa (DFID)
CC:DARE	Climate Change Adaptation and Development Initiative
CCEMA	Climate Change, Environment, and Migration Alliance
CDM	Clean Development Mechanism
CEEPA	Center for Environmental Economics and Policy in Africa
CLACC	Capacity Strengthening of Least Developed Countries to Climate Change
CARE	Cooperative for Assistance and Relief Everywhere
CGIAR	Consultative Group for International Agricultural Research
COMESA	Common Market for Eastern and Southern Africa
DEPI	Division of Environmental Policy and Implementation (UNEP)
DFID	Department for International Development (UK)
DMC	Drought Monitoring Center (WMO)
EAC	East African Community
FAO	Food and Agriculture Organization (United Nations)
FEWSNET	Famine Early Warning Systems Network (USAID)
FSNWG	Food Security and Nutrition Working Group
GCCI	Global Climate Change Initiative (USAID)
GEF	Global Environment Facility
GHARP	Greater Horn of Africa Rainwater Partnership
GTZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German implementation agency for cooperation)
ICARDA	International Center for Agricultural Research in the Dry Areas
ICGLR	International Conference on the Great Lakes Region
ICPAC	International Climate Prediction and Application Center
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Center (Canada)
IFAD	International Fund for Agricultural Development
IGAD	Intergovernmental Authority on Development
IIED	International Institute for Environment and Development
IISD	International Institute for Sustainable Development
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IOM	International Organization for International Migration (UN)
JICA	Japanese International Cooperation Agency
KEFRI	Kenya Forestry Research Institute
KENDAT	Kenya Network for Dissemination of Agricultural Technologies
LDCF	Least Developed Countries Fund
LVBC	Lake Victoria Basin Commission
MSU	Michigan State University
NARI	national agricultural research institution

NARO	National Agricultural Research Organization (Uganda)
NASA	National Aeronautics and Space Administration (US)
NEMA	national environmental management authority
NEPAD	New Partnership for African Development
NOAA	National Oceanic and Atmospheric Administration (US)
OCHA	Office for the Coordination of Humanitarian Affairs (UN)
RADA	Rwanda Agricultural Development Authority
RCE	Regional Center of Excellence
RCMRD	Regional Center for Mapping of Resources for Development
REDD	Reducing Emissions from Deforestation and Degradation
RF	Rockefeller Foundation
SARI	Sahelian Agricultural Research Institute
SCCF	Special Climate Change Fun
SIDA	Swedish International Development Agency
START	System for Analysis, Research, and Training
TMEA	Trade Mark / East Africa (DFID)
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Program
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Program
UNREDD	UN Collaborative Program on Reducing Emissions from Deforestation and Degradation in Developing Countries
USAID	United States Agency for International Development
USGS	United States Geological Survey
WB	World Bank
WE	We Adapt (EAC)
WMO	World Meteorological Organization (UN)

INTRODUCTION

This document attempts to elaborate upon the activities of donors, institutions and organizations relating to climate change adaptation within the scope and geographic areas covered by USAID/ East Africa. The focus is on climate change **adaptation**, as opposed to other climate change mitigation actions, such as fuel-switching, LEDS, or clean energy. It also focuses on those institutions that have active adaptation interests, as opposed to latent. Furthermore, rather than produce a comprehensive compendium of all projects for each institution or organization, this document highlights those with a regional or trans-boundary purpose. Some national-level projects with particular relevance are also cited.

The following institutions are discussed in this report:

INTERNATIONAL ORGANIZATIONS

United Nations Environment Program (UNEP)
United Nations Development Program (UNDP)
United Nations Economic Commission for Africa (UNECA)
United Nations Food and Agriculture Organization (FAO)
Common Market for Eastern and Southern Africa (COMESA)
African Union (AU)
East Africa Community (EAC)
Intergovernmental Authority on Development (IGAD)
International Climate Prediction and Application Center (ICPAC)
Regional Center for Mapping of Resources for Development (RCMRD)
International Development Research Center (IDRC)
Famine Early Warning Systems Network (FEWSNET)
Food Security and Nutrition Working Group (FSNWG)
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
International Fund for Agricultural Development (IFAD)

INTERNATIONAL DONORS

The World Bank
Global Environment Facility (GEF)
African Development Bank Group
European Union
DFID
Rockefeller Foundation
Embassy of Denmark
Embassy of the Netherlands
Swedish International Development Agency (SIDA)
Japanese International Cooperation Agency (JICA)
Embassy of Norway
AusAid

INTERNATIONAL NGOS

Cooperative for Assistance and Relief Everywhere (CARE)
Concern Worldwide

REGIONAL/NATIONAL NGOS/PROGRAMS

Consultative Group for International Agricultural Research (CGIAR)
Climate Change Agriculture and Food Security (CCAFS)
Africa Water Network (AWN)
The African Conservation Tillage Network (ACT)
Greater Horn of Africa Rainwater Partnership (GHARP)
Rwanda Agricultural Development Authority (RADA)
Kenya Network for Dissemination of Agricultural Technologies (KENDAT)
Rwanda Rural Rehabilitation Initiative
AfricaAdapt
Capacity Strengthening of Least Developed Countries to Climate Change (CLACC)
Systems for Analysis, Research and Training (START)

RESEARCH ORGANIZATIONS

International Institute for Sustainable Development (IISD)
Center for Environmental Economics and Policy in Africa (CEEPA) (University of Pretoria)
Kenya Forestry Research Institute (KEFRI)
The National University of Rwanda (NUR)
Sahelian Agricultural Research Institute (SARI)
National Agricultural Research Organization (NARO) (Uganda)
Ethiopian Institute of Agricultural Research
Mekelle University (Ethiopia) Geo-Information and Earth Observation Sciences

INTERNATIONAL ORGANIZATIONS

UNITED NATIONS ENVIRONMENT PROGRAM

Contacts: Merelyn VanVoore, Regional Office for Africa Program Officer of Climate Change, +254-20-7625631; Mounkaila Goumandakoye, Director, Regional Office for Africa +254-20-7624284 roa.Information.Officer@unep.org; Musonda Mumba/Project Officer/Climate Change Adaptation Unit; email: Musonda.mumba@unep.org; tel: 254-20-762-5720

Websites: www.ccema-portal.org

UNEP's Regional Office for Africa emphasizes building capacity for early warning and environmental assessment and ensuring that proper mechanisms are put in place for economically sound development. Key areas include the provision of clean water and reversal of land degradation.

Current Projects Include:

- UNDP-UNEP Poverty-Environment Initiative - http://www.unep.org/roa/Projects_Programmes/PEI/index.asp
- Natural Resources Program_(Support African countries in undertaking environmental assessment in post conflict/post environmental crisis situations) http://www.unep.org/roa/projects_programmes/Natural_Resources/index.asp
- Nairobi River Basin Programme - http://www.unep.org/roa/Nairobi_River_Basin/default.asp

UNEP's Division of Environmental Policy and Implementation (DEPI) is investing more in adaptation for developing regions. It has four components: adaptation, mitigation, science, and communication. Under their climate change program they focus on:

- clean technology
- REDD +
- Ecosystem adaptation.

Ecosystems are the drivers of economies in communities. UNEP is looking at how to assess ecosystems and build resilience. Geographic focus is on low lying coastal regions, mountain ecosystems, river basins and wetlands, and drylands. They are developing scenarios and overlaying socioeconomic information in particular hotspots. The information will be used to advise government policy makers.

A sub-component is inter-agency advocacy. They have a program on "Security and Mobility" to deal with migration and pastoralists in drylands (with the International Office for Migration and the UN Office for the Coordination of Humanitarian Affairs). They are trying to improve policy frameworks and mechanisms to facilitate migration/movement across borders. There is not enough data on migration. USAID has supported this in the past. EU is a lead donor and is coming in with "a lot of funding." (Also AU, IOM).

There is a global forum called the Climate Change, Environment, and Migration Alliance (CCEMA) (website above). They need partners to help pilot methodologies and roll out the methodologies. Forecasting and mapping needs to be packaged for the local level. The approach is very fragmented at the community level.

The Climate Change Adaptation Network in Africa is being coordinated by DEPI (Musonda Mumba), as part of the Global Network on Climate Change Adaptation (an idea first mooted in Korea in 2008, and currently being proposed around the world). A regional consultation meeting for the Climate Change Adaptation Network in Africa took place in early 2009 in Nairobi, and outlined the plans for information sharing and collaboration, as mandated, *inter alia*, by the Nairobi Work Programme on Impacts, Adaptation and Vulnerability to Climate Change (under the UNFCCC). The network is planned to be operational by 2014. Policies need to be regionally integrated.

Areas of interest to USAID: Gathering best practices across regions and packaging information to the local level, regional policy level, dialogue, and coordination. Rolling up migration pilot projects is a possibility, but there may be sufficient support through the EU. Further dialogue needs to take place with Africa Regional Coordinator for UNEP. The Division for Regional Cooperation may be more helpful for USAID to focus on regional issues of East Africa.

UNITED NATIONS DEVELOPMENT PROGRAM (UNDP)

Contact: UNDP Regional Center for Eastern and Southern Africa Private bag X46, 7 Naivasha Road, Sunninghill 2157, Johannesburg, South Africa Phone: +27 11 603 5000
Fax: +27 11 603 5087 http://www.undp.org/africa/
UNDP's Regional Office is SADCC but this covers East Africa as well. Contact:
Sasha.lagrange@cges.co.za or david.githaige@undp.org

The UNDP supports countries to integrate climate-related risks and opportunities into national planning and poverty reduction plans and addresses the needs of more vulnerable groups, such as women and indigenous people. The UNDP focuses first on capacity development in its approach to climate change adaptation, supporting the creation of robust and responsive state institutions, capable public and private sector management, and skilled human resources able to innovate, adapt and deliver to the changing conditions. The UNDP provides support in three key areas: Integrated Policy and Planning/Formulating, Financing and Implementing Climate Resilient Projects and Programs, and Knowledge Management and Methodology Support.

