ADAPTCost Project: Analysis of the Economic Costs of Climate Change Adaptation in Africa

United National Environment Programme

ADAPTCost

This monograph summarises the findings from the AdaptCost project, which support the statement from the Tunis Roundtable. The full report of the Tunis Roundtable, policy briefs and technical papers from the AdaptCost project are available from: http://tinyurl.com/UNEP-AdaptCost. A section of weADAPT includes additional material: <www.weadapt.org/wiki/Economics_of_adaptation>.

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Tunis Roundtable on Economics of Adaptation

The AdaptCost project, funded by United Nations Environment Programme (UNEP) under the Climate Change – Norway Partnership, has investigated and built evidence on the potential costs of adaptation in Africa.

The project has undertaken a detailed review of the estimated economic costs of adaptation in Africa, investigating several lines of evidence, and commissioning new model runs or sector analysis.

These include global analysis, sector and national studies. It also includes a range of methodological approaches, including integrated assessments, investment and financial flow assessment and project based assessments. A key theme of the project has been to recognise that each of these aggregation levels and methodological approaches brings insight into a complex area, where we have relatively little experience.

The findings from the study were brought together and discussed in an expert workshop in April 2010. At the Tunis Roundtable on the Economics of Adaptation the evidence of the potential costs of adaptation in Africa and the methods for assessing the economics of adaptation were reviewed. The aim was to identify strategic policy responses and urgent investment priorities.

The process and conclusions that they reached are summarised here:

The group endorsed the calls for urgent and additional finance for adaptation in Africa. It was agreed that this is essential given the potentially high economic costs of climate change for the continent even in the short-term. The evidence revealed a wide range of estimates of the amount of funding necessary for Africa, with current (2010-2015) financing needs that range from $5-30 billion a year. These needs are likely to rise over time, with studies reporting a range from $20-60 billion a year by the period 2020-2030. The large differences between these figures is due to the different methods of each study. For example, estimates that include the need to reduce vulnerability to current climate variability and associated social protection have much higher costs than those that only address future climate change.

However, the current evidence base is founded on highly aggregated studies, which have high uncertainty and omit categories of potentially large adaptation costs such as ecosystem services: they can only be considered indicative given the current level of knowledge. Nonetheless, these large differences in estimates should not be allowed to slow progress and there is a need to secure finance flows for the future, now. This is essential to establish sound pathways for adaptation in Africa and to develop national policies and strategies, expanding capacity in research, assessment, knowledge management and practice, enabling existing and new institutions to prepare for the challenges ahead.

The Roundtable also considered the methods available for assessing the costs and benefits of adaptation. It recognised that there are different questions which need addressing and require different types of assessment – including the level of aggregate funding needs – for national planning – through to project appraisal. Such assessments are more complex than with low carbon analysis and there is a need to consider specific sector and geographical issues. Each method has its strengths and weaknesses but many of them can be used together to gain information.

A key finding of the workshop was to consider adaptation as a process. Consequently there is an economic rationale for building lasting adaptive capacity and knowledge management, rather than just raising financial aid. This requires a greater focus on basic monitoring and observation, competency building, institutional and organisational investment, non-technical adaptation and policy reform. These ‘soft’ measures are es-

sential to allow Africa to adapt effectively in the future, giving longevity to a process which will allow flexibility in the future. These options have received less attention to date as they are more difficult to assess within a standard economic framework, but they are an essential complement to hard technical-based adaptation.

The workshop also acknowledged a need for multi-disciplinary, cross-sectoral and cross-border analysis, which involves current institutions and organisations working more productively in the future. In addition, the need to widen the current focus of climate change to cover bio-physical and socio-economic aspects, as well as climate data, linking institutions together to provide the necessary expertise was highlighted.

The Roundtable noted the initiatives already underway in Africa but emphasised the need to further build an African-led process. This involves investment in local institutions and organisations. There is also a need to build greater south-south collaboration.

A number of concrete actions to advance this statement were proposed:

Firstly, the Roundtable is setting up a working group to address the issues raised above and to form a cross-disciplinary, cross-sectoral pilot study that considers the economics of adaptation. The group will consider the future analysis of a major ecosystem based study which crosses sectors and countries and assesses the economics of capacity/ competence building and knowledge management alongside policy reform and hard adaptation, using an approach that builds relations between institutions and organisations.