Projects Include:

- Africa Adaptation Program - http://www.undp-adaptation.org/africaprogramme/
- UN Collaborative Program on Reducing Emissions from Deforestation and Degradation in Developing Countries (UN-REDD) – Tanzania is a pilot country, and Kenya is an observer country, meaning that it is likely to have a program in the next round of funding. http://www.un-redd.org/

CC:DARE (Climate Change Adaptation and Development Initiative)

CC:DARE is a joint UNEP-UNDP initiative that aims to integrate climate change into planning in several African countries, including Ethiopia (very recently started), Rwanda, Tanzania and Uganda. Because of the nature of this program, there is useful information available relating to vulnerability of those countries. - http://www.ccdare.org/

Contacts (all based at UNON)
Richard Munang (Richard.munang@unep.org)
Johnson Nkem (johnson.nkem@undp.org)

Bubu Jallow (bubu.jallow@unep.org)

UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA (UNECA)

Contact: Daya Bragante, Economic Affairs Officer, Sub-regional Office for Eastern Africa
Email: dbragante@uneca.org; tel: 250 (0) 252 58 65 48
Kigali, Rwanda

UNECA works with 13 countries and ten clients including the Regional Centers of Excellence (IGAD, EAC, AU, CGIAR, COMESA). It is a coordinating body, with five subregional offices. They have recently developed a common food security strategy and are working with the "International Conference on the Great Lakes Region" (ICGLR) which is a high level coordinating body at the policy level. It is to be the Program Management Coordinating Unit for four components: market development, research and development, sustainable NRM and nutrition/safety nets (insurance schemes). The latter two integrate climate change mitigation issues. These four components mirror the Comprehensive Africa Agriculture Development Program.

The ICGLR is focused on maintaining peace and security in the region. UNECA is trying to identify leading partners to be the sponsors and implementers of one of the components.

UNECA has also just launched the "Africa Climate Change Policy Center" which is funded by Norway and the African Development Bank and hosted by the African Union. The two focal areas are: policy harmonization and developing a knowledge management system. More information will be sent by email, but preliminarily this would be a key player with whom to collaborate.

UNITED NATIONS FOOD AND AGRICULTURE ASSOCIATION (FAO)

Contact: Subregional Office for Eastern Africa, Mafa E. Chipeta, Subregional Coordinator
Tel: +251 11 551 7230 Fax: +251 11 551 5266 FAO-SFE@fao.org, mafa.chipeta@fao.org
http://www.fao.org/africa/sfe/subregional-office/en/

The FAO is a forum for nations to meet to negotiate agreements and debate policy. The FAO also serves as a source of data and knowledge regarding food and agriculture worldwide. The Subregional Office for Eastern Africa concentrates on supporting sustainable agriculture and natural resource use, helping vulnerable communities prepare for disasters and shocks, promoting coordination across sectors (agriculture, water, nutrition, etc.) for increased efficiency, and promoting trade improvement.

Current projects include:

- Support the aquaculture subsector in the riparian countries around Lake Victoria (Kenya, Uganda, Tanzania) http://www.fao.org/africa/sfe/projects0/technical-co-operation-programme-tcp/en/
- Information products for decisions on water policy and water (to develop sustainable water policies and practices in Eritrea, Ethiopia, Uganda, Rwanda, Tanzania, and Kenya) http://www.fao.org/africa/sfe/projects0/gcp/en/
- Rift Valley Fever and climate change related diseases control in Eastern Africa (Ethiopia, Kenya, Somalia, Tanzania) http://www.fao.org/africa/sfe/projects0/osro/rift-valley-fever-and-climate-related-diseases-control-in-eastern-africa/en/

- Improvement of food security in cross-border districts of Burundi, Rwanda and Uganda, in support of the modernization of agriculture under NEPAD framework (Burundi, Uganda, Rwanda) http://www.fao.org/africa/sfe/projects0/gtfs/en/
- Global Information and Early Warning Systems (GIEWS) on Food and Agriculture (a research organization at continuously reviews the world good supply and state of global agriculture, including in East Africa.) http://www.fao.org/giews/english/index.htm

COMMON MARKET FOR EASTERN AND SOUTHERN AFRICA (COMESA)

COMESA is a preferential trading area, with 19 member countries in Eastern and Southern Africa. The goal of COMESA's climate change program is "achieving economic prosperity and climate change protection." COMESA has developed a carbon fund and is currently seeking submission of proposals. The specific objective are to:

- Consolidate a shared vision for Africa on climate change and a common and informed voice for the continent in the Post Kyoto Climate Change negotiations and beyond.
- Foster regional and national cooperation to address climate change and its impacts,
- Promote integration of climate change considerations into regional, national policies, sectoral planning and development and budgeting,
- Enhance human and institutional capacities of COMESA Secretariat, specialized institutions and Member States to effectively address the challenges of climate change,
- Mobilize African and international scientific and technical communities to increase knowledge base and its management to support informed decision making processes,
- Promote and enhance collaboration, synergy, partnerships and effective participation of Governments, business community, civil society and other stakeholders in climate change matters and
- Provide a framework for the establishment of an African BioCarbon Facility that combines market-based offsets, public and private funds.

Examples of Projects:

- COMESA Energy Program - http://programmes.comesa.int/index.php?option=com_content&view=article&id=43&Itemid=53&lang=en
- Comprehensive Africa Agriculture Development Program (CAADP) Contact: Prof. Richard Mkandawire Advisor and Head of Agriculture Unit and CAADP, RichardM@nepad.org, +27 (0) 11 256 3626 http://www.nepad-caadp.net/
- COMESA Food Security Program http://programmes.comesa.int/index.php?option=com_content&view=article&id=24&Itemid=40&lang=en
- Forestry Management Strategy Program - http://programmes.comesa.int/index.php?option=com_content&view=article&id=50&Itemid=60&lang=en

The goal of the CAADP is to help African countries reach a higher path of economic growth through agriculture-led development to eliminate hunger, reduce poverty and food insecurity, and enable expansion of exports. The CAADP focuses its interventions in four key pillars: (1) extending the area under sustainable land management and reliable water control systems, (2) improving rural infrastructure and trade-related capacities for market access, (3) increasing food supply, reducing hunger, and improving responses to food emergency crises, and (4) improving agriculture research, technology dissemination, and adoption.

From their website (http://www.comesa.int/):

> The Secretariat for the Common Market for East and Southern Africa (COMESA) and the Government of Norway signed a grant agreement in which Norway will make available to COMESA a financial grant amounting to NOK 17 000 000 (US$2.5 million) for the implementation of the Climate Change program in 2009.
>
> The Climate Change program is a joint effort of COMESA, East African Community (EAC) and Southern Africa Development Community (SADC). Its aim is to support the sub-region's vision and efforts to address climate change challenges, including its impact on socio-economic development and poverty reduction. Further, the program will build and strengthen the capacity of African countries to address adaptation and mitigation to climate change, and to facilitate an African dialogue on the inclusion of sustainable agriculture and land-use practices, forestry, biodiversity conservation, and maintenance of environmental services in the post Kyoto Climate regime.

Gaps: From telephone conference call: COMESA's climate change initiatives include: a) developing a unified common position in climate change negotiations (this needs support, there is a lack of data to support positions and there has not been enough stakeholder input to inform positions) b) carbon financing (there is no capacity to implement this, need more donor financing) c) Smart Agriculture (support needed to develop partnerships at the national level and build capacity for implementing agricultural frameworks at community level) d) energy. The COMESA Climate Change Unit contains four staff: two advisors (one for negotiations, one for CDM), one specialist on developing the carbon fund, and one specialist on agriculture and forestry. The Rockefeller Foundation and the Norwegian Government are supporting the Climate Change Unit in developing their negotiation positions and mainstreaming climate change into line ministries and development plans.

Potential Opportunities: The climate change unit is being supported by Rockefeller and the Norwegian Government but USAID could provide additional support either directly or indirectly in developing data that is needed to support negotiating positions and in obtaining stakeholder input through workshops/roundtables or by developing knowledge management systems that feed into policy development.

AFRICAN UNION (AU)

Contact: Commissioner for Infrastructure and Energy, H.E. Dr. Elham Mahmood Ahmed Ibrahim (Mrs.) Tel**:** (251) 11 551 77 00 ext 147, Fax: (251) 11 552 58 55 http://www.africa-union.org/

The AU is an intergovernmental organization made up of both political and administrative bodies from 53 African nations. Among the objectives of the AU's leading institutions are: to accelerate the political and socio-economic integration of the continent; to promote and defend African common positions on issues of interest to the continent and its peoples; to achieve peace and security in Africa; and to promote democratic institutions, good governance and human rights.

Examples of Programs:

- New Partnership for African Development (NEPAD) One aspect of NEPAD focuses on Climate Change and Natural Resource Management throughout Africa. Currently, NEPAD activities include strengthening existing water governance institutions and promote strategies for increased water storage capacities. http://www.nepad.org/

- ClimDev Africa_The Climate for Development in Africa is a joint initiative involving the African Development Bank, the African Union, and the UN Economic Commission for Africa which began in 2009 and became fully operation in 2010. ClimDev-Africa consists of three components: (1) building the capacity of African Climate institutions to generate and widely disseminate climate information necessary for planning, (2) enhancing the capacity of end-users, particularly national development policy-makers, to be able to mainstream climate change into development plans on the continent, and (3) implementing adaptation programs and projects to incorporate climate-related information. At the moment this initiative is still new, but it has been widely discussed and has political support. http://www.afdb.org/en/topics-sectors/initiatives-partnerships/climate-for-development-in-africa-climdev-africa-initiative/

EAST AFRICAN COMMUNITY (EAC)

Contact: EAC, Arusha International Conference Center, +255 27 2504253 / 8
http://www.eac.int/environment/

The EAC is a regional intergovernmental organization involving Kenya, Uganda, Tanzania, Rwanda, and Burundi. While the EAC has no specific projects on the ground with relation to climate change and natural resources, it was worked with individual member nations in the development of National Adaptation Programs of Action (NAPA). Furthermore, it has helped Kenya, Tanzania, and Uganda to develop and register their respective clean energy development projects.

The East Africa Community secretariat has set up a regional advisory group comprised of representatives of partner-states to support consolidation of a regional position on climate change and develop over-see the development of a Climate Change Master Plan for East Africa.

The EAC held a meeting in January 2010 and produced a "Report of the Stakeholders Preparatory Meeting for the Special Summit of EAC Heads of State on Food Security and Climate Change." This report issued the following statements:

"The Summit directed the urgent development of a climate change policy and strategies to address the adverse impact of climate change, including determining how surplus food in one country can be shared in countries that are worst hit."