Secondly, a significant number of national studies on the economics of adaptation will emerge over the next year, as well as several sectoral and project case studies, providing vital new information. There is a need to undertake a revised stocktake on the likely costs of adaptation in Africa when these studies are available and to compare the methods and information they provide. There is also a need for a larger workshop on the economics of adaptation in Africa after the next Conference of Parties of the climate convention. This will help the development of professional African capacity in the economics of adaptation.

The Roundtable was convened by the African Development Bank (AfDB), the Sahara and Sahel Observatory (OSS), UN Environment Programme (UNEP) and Stockholm Environment Institute (SEI), and included representation from International Institute for Environment and Development (IIED), ENDA Tiers Monde, the African Technology Policy Studies Network (ATPS) and the National Development Planning Commission Ghana, though the ideas above only reflect the views of the individual experts.

Introduction

The IPCC 4th Assessment (WG II summary, Parry et al., IPCC, 2007) makes it clear that the impacts of future climate change will be varied across regions. It is now commonly understood that the most significant climate change damage will be felt in developing countries (e.g. Stern, 2006), with Africa being the continent which causes the most concern.

There are several reasons for this: many of the largest adverse changes are predicted to occur in these countries; their economies rely more on climate-sensitive activities; many operate close to environmental and climatic tolerance levels; and their ability to adapt may be limited because of technical, economic and institutional limitations (Tol et al., 2004).

In line with this, economic assessments (integrated assessment analysis) identify particularly high economic costs from climate change in Africa (Downing et al., 2005). Conservative estimates are that African economies could be facing losses of at least 1-2% of GDP, or US$10-20 billion, annually (van Aalst et al., 2007) though some sectors will be much more exposed.

Africa is already highly vulnerable to climate variability and extremes, as evident from the impacts of current climate variability and weather extremes e.g. floods and droughts, which in turn affect economic performance, food security, livelihoods of the poor, and assets (both natural resources and infrastructure).

The future impacts of climate change will effect the pattern of such extreme events, but it will also lead to change associated with increased mean temperature, sea level rise, variations in annual and seasonal precipitation, etc. which in turn will also potentially have significant economic effects.

These will be compounded because Africa is already highly vulnerable, and climate change will only make this worse. Nkomo et al. (2006) and Boko et al. (2007) identify existing developmental challenges such as: endemic poverty, complex governance and institutional dimensions; the high population growth rate, the prevalence of malnutrition, low literacy rates, a high burden of disease; limited access to capital including markets, infrastructure and technology; current ecosystem degradation and loss of natural resources; complex disasters and conflicts (including environmental disasters such as floods and droughts); and poor governance, corruption, conflicts and weak institutions.

Whilst adaptation is needed to address the potential challenges of current variability and future climate change, Africa has low adaptive capacity due to low financial resources, low technical capability, weak institutions and limited awareness of the impacts of climate change.

The combined effects (high vulnerability and low adaptive capacity) are likely to be greatest for the poor within Africa, and they may potentially exacerbate inequalities in health status and access to adequate food, clean water, and other resources. These multiple constraints – linked to low income and poverty – are likely to limit the ability of vulnerable groups to adapt successfully to climate change, and unless action is taken, the effects of existing constraints will be compounded (see Stern et al., 2006, Adaptation in the Developing World). In particular, these constraints pose problems for rural livelihoods, and have potentially wide reaching effects.

In turn, these effects are likely to impact upon the ability of country governments to meet strategic objectives, potentially hindering progress towards poverty alleviation and pro-poor growth. There is, therefore, a need to increase the resilience of livelihoods, reduce their vulnerability and raise capacity to adapt.

Related to the above, climate change also has implications for the programmes of development agencies such as the African Development Bank (AfDB) and their portfolio (AfDB, 2009, see van Aalst et al., 2007). Climate change could potentially affect the achievement of, and long-term progress towards sustainable poverty alleviation and economic development in Africa. Climate change also has the potential to set back development and poverty reduction, threatening the attainment of, or even reversing, the Millennium Development Goals (MDGs). However, there is currently a lack of information on how large the costs of adaptation might be. The IPCC 4th Assessment Report (AR4) reported that the literature on adaptation costs and benefits was 'quite limited and fragmented' (Adger et al., 2007). Similarly, the OECD study on adaptation costs and benefits (Agrawala and Fankhauser, 2008) found little quantified information available, with particular gaps for Africa, and low coverage across many sectors.

Study Objectives and Approach

Against this background, the AdaptCost project, funded by United Nations Environment Programme (UNEP) under the Climate Change – Norway Partnership, has investigated and built evidence of the costs of adaptation, producing a range of estimates for climate adaptation in Africa using different evidence. The study aims were:

- To help African policymakers and the international climate change community to establish a collective target for financing adaptation in Africa.