Key Issues from the presentations

1. Task Partner States to commit resources so that combating climate change impacts is not donor reliant.
2. Supporting rural community's adaptive capacity.
3. Promote and provide incentives land management practices that serve climate change (adaptation and mitigation) and food security such as agro forestry, sustainable land management (SLM) and conservation agriculture.
4. Promote access to carbon markets for purposes of improving income and funding at multiple levels.
5. Adopt transboundary water resources management as a strategy for both food security and climate change.
6. Promote sustainable energy policies and actions that take advantage of the mechanisms such as NEMAs within the UNFCCC (e.g. adopting biofuel development that does not impact negatively on food production).

7. Promote Disaster risk preparedness and management as a key for adaptation and sustainable development
8. Promote science driven adaptation strategies that incorporates indigenous knowledge
9. Promoting drought (and other stress) tolerant/resistant varieties.
10. Regional and national climate change strategies should be developed
11. EAC should develop institution or focal points with clear mandates to coordinate climate changes issues at both national and regional levels.
12. Recognition of climate change as a cross cutting challenge. Due the cross cutting nature of climate change it should be addressed in an integrated manner.

Conclusions

- Although it is evident that the climate is changing, the magnitude of change in the various agro-ecological zones is not well known and needs further quantification to enable the separation of climate change impacts from other non-climatic effects and facilitate appropriate adaptation planning.
- Also, the economic implications of climate change need further investigations to inform policy/decision processes.

Economic impact reviews of climate change are being funded by DFID commencing in Kenya, Rwanda, Burundi and possibly Tanzania and Uganda. The EAC Secretariat has requested assistance in drawing together implications of this country level analysis regionally. These studies will support the EAC to draw together analysis of the impact of climate change on regional infrastructure and corridor development. These national level studies will then feed into a regional climate change strategy as requested by the EAC's Secretary General in a recent visit to London. The work stream will be closely co-ordinated with GTZ, which has initiated some work in this area already.

DFID's TradeMark/EA will take steps to improve the coordination of efforts by national and regional level sectoral committees on environment related work. Using the jointly developed climate change strategy as a coordination device, TMEA will work with the EAC Secretariat to develop proposals for building the capacities of environmental organizations i.e. organizations focusing on: agriculture and food security, energy, environmental and natural resources, tourism and wildlife, conservation, transport, communications and meteorology; to implement climate change action plans. TMEA may also support the development of carbon trading markets at a national level.

INTERGOVERNMENTAL AUTHORITY ON DEVELOPMENT (IGAD)

IGAD Secretariat, Avenue Georges Clemenceau, P.O. Box 2653 Djibouti Republic of Djibouti, +253-354050

IGAD is an intergovernmental organization in East Africa designed to assist and complement the efforts of its member states in achieving food security, environmental protection, promotion and maintenance of peace, security, and humanitarian affairs, and economic cooperation and integration. Areas of focus include Agriculture, Livestock and Food Security, Natural Resource Management, Environmental Protection, and Dryland Agricultural Research and Technology.

IGAD's CLIMATE PREDICTION AND APPLICATION CENTER (ICPAC)

Based in Nairobi, Kenya

Contact: Prof. Laban Ogallo email: 10galloiaJ,icpac.net; Tel: 25420351 *4426/cell: 0722* 526 809; Dolphine Ndeda cPR Officer) dndedaiaJ,icpac.net cell: 0722 686867 http://www.icpac.net/

Ten countries are members: Rwanda, Burundi, Tanzania, Ethiopia, Kenya, Somalia, Djibouti, Eritrea, Uganda, and Sudan. It is the technical arm of IGAD and is a Regional Center of Excellence (RCE).

ICPAC is a specialized institution of the Intergovernmental Authority on Development (IGAD) working with the National Meteorological Services, World Meteorological Organization (WMO) and other partners to address regional challenges of climate risks including climate change. It has its headquarters in Kenya. The mission of ICPAC is to foster sub-regional and national capacity for climate information, prediction products and services, early warning, and related applications for sustainable development in the IGAD SubRegion. Within its core program, it has computer services and data management, climate diagnostics, prediction and climatology, climate applications, documentation, research and development and end-user liaison. It has managed to create a climate data bank that is constantly updated. It has been capacity building in data processing, climate monitoring & modeling, and prediction. Upgrading of ICPAC computing facilities has improved regional climate modeling and prediction capacity.

The objectives of the Centre are:

- To provide timely climate early warning information and support specific sector applications for the mitigation of the impacts of climate variability and change for poverty alleviation, management of environment and sustainable development,
- To improve the technical capacity of producers and users of climatic information, in order to enhance the use of climate monitoring and forecasting products in climate risk management and environment management,
- To develop an improved, proactive, timely, broad-based system of information/product dissemination and feedback, at both sub-regional and national scales through national partners,
- To expand climate knowledge base and applications within the sub-region in order to facilitate informed decision making on climate risk related issues; and
- To maintain quality controlled databases and information systems required for risk/vulnerability assessment, mapping and general support to the national/ regional climate risk reduction strategies.

They deal with all climate risk issues, and leave policy and policy coordination to higher levels in Djibouti. However, they do see their mandate as educating policy makers and regularly attend conferences, workshops for government officials across the region. In a meeting the comment was made that "climate change policy is all over the place right now, and there is a need to help everyone understand what climate change adaptation strategies are all about." Activities: largely a center for information, education and training. They do mapping, including social economic dimensions, and modeling.

Funding: USAID has been supporting institutional capacity which they say was instrumental in making them a viable organization. USDA is still supporting them in technical components of early warning, and disaster risk capacity building. USDA funding is ending but they are supporting them to do a small study on hydrological impacts. They receive some funding from IDRC, WE, UNDP, Korea (hardware/ software), Red Cross for discrete activities.

Their critical role is to do what individual countries cannot do alone, they provide information and identify local organizations with which countries can work with to get early warning and monitoring systems in place. Member countries don't have the capacity to project beyond five days and ICPAC does

this for them. Countries only do this on a limited scale, they do it on a regional scale. ICPAC helps build the capacity of member countries and they provide baselines to standardize information regionally.

ICPAC is going to hold a workshop on climate change and water resources sponsored by the UNDP for nine countries. UNDP is concerned about the impacts of climate change on huge investments. They are also going to have a world wide conference to assess different modeling systems. Modeling is still in research mode.

Their critical issue is looking at risk management and downscaling information to the community level, and information dissemination. They see climate and security as the biggest issue, and need support for models to demystify information so that communities and local governments can work with/implement mitigation in agriculture, health, water, etc.

Capacity: they have a small but effective staff, a Public Relations unit which specializes in how to get information to communities, making the message digestible at local level and national level for the general public. They are constrained by lack of staff and lack of the latest hardware and software. They have recently undergone an institutional assessment and are doing a strategy with Rockefeller funding. Their strategy is to be project driven. They are working on a funding strategy (national contributions plus an endowment).

Gaps: ICPAC has the capacity to implement effective projects but it is difficult to ascertain what is being covered by other donors. It seems they have a lot of discrete activities funded but no institutional development funding. The critical role they play is as a technical arm of a Regional Center of Excellence. Almost everyone goes through ICPAC at one stage or another. They are undergoing an institutional assessment and a strategy development.

Potential for partnering: Could be expanded to provide wider services/dissemination of meteorological predictions of impacts of climate change, early warning systems. Other areas are risk management and downscaling information to the community level, information dissemination. They see climate and security as biggest issue. They want to demystify models so that communities and local governments can work with/implement models in agriculture, health, water, etc.

REGIONAL CENTER FOR MAPPING OF RESOURCES FOR DEVELOPMENT (RCMRD)

Contact: Dr. Hussein O. Farah, Director General, tel: 254-20-856-1775, email: farah@rcmrd.org
http://www.rcmrd.org/; www.servir.net/africa
Type: Inter-governmental non-profit

Mission: to be a center of excellence in providing quality geo-information and allied ICT products and services to member states (East Africa and more)

Core staff: 30 professionals

Provide geo-informational and information technology courses, advisory and consultancy services in surveying and mapping, development of databases, and technical services.
The Center has a modern and well-equipped engineering lab, one of the best in Sub-Saharan region. They also do research and development for predicting floods and rapid mapping tools for mapping disasters. They have a resource assessment tool to look at climate change impacts on communities which they use to alert governments.

Servir/USAID comprises 15% of their funding/overall portfolio. SEVIR collects data from all sources and disseminating (international disaster charters to show magnitude) to government decision makers for policy decision making.

The main gap in their portfolio is in getting information down to the community level. They have a project in place but this could be an opportunity for USAID to provide further support. In specific, a "climate modeler" is being downscaled to community level. In addition, they report that the demand for their services is growing as more users are aware of their ability to use RCMRD's data collection and mapping services for mapping health vectors, water, electoral polling, urban planning, etc. Their adaptation focus is on mapping water and resources for livestock, food security, and conflict.

They work closely with ICPAC and report that they have complementary and supportive roles.

The "African Monitoring of Environment for Sustainable Development" project is funded through the EU (via IGAD) which looks at land degradation and natural habitat conservation. In addition, they are working in two sites to develop wind alternative energy.

Challenges: staffing constraints and updating their technology/hardware/software. The gap in adaptation is mapping/data on what the potential impacts of climate change will be. IGAD and others have done studies, but they all exist in pockets and at national or local level. There is a need for a comprehensive regional study focusing on transboundary water resources (especially in Tanzania, Kenya, Mara area, Mau forest, Rift Valley) which have social economic and political consequences, arid zones where the most vulnerable groups are and grazing areas where pastoralists live.

Potential for partnering: Not as a direct grantee, but could be useful to tap into for mapping areas of interest where USAID/GCC will focus, possibly to create a buy-in mechanism to respond to regional bilateral Mission needs for their services. Also, funding data collection, monitoring, prediction on regional scale then focusing down on hot spots (water, drought, grazing lands).

FAMINE EARLY WARNING SYSTEM NETWORK (FEWSNET)

FEWSNET is a USAID-funded activity that collaborates with international, regional and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. Its professionals monitor and analyze relevant data and information in terms of its impacts on livelihoods and markets to identify potential threats to food security. Once these issues are identified, FEWSNET uses a suite of communications and decision support products to help decision-makers act to mitigate food insecurity. FEWSNET also focuses its efforts on strengthening early warning and food security networks. Activities in this area include developing capacity, building and strengthening networks, developing policy-useful information, and building consensus around food security problems and solutions. Its approach is guided by several main pillars that support its core objectives. These include: continued production of high quality targeted early warning information, emphasis on developing sustainable networks, emphasis on policy-useful information and continued innovation in analytical tools and methods. The FEWSNET implementing partners are: Chemonics International, Inc., United States Geological Survey (USGS), National Aeronautics and Space Administration (NASA), National Oceanographic and Atmospheric Administration (NOAA) and United States Department of Agriculture (USDA).

Gaps: Data are not available to produce trend analyses for many of the East African countries.

REGIONAL FOOD SECURITY AND NUTRITION WORKING GROUP (FSNWG)

The FAO chairs the FSNWG which is a multi-stakeholder forum including more than 20 NGOs, 10 UN agencies, 13 donors and regional initiatives. Regional and national governments are key stakeholders covering 12 countries in Central and Eastern Africa. IGAD is being proposed to be a co-chair with FAO in this next phase. The objectives are to create a consensus and information sharing across the region, develop joint FSN tools, strengthen links between risk profiling, situation analysis and appropriate response identification, initiate regional joint programming, build FSN capacity at country and regional levels, coordinate donor and partner advocacy towards strategic response. Thematic groups include protection, health, and climate change adaptation. Partners include WFP, FEWSNET, ICPAC.

The FSNWG's objective is to convert information into action from preparedness (risk profiling, situation analysis) to response implementation. It is developing a common approach to capacity building and highlighting best practices and tools to turn information into action, it has the buy-in from institutional members who are governments, it provides cross-border comparability to make prioritized decisions across borders, attempts to disseminate information to local levels through NGOs and local authorities.

Following from concern raised on the possible impact of the forecasted La Niña event on the region, the Regional Food Security and Nutrition Working Group has formed a La Niña task force in order to:

- Coordinate the dissemination of timely and comparable regional level food security updates;
- Create a forum for the exchange of inter-agency and cross-border response tracking;
- Identify past effective response interventions and livelihood resilience building/mitigation best practices;
- Provide technical backstopping support on prioritized tools to food security national clusters & platforms within the region.

A webpage for information dissemination on La Niña is now online (http://www.disasterrisk reduction.net/La_nina), where you can find forecasts (3, 7, 10 days), best practices, tools, as well as other relevant documents as the FEWS NET Hazards Impacts Assessment for Africa. http://www.disasterriskreduction.net/fileadmin/templates/drought/ docs/lanina/Hazards_impacts_ assessment.pdf

This task force may evolve into a Climate Change Task Force as La Nina is likely to evolve into other climate variability events.

With IGAD becoming a co-chair the FSNWG will be able to provide IGAD with issues that come out of the FSNWG and vice versa, IGAD can provide the high level conduit (with its links to COMESA and ECA) of information to national governments. ICPAC is already a key provider of information/data as well as FEWSNET. The FSNWG also has "focal points" in each country which provide the linkages between governments and across sectors.

Opportunities: The FSNWG would be an interesting link for the CC team if the CC team were to support ICPAC for example. The Climate Change Adaptation thematic group needs support. Members of this group are NGOs (CARE, WV, ACF, Save the Children). The IPC project is the technical working group that collects information and provides situation analysis, risks and response scenarios. IPC consolidates information and plays the role of advocacy to donors and country-level government institutions. Feed the Future is a likely partner for this unit, but some synergy should be explored. The

La Nina Task Force could be supported as it takes on a more long term climate change strategic approach. USAID could also explore the FSNWG as a model for forming a Regional Climate Change Working Group that it could co-chair with EAC or ICPAC for example. The FSNWG is an impressive model for its regional objectives, scope, and reach.

Gaps: The FSNWG has strong presence at the regional national level, but there needs to be stronger links from the national level to decision-makers and communities. The information is packaged so far only on websites and in bulletins, and there is not enough evidence so far that the websites are being used/tracked. Information systems need to be strengthened to get the information to flow from regional to country to ground level, and back up. A system needs to be developed to coordinate Fewsnet and ICPAC information and to make it available to provide timely information and comparable information. Interagency coordination needs to take place on response tracking in order to develop up to date information, as well as lessons learned/best practices.

ASARECA

Contact: ASARECA Secretariat, Plot 5 Mpigi Road, P.O.Box 765 Entebbe, Uganda
Tel: 256 414 320556 / 320212, Fax: 256 414 321126 Email: secretariat@asareca.org, or asareca@imul.com

ASARECA is a non-political organization comprised of the National Agricultural Research Systems of its ten member countries, which include Burundi, Eritrea, Kenya, Rwanda, Tanzania, and Uganda.. ASARECA aims at increasing the efficiency of agricultural research to facilitate economic growth, food security, and export competitiveness through productive and sustainable agriculture. ASARECA also maintains a database of "best practice" research findings that can be searched by country, theme, or practice/technology type.

Examples of Programs:

- Staple Crops Research Program - http://www.asareca.org/staples/
- Livestock and Fisheries Research Program - http://www.asareca.org/index.php?page&as=89
- Natural Resource Management and Forestry Research Program - http://www.asareca.org/index.php?page&as=91

For additional information on specific CGIAR projects, see the CCAFS CGIAR Climate Change Related Research Annex Spreadsheet

ASARECA plays a coordinating role for the region on research (on agriculture and including climate change). It is funded through a multi-donor trust fund, but also has project funding.
They have seven programs: staples, biodiversity, livestock, biophysical (?), policy and knowledge management.

A recent ASARECA conference was held with its ten member countries to look at policy issues across the region and aggregate technologies across the region that are available for direct uptake. This resulted in discovering that there are national policies that are in place that do not take into account available research, regional issues, nor lessons learned from neighboring countries. It also revealed that there are many technologies available for uptake that are could be disseminated across the region.

Their focus in the policy arena is to help policy-makers access information and analysis to inform decision making.

They are working with IFPRI in cataloguing adaptation measures at country levels and adopting them to lower levels. Part of this is the CCAFS mapping exercise to overlay market access, population, vulnerability with policy framework in order to develop conservation/mitigation strategies. Five initiatives are also ongoing (in various countries, but not regionally):

1) facilitating and accessing information dissemination, managing innovative ways to get information to decision-makers, facilitating cooperation between research institutions and meteorological institutions which is very weak.
2) Downscaling forecasting models to users, looking at best practices across the region
3) Carbon sequestration
4) Water productivity and livelihood
5) Developing scenarios, mapping

They also have a livestock and fisheries program which includes sending out monthly bulletins to farmers and pastoralists to warn them of potential climate impacts at a certain point in time to enable them to move or sell their cattle in anticipation of the events.

The gap is that ASARECA is carrying out these initiatives in small-scale and really would like to be able to increase the scope within countries and regionalize these projects. They believe the main gaps are in mapping areas and rolling them out and capacity building (research needs to be shared across the region).

Strength/Opportunities: They work in partnership with CCAFS which could provide synergy with USAID interests in supporting CCAFS, and they clearly have a regional mandate. Weakness: They issue sub-grants as opposed to implement themselves, this can be inefficient. They also tend to focus on Kenya, Uganda, Ethiopia by default (science/research concentrated in these three countries in East Africa). Specific areas that could be further investigated are: looking at policies that cut across the region, policy enabling environment to share and adopt best practices, sharing of technologies across region, downscaling forecasting models, mapping vulnerable areas, and capacity building (at all levels, policy, research, private sector, farming).

INTERNATIONAL DEVELOPMENT RESEARCH CENTER (IDRC)

Contact: Evans Kituyi, Climate Change Adaptation in Africa Senior Program Specialist
Tel: 254 20 271 3160 email: ekituyi@idrc.or.ke www.idrc.ca/www.crdi.ca

IDRC is a Canadian Crown corporation that works in close collaboration with researches from the developing world. They launched a Climate Change Adaptation in Africa program (CCAA) in 2006 jointly with DFID. They have three regional offices one of which is in Nairobi. It is a $65 million program with 43 projects worldwide. DFID is the lead donor $460 million in adaptation funds for Africa.

The CCAA program has undertaken locally-led Participatory Action Research in a number of East African countries, including Kenya, Tanzania and Ethiopia.IDRC is launching a new "Climate Change and Water Program" fully funded by IDRC. It is a global project, $40 million over 5 years. It will focus on energy, water, ICT. It will be launched in 2010. http://www.idrc.ca/ccaa/

IDRC partners with the CGIAR centers ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) and IITA (International Institute of Tropical Agriculture), and with universities. The universities take the lead and work with the CGIAR centers. The objective is to build capacity of local researchers and institutions to apply adaptation measures. They also work with governments at the local level and private sector (seed/fertilizer companies).

They also have a "Bridging Research and Policy" project to identify policy gaps at the grassroots level. It is in a pilot phase in Kenya, Tanzania, and Malawi. There could be some potential synergy for USAID in capturing lessons learned and collecting these to share at a regional level.

Their grant to ICPAC to demystify indigenous knowledge and produce joint forecasts with scientific modeling has finished. They provided them with some further funds to do a self-assessment. They have no plans to further fund them at this time, but it is not out of the question. They emphasized that ICPAC has high potential but suffers from lack of staff and has some organizational challenges. They need a Finance and Administration person to alleviate the Director. Monitoring of projects is a bit weak because of lack of staff, and they use researchers from Universities who are not permanent staff. They could benefit from having a permanent cadre of scientists on board. But, ICPAC is a key institution, plays a pivotal role in providing data, interpreting data and advising governments. ICPAC is the technical arm of IGAD which is a Regional Center of Excellence (RCE).

Advice to USAID: RCEs themselves are very difficult to work with and IDRC has had few results. They are moving away from supporting RCEs and instead highly recommend working with the technical arms of the RCEs such as ICPAC or the Lake Victoria Basin Commission (LVBC), which is an arm of EAC.

IDRC is supporting the LVBC with a grant to establish a climate change unit, which will roll out the community strategy of the African Ministerial Conference on Environment. There could be some synergy for USAID with its biodiversity project as well as with the GCCI.

The EAC has a Climate Change Unit within the Natural Resource Department, but with only three people staffing it, they are unmotivated with little structure around it. USAID could possibly support the institutionalization of this unit, but IDRC recommends working with the LVBC and ICPAC. ASARECA gets mixed reviews, depending on the department and the personnel. The Climate Change unit is still trying to define itself. There is again an opportunity for USAID to do some institutional strengthening there. COMESA has a strong climate change advisor in a unit is supported by Norway.