The assessment of the costs of adaptation is still emerging and there are no agreed approaches. There are strong benefits in considering multiple lines of evidence: each of these brings insight into a complex area, where we presently have relatively little information.

Such an approach also builds up a more comprehensive evidence base for policy makers, and allows validation between different aggregation levels. A key focus going forward is to consider different approaches to provide complimentary information within iterative analyses.

• To investigate estimates of the economic costs of adaptation to climate change and improve understanding of adaptation processes, to provide useful information for planning adaptation programmes and supporting decision-making by national governments and multi and bilateral donor capital.

Estimates of the economic costs of adaptation require investigation of several sources of evidence. These range from case studies of projects and plans through to global scale assessments.

The AdaptCost project has investigated a number of such sources. These include the results of global economic models, estimates from investment and financial flow assessments, studies which report continental, national or continental costs of adaptation for Africa, and sector and country studies. The study has primarily been based on review, but has also commissioned specific model runs (with integrated assessment models) as well as some new sector modelling assessments, notably for coastal zones.

These multiple sources of evidence are also important for two additional reasons. Firstly, some approaches (and models) will be more appropriate than others for tackling certain policy questions. Secondly, there will also be a need for different approaches (and models) to assess various aggregation levels, i.e. from an African level analysis through to sector or local adaptation.

The project has assessed three key methods of analysis:

• Global integrated assessment models,

• Estimates from the global and African investment and financial flow assessments,

• Studies which report continental, national or Africa costs of adaptation for Africa.

The studies and their most relevant geographical scales are shown in the table at the bottom of this page. Note that these approaches are not mutually exclusive, so it is possible to combine local sectoral studies with a sectoral Investment and Financial Flow (IFF) analysis for example.

From Climate Impacts to Adaptation

The AdaptCost study pioneered an approach to understanding adaptation that moves beyond the assumption that it is possible to predict future climate impacts and effective adaptation strategies and measures. The starting point for this approach is recognition of the fundamental nature of uncertainty.

Climate change projections and impact assessments are highly uncertain. This is partly because our understanding of climate change and its impacts is incomplete, but also because future socio-economic conditions are highly uncertain. The current state of knowledge is not good enough to provide firm projections. It is inappropriate to design adaptation strategy against a single future projection of modelled climate.

	Africa	National	Local
Integrated assessment models	✓✓	✓	
Investment & Financial Flow #	✓✓	✓✓✓	✓
National to sectoral studies*	✓	✓✓✓	✓✓

Sources of Economic Evidence for Adaptation. Main focus areas are shaded

 # IFF studies at national level including sectoral analysis.
** including wider economic studies (such as general equilibrium modelling) through to bottom-up sectoral analysis.*

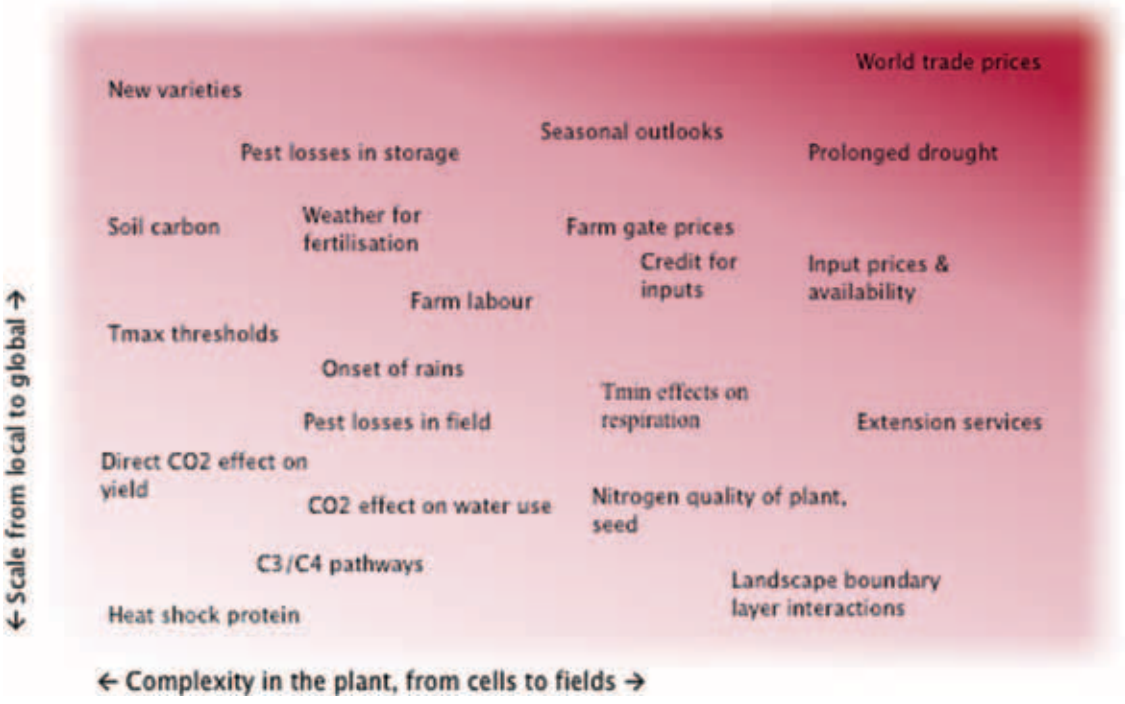
As an example of uncertainty, the diagram below shows the wide range of factors that link climate change, agriculture and food security in Africa. No model assessment covers all of these factors, let alone their interactions, future pathways and surprises inherent in complex socio-ecological systems.