The major issues in climate change overall according to IDRC are food security and water, but within that, it is climate change information: flow, type and quality of information is not reaching those who need it in a form that can be accessed. Second is linking lessons learned to policy and then translating that to action (scaling up, spreading out), and capacity building.

INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT (IFAD)

IFAD is a specialized UN agency that was established as an international financial institution in 1977 as one of the major outcomes of the 1974 World Food Conference. Its mission is to enable poor rural people to overcome poverty. It recognizes climate change as a key factor influencing affecting rural development, and is developing a number of mitigation and adaptation programs.

IFAD recently announced support for a new research-for-development project to improve livelihoods and climate change adaptation in five countries, including Eritrea and Ethiopia in East Africa. This 3-year project, to be run by the International Center for Agricultural Research in the Dry Areas (ICARDA), plans to identify, test and promote crop and livestock technologies to improve food security and reduce the vulnerability of both rainfed and irrigated smallholder farmers to climate change impacts. Through working with partner organizations and communities, the project plans to build on ongoing research in crop improvement, livestock production, water productivity, conservation agriculture and other land management practices, and the use of poverty mapping and other tools for research targeting.

INTERNATIONAL DONORS

WORLD BANK

The World Bank's development strategies for Africa include investments in water storage, flood control, irrigation infrastructure, and diversification of water sources. Adaptation – specific areas on which the World Bank focuses are disaster-risk reduction, sustainable management of land, water and forests, coastal and urban development, agricultural productivity, and health and social issues.

Projects Include:

- Climate Observations and Regional Modeling in Support of Climate Risk Management and Sustainable Development - http://web.worldbank.org/external/projects/ main?pagePK= 64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P112830
- GFDRR Recipient Grant for IGAD in Eastern Africa regional risk reduction and sustainable development Initiative - http://web.worldbank.org/external/projects/main?pagePK=64283627& piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P119877
- Uganda Sustainable Land Management Country Program - http://web.worldbank.org/external/ projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P10 8886
- Kenya: Adaptation to Climate Change in Arid and Semi-Arid Lands (KACCAL) - http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941 &menuPK=228424&Projectid=P091979
- Multisectoral Water and Electricity Infrastructure Project - http://web.worldbank.org/external/ projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P09 7974
- ET-Sustainable Land Management Program (Ethiopia) - http://web.worldbank.org/external/ projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P09 0789
- Western Kenya Integrated Ecosystem Management Project - http://web.worldbank.org/external/ projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P07 2981
- Arid and Semi-Arid Lands Sector-Wide Program_(Kenya) - http://web.worldbank.org/external/ projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P12 0959
- Sustainable Wildlife and Biodiversity Management Project - http://web.worldbank.org/external/ projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P10 7485

Issues: The World Bank representative in Nairobi reports that there is little coordination at the regional level on climate change, all programs end up being bilateral. Even going through the EAC, there is not enough capacity or systems in place for coordinating, so funds end up being disbursed on a bilateral basis.

The WB representative discussed how there seems to be a lot of funding for climate change but confusion about how to program it, especially at a regional level. In fact, there is some frustration about how there is no strategic disbursement of funds, and that Tanzania for example is swimming in funding (from Norway) and distorting the regional allocation. There needs to be much more donor coordination and systems put in place to fund regional programs.

The WB has just produced a Climate Change Strategy for Africa. They are trying to work regionally but so far disbursements are still bilateral. There will be a new Regional Integration Director to be based in Addis (as it is the headquarters of the AU). It is not clear how the climate change strategy will be implemented at the sub-regional level. This is the bottleneck, from regional to sub-regional, to local. This is true for climate modeling, risk assessments as well. Communications and policies are needed to get the information out.

The WB and UNDP have a Regional Alternative Energy program that focuses on woodfuels, biomass, migration (based in Uganda, Tanzania, Zambia, Ethiopia, Angola and could expand to Mozambique, Rwanda and Burundi).

In Kenya, the climate change funding goes to the Ministry of Environment when it should go to the Ministry of Planning and Finance. JICA is supporting Kenya in climate change ($5.5) with UNDP in a program called "African Adaptation Program".

WB is also funding the Lake Victoria River Basin with the GEF.

There will be a Climate Change EXPO in 2011.

Gaps: Donors need to be more coordinated, regional systems need to be developed to disburse funds for climate change projects in a strategic manner, through regional mechanisms versus bilateral, to achieve greater impact. One of the most effective uses of aid assistance would be to support the meteorological departments/institutions in countries, regionally. There is a gap in making information available that is being developed or already in some form, such as baselines, dynamic modeling. The information is not being disbursed and packaged or directed to the right target audiences (at every level).

Contact person who is coordinator for climate change for DFID: m-banasiak@dfid.gov.uk and nigel@agulhas.co.uk

GLOBAL ENVIRONMENT FACILITY (GEF)

Contact: 1818 H Street, NW, MSN G6-602, Washington, DC 20433 USA
Tel: (202) 473-0508, Fax: (202) 522-3240/3245Email: secretariat@thegef.org

GEF is an independent international finance organization that unites over 180 governments worldwide in partnership with nongovernmental organizations, international institutions, and the private sector to address climate change.

In relation to climate change adaptation, GEF manages several funds, the first of which is the Least Developed Countries Fund (LDCF), which aims to support projects addressing the urgent and immediate adaptation needs of least developed countries, focusing on reducing the vulnerability of those sectors and resources that are central to human and national development, such as water, agriculture, and food security; health; disaster risk management and prevention; and infrastructure, as identified and prioritized in their National Adaptation Programmes of Action (NAPAs).

GEF funds are distributed through UN agencies – and so searching with UN agencies can prove fruitful here (e.g. NAPAs, LDCF, the Special Climate Change Fund (SCCF) etc)

The SCCF focuses on adaptation, transfer of technologies, energy, transport, industry, agriculture, forestry, and waste management, and activities to assist developing countries whose economies are highly dependent on income generated from the production, processing, and export or on consumption of fossil fuels and associated energy-intensive products in diversifying their economies.

Examples of Funded Projects:

- Enhancing Climate Risk Management and Adaptation in Burundi (ECRMAB) - http://gefonline.org/projectDetailsSQL.cfm?projID=3701
- Climate Change Enabling Activity (Additional Financing for Capacity Building in Priority Areas) – Burundi - http://gefonline.org/projectDetailsSQL.cfm?projID=1001Burundi
- Implementing NAPA Priority Interventions to Build Resilience in the most Vulnerable Coastal Zones in Djibouti - http://gefonline.org/projectDetailsSQL.cfm?projID=3408
- Establishing Effectively Managed Marine Protected Areas in Djibouti - http://gefonline.org/projectDetailsSQL.cfm?projID=3713
- Integrating Climate Change Risk into Community-Level Livestock and Water Management in the Northwestern Lowlands in Eritrea - http://gefonline.org/projectDetailsSQL.cfm?projID=3406
- Expedited Financing of Climate Change Enabling Activities Part II: Expedited Financing for (interim) Measures for Capacity Building in Priority Areas – Kenya - http://gefonline.org/projectDetailsSQL.cfm?projID=1817
- Adaptation to Climate Change in Arid Lands (KACCAL) – Kenya - http://gefonline.org/projectDetailsSQL.cfm?projID=3249
- Reducing Vulnerability to Climate Change by Establishing Early Warning and Disaster Preparedness Systems and Support for Integrated Watershed Management in Flood Prone Areas – Rwanda - http://gefonline.org/projectDetailsSQL.cfm?projID=3838
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THE AFRICAN DEVELOPMENT BANK (AfDB)

Contact: 15 Avenue du Ghana, P.O.Box 323-1002 Tunis-Belvedère, Tunisia
Tel: (+216) 71 10 39 00/(+216) 71 35 19 33, Email: afdb@afdb.org

The AfDB group currently funds over 180 projects throughout Africa. The African Development Bank Group also serves as a collector and source of economics and research, as well as statistics. The AfDB maintains a country-based statistical data portal. With the Data Portal, one can visualize socio-economic indicators over a period of time.

Examples of programs:

- ClimDev Africa - The Climate for Development in Africa is a joint initiative involving the African Development Bank, the African Union, and the UN Economic Commission for Africa. ClimDev-Africa consists of three components: (1) building the capacity of African Climate institutions to generate and widely disseminate climate information necessary for planning, (2) enhancing the capacity of end-users, particularly national development policy-makers, to be able to mainstream climate change into development plans on the continent, and (3) implementing adaptation programs and projects to incorporate climate-related information.
- Agriculture Sector Support Project - Ethiopia, focuses on watershed management, small scale agriculture, and water harvesting for human and livestock use - http://www.afdb.org/en/projects-operations/project-portfolio/project/p-et-a00-004/

DEPARTMENT FOR INTERNATIONAL DEVELOPMENT (DFID)

Contact: Magdalena Banasiak, Climate Change Advisor/Kenya and Tanzania
Email: M-Banasiak@dfid.gov.uk, tel: 255 754 210 104

DFID provides its climate change support through the EAC, but its regional program funds are managed by Tim…in headquarters/UK. Their overall budget for Africa is large: 40 million GBP and next year it could double. They are the largest donor in climate change in the region. The UK is concerned that "adaptation" remains on the agenda, it is beginning to get marginalized". The UK focus is to show that climate change is an "economic issue" not just an environment issue.

IDRC and DFID's program on Climate Change Adaptation in Africa (CCAA) is assisting African countries build their capacity to adapt to climate change. Through both research and capacity building, CCAA aims to establish a self-sustained skilled body of expertise in Africa to enhance the ability of African countries to adapt to climate change. The Nairobi Framework has been launched and is assisting developing countries, particularly those in sub-Saharan Africa to improve their level of participation in the Clean Development Mechanism (CDM). UNDP, UNEP, World Bank Group, AfDB, and the UNFCCC Secretariat initiated this Framework in 2006. Capacity building for monitoring, prediction and timely early warning in the region is being supported by the WMO-funded Drought Monitoring Centre (DMC) located in Nairobi, Kenya and sub-centers in Niamey, Niger and Harare, Zimbabwe.

Their flagship regional project is "African Enterprise Challenge Fund," which is managed by the EAC in five countries (£10 million). This is to stimulate the private sector innovation using new technologies and renewables. Tanzania will receive a further 5 million and Kenya a further 10 million (cosponsored with DANIDA).

In addition they have a regional program with CARE "Adaptation Learning Program" piloting learning methods from the bottom up (5 million).

Their bilateral programs are focused on civil society, institutional strengthening/policy framework, private sector innovation.

Key challenges: Funding is very fragmented at the national level, let alone regionally. Donors need to coordinate better with governments that are overstretched and confused about funding streams. There is a proliferation of initiatives and duplication at national and regional levels. Agriculture and water are the key sectors. Standardization of policies are needed to develop baselines and for Monitoring Review and Verification (MRV). Knowledge systems need to be developed (there is plenty of information but it is not being used.) There is a need to focus on the district level not just the national level, and a broader group of stakeholders need to be engaged (eg; private sector).

Opportunities: The EAC may need more support as climate change is a new focus for them. USAID may want to talk to the UK Project Officer for TradeMark who has more in depth knowledge of the institutional strengths and weaknesses of the EAC. ICPAC is a credible partner, DFID was "very impressed" and would encourage USAID to investigate opportunities to partner/support ICPAC. "We Adapt" (WE) is a platform knowledge sharing portal that needs support to be expanded. Supporting a regional climate change fund (through the EAC) to streamline the fragmented approach has been discussed.

DFID has done several studies including "Economics of Climate Change" in Kenya, Rwanda, Burundi (Tanzania coming out in January). These look at macro-economic impacts as well as key sectors and then costs out adaptation through 2030. They have also done a Low Carbon Study looking at win-win opportunities. They also did a study on the EAC "East African Community's comparative advantage in Climate Change". These reports should be sent to USAID.

THE ROCKEFELLER FOUNDATION

Contact: James Nyoro, Managing Director, Betty Kibaara; email: jnyoro@rockfound.org ;Tel: 700 222333

Rockefeller Foundation's global "Climate Change Initiative" has three components: in Africa it is climate change adaptation/building resilience in agricultural crops. In Asia it is resilience in cities, and in the US it is focused on influencing domestic policy.

In the East Africa Region, the RF found that there is a lack of communication/information exchange between National Agricultural Research Institutions (NARIs), Meteorological Departments, ICPAC and Western information sources on modeling (such as Michigan State University (MSU) and the International Institute for Environment and Development (IIED)). National Ministry of Agricultures are not communicating with Ministry of Environments (let alone other line Ministries). The RF decided the key entry points were to a) build the capacity of the National Agricultural Research Institutions because none of them were addressing climate change specifically (developing their climate change strategies, creating climate change units within the NARIs, developing action plans such as to review the agricultural policies of EA governments, and develop curriculum), b) provide grants to US institutions to partner with NARIs, and c) work on policy issues that affect the access to/exchange of information through building "networks" and forums. They also work with policy think tanks to influence governments to incorporate climate change in their development plans.

One of the forums RF works with is COMESA. They report that COMESA (Jojo Mokoya) is doing "a fantastic job", he has been very instrumental trying to roll out/replicate policies and strategies across the region.

They also run a pilot project with the World Bank called the "Global Index Insurance Facility" to provide farmers with "weather insurance". There are several hurdles with this program (premiums still too high, length of time to achieve economies of scale requires "patience capital", and need to insure the value chain, not just the crops.)

Rockefeller Foundation has strong regard for ICPAC and its pivotal role in the region. However, ICPAC needs institutional strengthening and capacity building. It is not communicating effectively with the national Meteorological Departments they are supposed to serve, nor with the NARIs in the region. ICPAC has tremendous potential for influencing the region but it is almost unaware of its important role and is under-capacitated. RF is funding an agroclimatologist at ICPAC whose role it is to downscale information for communities. It was RF's opinion that if USAID or a donor were to fund ICPAC it could really turn it around and have tremendous impact for the region as ICPAC influences 9 countries and interfaces with Meteorological Departments, NARIs and agricultural departments/institutions.

Another issue raised by RF is that meteorological departments traditionally do not share information; rather they require payment for information. It is Rockefeller's opinion that this should be a public good and that policies need to be developed to reflect this. Rockefeller found that all of these institutions

need to be "networked" and need to develop specific climate change programs (rather than the ad hoc "project-funding" that exists presently).

Gaps/Constraints: Lack of information systems to "network" NARIs, national Meteorological Departments, ICPAC, and research institutions based in the West. Rockefeller found that these institutions were working on climate change in scattered, disbursed pilot projects, with no cohesive strategy or coordination on climate change. National Meteorological Departments are very weak, are not sharing data, and need capacity building. They do not have enough data and they lack infrastructure (for example, there is an urgent need to build widely scattered micro-climate weather stations). There has not been enough attention paid to climate change and livestock, and projects in water (storage) are not well coordinated. Policies need to be developed to help governments incorporate climate change in their development plans, and to use and exchange data/information across sectors, institutions and borders.

Opportunities: More work needs to be done with policy think tanks to coordinate and mainstream climate change into development priorities and to enhance communication within and between governments and institutions. COMESA has been doing a good job of this, but could use more support. RF did this via a grant to WWF that funded Jojo Mokoya's position to assist COMESA. This enabled him to be much more effective in overcoming bureaucratic hurdles and being an intermediary/change maker. The EAC does not have enough capacity to effectively implement projects right now, but it would be ideal should a donor work with them to identify the weaknesses and solutions, to build their capacity to lead climate change initiatives. Supporting ICPAC could be pivotal, it has a lot of comparative advantage with its reach to Met Departments, NARIs and Agricultural sector. In any of these cases, it would require finding a strategic partner, a "broker organization" (such as a grant to a third party) to cut through inherent built-in bureaucracies.

EMBASSY OF DENMARK

Contact: Anne Angwenyi, email: annean@um.dk, tel: 254 710 607 385
Website: www.ambnairobi.um.dk

The Danish Embassy is the lead donor for the Environmental Coordinating Working Group (Kenya) and DFID is the lead donor for Climate Change. (There are no donor regional coordinating working groups.) All of the donors for the most part work on bilateral programs. They have produced a "National Climate Change Response Strategy" document for Kenya (which contains a host of information). Their website also contains a document produced in 2008 on institutions/stakeholders in climate change in Kenya which could be useful.

DFID is doing an institutional framework/concept note on climate change which should be out shortly. There are five major donors in Kenya focused on climate change: Denmark, DFID, French, SIDA, JICA. JICA is the lead on water. French are lead on Energy and Biodiversity. Most of the support is institutional support to the government.

All the donors are supporting the private sector, looking at value chain approaches. There is a project called "African Enterprise Challenge Fund" to encourage innovations in technologies to adapt to climate change. There is also a project called "InfoDev" in which entrepreneurs can apply for funds (research & development,, marketing) to address climate change. This could be widened to the region.

The East Africa Community is focusing on climate change. Their mandate is to coordinate negotiations as a bloc, but they need assistance.

The World Bank and Denmark are collaborating on an Arid Lands Resource Project that supports communities in developing renewable technologies. The World Bank also has a project in climate adaptation working in five districts in Kenya that could be upscaled.

The gaps are in empowering communities to address the impacts themselves. There is a need to share best practices regionally and package it to the community level. Policies are also weak nationally, and need to adapt to the region.

Potential opportunities: USAID/EA Mission plays a unique role in the donor community with its regional mandate. It appears to be one of the few that has a regional focus. Assisting governments develop more regionally focused policies is needed, as well as linking policies to communities. Standardizing information, sharing information, putting in place information management systems to ensure downwards and upwards flow of information, and strengthening national/regional institutions to enhance coordination and consistency would be a good fit for USAID/EA.

EMBASSY OF THE NETHERLANDS

Contact: Phyllis Karanja; cell: 0735 333 003; office: 445 0137; Phyllis.Karanja@minbuza.nl

The new government is taking a hard look at foreign assistance and re-prioritizing and downsizing (.7%) in line with other European countries. There is a new emphasis on making foreign assistance fit in with national priorities. The focus will be on food security (because of immigration into the Netherlands), agriculture (dairy and flowers) because of the ties to Dutch industry. More emphasis will be placed on delivering aid through and with the private sector, and a scale back of budgetary support to host governments. There will be less emphasis on the social sectors (health, education) and more on economic growth.

The Dutch program climate change is indirect, through agriculture/environment lens, in other words, no projects with climate change as the primary focus. Their climate change funds are programmed from headquarters. EUR 350 million of the Dutch overseas development assistance budget has been earmarked for climate-related activities for the 2010-2012 period: EUR 95 million for renewable energy, EUR 195 million for REDD and EUR 60 million for adaptation. In the Republic of Kenya EUR 15 million has been programmed for: Africa Biogas Partnership Programme, which supports biogas in six countries (Ethiopia, Kenya, Tanzania, Uganda, Senegal and Burkina Faso); Energizing Development (cooking stoves); and Scaling up Renewable Energy Program for Low Income Countries (SREP/World Bank).

There was an Inter-Ministerial conference in The Hague on Food Security and Climate Change recently, but the results have not yet been published. They are happy to share those with us.
There is a Donor's Working Group on the Environment which includes climate change, and there will be a meeting on November 29 in which all the sectors will present papers on their sectors at the "Development Partnership Forum" (not clear if this is national or regional).

Denmark is the lead for the Environment sector. The Dutch are more active in the water sector.
There is a coordinating mechanism for donors and a website "Aid Effectiveness Group" but it is not populated with information in either the environment or climate change pages yet.

SWEDISH INTERNATIONAL DEVELOPMENT AGENCY (SIDA)

Contact: kikki.novdin@foreign.ministry.se is the team leader for SIDA's regional environment program.

SIDA is supporting UNEP/DEPI to program its funds in climate change/environment/water. They will be supporting the EAC's Master Plan for Climate Change and possibly the Strategy. Their main project is in the Nile River Basin, the Nile Basin Region Water Resources Project ($3.5 million). This includes a component with the Lake Victoria Partnership Fund.

SIDA is developing a regional environment/natural resources program that integrates climate change. It is in the scoping stage. They also have a Swedish Policy on Climate Change (global) which can be found on their website. They are funding civil society capacity building in Kenya, to help them be able to advocate at the policy level. They also have a "Disaster Risk Management" project assisting pastoralists adapt and mitigate climate change in semi-arid and arid lands.

SIDA/Kenya is setting up an Environment Facility (run by Pact) to manage proposals from civil society to build the capacity of community-based organizations and local NGOs to become advocates for environmental issues. They would like to see other donors support this in order to scale it up across the region, there are more community-based organizations than donor funding especially with decentralization and devolution.

Major issues: Water resources are the main issue because they are transboundary. There is a need to develop more storage capacity. The Nile Agreement needs to develop sub-Agreements that are flexible and adaptive enough to change with climate variability.

Gaps: There is a need to find regional champions of climate change, champions who have status and clout. There are no formal structures in place to coordinate climate change issues within governments nor across the region. The Water Donor Coordinating Group functions well through the trust fund, but there is nothing comparable for climate change for strategic programming and tracking financial streams. Flexible policies/agreements need to be developed that allow changes with climate variability.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Contact: John Ngugi, Senior Program Officer, Environment and Water
Tel: 020 272 4121, email: johnngugi.ky@jica.go.jp

JICA's program in Kenya is bilateral and they are the lead in the water sector. Climate change is integrated into its environment portfolio of activities. Their only regional program is "Africa Adaptation Program," cofunded by DFID. This is a regional capacity building project at the policy level.

JICA reported that there are too many donors in the climate change sector in Kenya and it is overstretching the Ministry of Environment. The climate change coordinating group is growing larger and less coordinated with different partner agendas.

JICA's support to Kenya in the climate change sector is in helping to mainstream climate change into line Ministries. A decision has been made that each Ministry should have a focal point person appointed but this has not really happened due to lack of capacity, lack of incentives, lack of activities to focus on. The

"National Response Strategy" has not been distributed properly, or if it has, no one is using the document.

The problem with regional programs is that they all end up being bilateral, and bilateral Ministries have no capacity to implement national programs let alone regional programs. JICA questions whether national governments have the capacity to either implement projects or absorb funding from a regional program because there is little capacity.

EMBASSY OF NORWAY

Contact: Harald Noreik, Counsellor/Deputy Permanent Representative/UNEP and UN-Habitat
Email: harald.noreik@mfa.no;tel: 254 20 42 51 219

Their regional funds are programmed out of Addis and Dar so there was limited information from the bilateral team. They are funding CC-DARE with UNDP and DANIDA which is looking for funding to upscale it. In coordination with UNEP, Norway funds the Poverty and Environment Initiative (valuing environmental assets, capacity building, policy). They are hoping this will be supported by other donors. Norway funds this at $1million/year.

The UN-Habitat program is supporting a "National Disaster Operations Center" in Kenya (preparedness, capacity building, mapping). There is also a Climate Change Network (CCN) that has indirect links to climate change (renewable energy/transportation/emerging issues).

INTERNATIONAL NGOS

COOPERATIVE FOR ASSISTANCE AND RELIEF EVERYWHERE (CARE)

Contact CARE Ethiopia: Abby Maxman,Country Director, E-mail: amaxman@care.org
Garth Vant Hul, Program Director, e-mail: VantHul@care.org.et
Tel: +251(0)116 18 32 94, Fax: +251(0)116 18 32 95, E-mail: care.eth@ethionet.et

Contact CARE Kenya: Mucai Road Off Ngong Road, P.O.Box 43864 - 00100 GPO Nairobi, Kenya Tel + 254 (020) 2710069/2712374 Fax + 254 (020) 2728493 Email: info@care.or.ke http://www.care.or.ke/

CARE is an international humanitarian organization aimed at fighting global poverty. In addition, CARE acts as an emergency aid organization, delivering aid to survivors of war and natural disasters. As noted above, CARE has offices in both Kenya and Ethiopia. In Eastern Africa, CARE focuses on Food and Livelihood Security, Pastoralist Livelihoods, and Water, Sanitation and Hygiene Initiatives, among others.

CARE have developed a useful Community Vulnerability Capacity Analysis tool which has been widely used to assess vulnerability at a community level across Africa. http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf

In terms of work in East African countries, CARE has provided training on the use of the CrISTAL tool (for integrating adaptation in development planning) in Ethiopia, in conjunction with IISD; and looked at climate related vulnerability and adaptive capacity in Ethiopia's Borana and Somali communities; and mainstreamed adaptation into the Global Water Initiative project: Sustaining School Children's Access to Safe Water (SaWa) in Garissa District, Kenya. In 2010 they launched the Adaptation Learning Programme for Africa in 40 communties in 4 countries, including Kenya, where they plan to promote CBA and use the lessons learned to inform policy-makers at the national level. http://www.careclimatechange.org/files/toolkit/CARE_GWI_Project.pdf

Their general approach has been to promote CBA and encourage mainstreaming of adaptation in their development initiatives (which also tend to be implemented at the local level).

REGIONAL/NATIONAL NGOS/PROGRAMS

AFRICA WATER NETWORK (AWN)

Contact: alanbenbotch@hotmail.com

Website not developed, but the organization seems to be a coalition of national water organizations aimed at resisting all privatization and commercialization of water by promoting alternatives and public investment in water.

THE AFRICAN CONSERVATION TILLAGE NETWORK (ACT)

Contact: Tel: +254 20 4444252 Fax: +254 20 4451391 Email: info@act-africa.org

The African Conservation Tillage Network (ACT) is a fast growing pan-African not-for-profit organization whose membership is voluntary and aims at bringing together stakeholders and players who are dedicated to improving agricultural productivity through sustainable utilization of natural resources of land and water in Africa's farming systems and committed to the principal of mutual collaboration, partnership and sharing of information/knowledge on sustainable natural resources management and drawing on synergies and complementarities. ACT focuses on building partnerships, and could be a potential source to build further partnerships for USAID.

Example of Projects: Conservation Agriculture (CA) for Sustainable Agriculture and Rural Development (SARD) (CA for SARD), Phase II in Kenya and Tanzania - http://www.act-africa.org/projects.html

GREATER HORN OF AFRICA RAINWATER PARTNERSHIP (GHARP)

Contact: Tel./fax: +254 (0) 20 2710657
Email: gharp@wananchi.com or gharp.kra@gharainwater.org

The Greater Horn of Africa Rainwater Partnership (GHARP) is a regional network of National Rainwater Associations (NRWA) in the Greater Horn of Africa (GHA) involved in promotion of Rainwater Harvesting and Management (RHM) systems and complementary technologies for improving water supply & sanitation, health & nutrition, food security, enterprises creation, environmental management and sustainable livelihoods. The GHARP Secretariat is currently being hosted by Kenya Rainwater Association (KRA) in Nairobi.

Examples of projects:

- Integrated Rainwater Harvesting & Management Systems and Complementary Technologies for Poverty Reduction and Sustainable Livelihoods in Semi-Arid Districts of Kenya - http://www.gharainwater.org/gharp_activities.html
- Promotion of Rainwater Management Technologies in the Horn of Africa: Multi Sectoral Approach Towards Sustainable Livelihoods of Pastoral Communities - http://www.gharainwater.org/USAID%20OFDA%20pROJECT%202.pdf

RWANDA AGRICULTURAL DEVELOPMENT AUTHORITY (RADA)

Contact: P.O Box: 538 - Kigali, Rwanda, Tel: (+250) 55 10 26 18
Email: infos@rada.gov.rw

RADA is a part of the Ministry of Agricultural and Animal Resources of Rwanda. The goals of RADA include: supplying farmers with appropriate technologies in order to increase their production; coordinating farmers' activities and those of other agricultural stakeholders, reinforcing the farmers technical capacity enabling them to be the pillar of their own development, coordinating all the agricultural activities bearing in mind their complementarities; and setting up adequate mechanisms to make markets accessible to farmers.

RADA projects include:

- Sustainable Land-Use Management Project - http://www.rada.gov.rw/spip.php?article7
- Erosion Control - http://www.rada.gov.rw/spip.php?article7

- Agricultural Extension Project - http://www.rada.gov.rw/spip.php?article46
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KENYA NETWORK FOR DISSEMINATION OF AGRICULTURAL TECHNOLOGIES (KENDAT)

Contact: P.O. Box 2859-00200, City Square, Nairobi, Kenya.
Tel/Fax: +254-20-6766939 Mobile: +254-720-830260 or +254-734-525716
Email: kendat@africaonline.co.ke OR info@kendat.org

RWANDA RURAL REHABILITATION INITIATIVE

Contact: Rwanda Rural Rehabilitation Initiative (RWARRI), B.P. 256 Kigali Rwanda
Tel/Fax : +250-514789, Tel : +250-585443, Email : rwarri@rwanda1.com

Disseminates various technologies related to agriculture to farmers, promotes modern farming practices, advising farmers on natural resource management practices and technologies . Other activities include promoting agricultural skills and knowledge through formal and informal education, and collaborating with research institutions to implement latest best practices.

Africa Adapt

Africa Adapt is a recently-launched web-based initiative (http://www.africa-adapt.net/) aimed at sharing resources, facilitation learning, and strengthening the African adaptation community. It is collaboratively hosted by Environment and Development in the Third World (ENDA-TM), Forum for Agricultural Research in Africa (FARA), the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Centre (ICPAC) and the Institute of Development Studies (IDS) in the UK; and funded by the Climate Change Adaptation in Africa program (see IDRC). Planned activities include innovation grants to encourage innovative approaches to sharing climate change knowledge, a database of expertise (scientists and institutions) on adaptation, and a multimedia repository of community adaptation initiatives.

They will be holding a forthcoming Climate Change Symposium (http://www.africa-adapt.net/AA/ ProjectOverview.aspx?PID=NxDcOtqzgiA%3d) in Addis Ababa, 9-11th March, which aims to explore the following themes:

- Links between adaptation, mitigation and low carbon, or "climate compatible" development
- Roles of local and indigenous knowledge in addressing climate change
- New thinking on community-led responses: From local to global
- The roles of media and intermediaries in translating, sharing, and advocating
- National and international policy: Linking policy and practice

CAPACITY STRENGTHENING OF LEAST DEVELOPED COUNTRIES TO CLIMATE CHANGE (CLACC)

http://www.clacc.net/

CLACC is a well-established international network of research and policy institutes in the non-governmental sector which have collaborated for many years in the field of sustainable development. The CLACC initiative was spearheaded by the International Institute for Environment and Development (IIED) with the aim of strengthening capacity of organisations in 12 developing countries (including Kenya, Tanzania and Uganda) and supporting their initiatives in sustainable development through a network of fellows. CLACC experts come from a wide variety of fields and believe that adaptation to climate change goes hand-in-hand with sustainable development.

SYSTEMS FOR ANALYSIS, RESEARCH AND TRAINING (START)

http://www.start.org/

The Pan-African Start Secretariat, located at the Institute for Resource Assessment at the University of Dar es Salaam coordinates START activities in Africa. There is an additional climate-related "node" at the Climate Systems Analysis Group at the University of Cape Town. In addition to conducting research and funding fellowship and postgraduate training opportunities, START coordinates a number of networks. One of these is the African Climate Research and Education (ACRE) network, which comprises academics and practitioners from around the continent who are concerned with adaptation issues. It arose out of a pan-African workshop held in July 2010 on the theme "Education and capacity building and climate change: A strategy for collective action in Africa."

RESEARCH ORGANIZATIONS

ICRAF/CLIMATE CHANGE AGRICULTURE AND FOOD SECURITY/CCAFS

Part of ICRAF, CCAFS objectives are to overcome critical gaps in knowledge of how to manage trade offs between food security, livelihood and environmental goals in the face of a changing climate; develop and evaluate options for adapting to a changing climate to inform agricultural development, food security policy and donor investment strategies; and assist farmers, policymakers, researchers and donor to continually monitor, assess and adjust their actions in response to a changing climate. CCAFS is undergoing an institutional change, and is still working out the kinks of amalgamating all the Consultative General partners under one umbrella. They recently undertook a very comprehensive process of assessing who is doing what where and what the gaps are in climate change. They produced a compendium of annexes that are invaluable to USAID/GCCI.

They are trying to get away from project funding and have created a "Fund" in which donors can invest in CCAFS 5-10 year programs which focus across regions. Their new framework combines adaptation, risk, and mitigation and seeks to address the impacts on the ground.

CCAFS is currently working on a project "REACT" with BMZ funding (German) to study adaptation strategies, look at best practices, and produce models for downscaling. This is in Western Kenya only at the moment.

They have a large initiative on Vulnerability Mapping, to downscale climate projections coupled with measures of vulnerability. This is a process of overlaying socio-economic information with geographic information system maps and modeling of climate change projections. They have only started this in specific sites but believe it's a powerful tool which could be scaled up if they had more funding. They could do this by sector, such as agricultural systems, or geographic areas, or commodities for example. (Note that RCMRD is doing something very similar, although they probably do more mapping than research). The International Livestock Research Institute (ILRI) is working with CCAFS on this, but CCAFS indicated there was a need for more funding. The Gates Foundation working with AFSA is also funding a soil/landscape study that will feed into the mapping project.

CCAFS is leading an effort to do regional and national scenarios through local level training and building local capacity. In addition, they are researching effective communication tools to inform policy and development strategies. A major weakness is communicating and packaging the information. University of Oxford is the lead on this. They emphasized the need for more research on effective communication methods (as well as research full stop).

Another area of interest to CCAFS is to research how insurance and micro-credit programs could provide safeguards to protect farmers. This is a very new area that needs to be explored.

Overall gaps: the region needs capacity building, more trained scientists, communication tools/strategy, and research. Potential for USAID is in supporting those organizations that CCAFS is partnering with. USAID could consider supporting directly some aspect of the communication strategy possibly in conjunction with ICPAC, or downscaling vulnerability maps by region or commodity (for example)possibly in conjunction with RCMRD.

Partners: ASARECA, East African Farmers Federation, Kenya Agriculture and Research Institute (KARI), and CARE because CARE works across the region. They mention that the private sector is

difficult to engage, but needs to be. Funds come from variety of sources: Gates, BMZ, Rockefeller Foundation.

CONSULTATIVE GROUP FOR INTERNATIONAL AGRICULTURAL RESEARCH (CGIAR)

The Consultative Group on International Agricultural Research (CGIAR) is a global partnership that unites organizations engaged in research for sustainable development with the funders of this work. The funders include developing and industrialized country governments, foundations, and international and regional organizations. The work they support is carried out by 15 members of the Consortium of International Agricultural Research Centers, in close collaboration with hundreds of partner organizations, including national and regional research institutes, civil society organizations, academia, and the private sector.

Programs and Research Centers:

International Livestock Research Institute (ILRI) - http://www.ilri.org/EastAfrica
Contact: ILRI-Kenya@cgiar.org , P +254-20 422 3000 (Kenya Office)
ILRI-Ethiopia@cgiar.org , P +251-11 617 2000 (Ethiopia Office)

Serves as a research organization, maintains a large database of research relating to livestock in East Africa and worldwide.

World Agroforestry Center - http://www.worldagroforestrycentre.org/
Contact: Eastern Africa Regional Program, United Nations Avenue, Gigiri PO Box 30677, Nairobi, 00100, Kenya Telephone: +254 20 7224000, Via USA: +1 650833 6645 Fax: +254 20 7224401, Via USA: +1 650833 6646 Kenya Email: j.mowo@cgiar.org

Projects:

- African Highlands Initiative (AHI) aims at "Developing methodologies for integrated natural resources management (INRM) and their institutionalization in partner NARS in the humid highlands of East and central Africa (ECA). http://worldagroforestry.org/eastafrica/programs/ahi

- Conservation Agriculture with Trees (CAWT) Conservation Agriculture with trees (CAWT) harnesses and combines the synergies of rapid improvement of livelihoods from conservation agriculture with the longer-term but sustained crop productivity and environmental resilience derived from "fertilizer and high value trees".

Is definitely interested in climate change as they've started pioneering index-linked weather insurance for pastoralists (see www.ilri.org for more info; this paper won an award at the PEGNet 2010 conference - http://www.pegnet.ifw-kiel.de/activities/events/documents_conference2010/chantarat-et-al-_willigness-to-pay-for-index-based-livestock-insurance, and Andrew Mude is based in Nairobi)

International Livestock Research Institute
P.O. Box 30709
Nairobi 00100, Kenya
P.O. Box 5689
Addis Ababa, Ethiopia

Tel: +254 20 422 3000 (Andrew direct +254 20 422 4369, a.mude@cgiar.org)

INTERNATIONAL INSTITUTE FOR SUSTAINABLE DEVELOPMENT (IISD)

Phone: +1 204 958-7700, Fax: +1 204 958-7710, E-mail: info@iisd.ca
IISD is a non-partisan Canadian charitable institution that specializes in policy research, analysis and information exchange. IISD's goal is to apply human ingenuity to help improve the well-being of the world's environment, economy and society. IISD also publishes information documents with the research of the organization.

Projects include:

- Rwanda: Reducing the Vulnerability of Rwanda's Energy Sector to the Impacts of Climate Change ***http://www.iisd.org/climate/vulnerability/adaptation_rwanda.asp***
- Kenya: Increase Community Resilience to Drought in Sakai Sub-location

CENTER FOR ENVIRONMENTAL ECONOMICS AND POLICY IN AFRICA – UNIVERSITY OF PRETORIA

Contact: Prof. Rashid Hassan Director, CEEPA University of Pretoria, +27 (012) 420 3317 +27 (012) 420 4958 rhassan@postino.up.ac.za

CEEPA is a part of the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria. The purpose of CEEPA is to enhance the capacity of African researchers to conduct environmental economics and policy inquiry of relevance to African problems and increase awareness of environmental and economic managers and policy makers of the role of environmental economics in sustainable development. While specific projects are not given, research projects are in the areas of climate change, poverty, biodiversity, water and environmental accounting.
CEEPA's advisory board consists of representatives from Makarere University (Uganda), The Institute for Development Studies of the University of Nairobi, the Economic Research Bureau of the University of Dar-Es-Salaam, the Addis-Ababa University Department of Economics (Ethiopia), and the Department of Agriculture and Economics of the University of Agriculture in Tanzania. The complete list of the advisory board, with contact information, can be found at http://www.ceepa.co.za/organization.html.

KENYA FORESTRY RESEARCH INSTITUTE (KEFRI)

Contact: P. O. Box 20412 – 00200, Nairobi Mobile: +254-0724-259781/2,
+254-722-157414, Wireless: +254-20-2010651/2 Email: director@kefri.org

KEFRI carries out research in forestry and related natural resources in Kenya and places a role in shaping related policy. KEFRI also holds various related workshops, such as the Regional Training Course "Mitigating Climate Change in Africa through Social Forestry." It also provides technical support to farmers in building sustainable practices and learning new agricultural technologies.

Examples of programs and projects:

- Social Forestry Training Center

- Developing drought-tolerant trees for Adaptation to Climate Change
- Drylands Forestry Program

THE NATIONAL UNIVERSITY OF RWANDA (NUR)

Contact: Tel:+250-252517876, +250-0255103090 Fax: +250-252530210
Email: research@nur.ac.rw

No specific information is given aside from the fact that they are doing research in relation to climate change in Rwanda. Robert Ford is reported to be working with them on a research project exploring malarial incidence dynamics attributable to climate change. geobobford@gmail.com

SELIAN AGRICULTURAL RESEARCH INSTITUTE (SARI)

Contact: sari@habari.co.tz (T) +255-272503883; (T) +255-272503971

SARI is considered the Zonal Headquarters for Agriculture and Livestock Research and Training for the Northern Zone of Tanzania, and its mandate now includes Research on all major grain crops grown in the zone based on a Farming Systems Research perspective. No additional information is given.

NATIONAL AGRICULTURAL RESEARCH ORGANIZATION (NARO) (UGANDA)

Contact: Tel: 256 -41- 320512, Tel: 256 -41- 320341/2, Tel: 256 -41- 320178
Fax: 256 -41- 321070, Email: dgnaro@infocom.co.ug

NARO is the body for guidance and coordination of all agricultural research activities in Uganda. It includes a database of all organizations doing research related to agriculture and fisheries in Uganda, and also maintains an information database.

ETHIOPIAN INSTITUTE OF AGRICULTURAL RESEARCH

Contact: Tel +251-11-6462633-41, Fax: 251-11-6461294, P.O. Box 2003

The Ethiopian Institute of Agricultural Research also maintains an "Agricultural Information Portal."

Examples of research projects:

Vulnerability of Agriculture to Climate Change - This research project assesses natural resources and the environment for climate negotiators in order to address vulnerability of the agricultural sector to climate change. It also highlights policies and programs already in place to smooth the progress of adaptation. - http://www.eiar.gov.et/

Rural Capacity Building Project - http://www.eiar.gov.et/projects/9-rural-capacity-building-project

MEKELLE UNIVERSITY (ETHIOPIA) GEO-INFORMATION AND EARTH OBSERVATION SCIENCES

Contact: Dr. Kiros Meles, e-mail kirhadgu@gmail.com

No specific information is listed on their website only that they conduct various research projects geared toward sustainable adaptation and natural resources development and food security.