Our approach focuses on decision-making under uncertainty, evaluating adaptation processes and outcomes that are robust against a wide range of future situations. Moreover, given this uncertainty there is value in using a suite of economic tools and methodologies. Different sources of evidence help cover against this uncertainty.

Adaptation is a process of social and institutional learning. It is not just a set of outcomes or options to respond to climate projections. Effective adaptation equips people and institutions to cope with a wide range of contingencies. Adaptation can include the need for building capacity and institutional strengthening. It can also include a range of measures that have broad multi-sectoral benefits, such as improved climate and weather forecasting, emergency warning and preparedness, awareness and education, etc. Furthermore, it can also include specific adaptation outcomes, including the use of technical (hard) and non-technical (soft) measures.

Methodological Issues

Evaluating the costs of adaptation is a relatively new and extremely complex area, which involves a large number of methodological challenges. These are important because the degree to which these are included – or the specific methodological approach that is taken to address these issues – has a considerable influence on the results and findings of an individual study.



Following review, a large number of such challenges have been identified. These include:

- The definition of the baseline, particularly in terms of future development.

- The degree to which uncertainty is taken into account, in particular across the climate projections, but also across socio-economic scenarios, analysis of impacts (and benefits) and adaptation responses.

- Whether distributional effects have been taken into account, or used in prioritisation.

- Specific issues with the discount rate used, and the study time horizon (including responses over time).

- The functional relationships used to define impacts and benefits, including cost or benefit curves for adaptation, and whether thresholds or non-linearity has been accounted for, including the limits of adaptation.

- The level of geographical and spatial disaggregation, and how this affects the resolution of the study findings.

- The coverage of impacts (and adaptation responses), i.e. across sectors. This also includes the coverage of economy-wide impacts, and cross-sectoral linkages.

- The consideration of adaptation responses, and notably whether these are constrained to 'hard' (technical) engineering solutions, or also include 'soft' (non-technical, behavioural or other) adaptation options.

- Whether responses have sought to predict and optimise, or considered a framework of decision making under uncertainty, and issues of reversibility, flexibility and adaptive management.

- Whether analysis has considered any additional impacts or benefits from action

- The specific attribution of costs or benefits to adaptation.

In the particular case of Africa, there is also a need to have a greater consideration of adaptation and development pathways, and how these are separated. This requires an early prioritization to understand and assess these linkages, which is still largely missing – and certainly not yet agreed.

This also involves consideration of the 'adaptation deficit', defined as a failure to adapt adequately to existing climate risks.

The degree to which the different studies address these issues varies enormously. A mapping of these types of methodological aspects against various studies and approaches has recently been completed (Markandya and Watkiss, 2009). Understanding and accounting for these issues is a particular focus for future assessments.

The following section outlines the key sectoral results and findings from the AdaptCost review and commissioned studies. A synthesis of the results follows.

Estimating the costs of adaptation involves a large number of methodological challenges, but perhaps the most important is the need to recognise uncertainty. There is a need to plan robust strategies to prepare for an uncertain future and not to use uncertainty as a reason for inaction.

Review of Lines of Evidence

This section summarises the key findings from the study, reporting the summarised information from the various areas of research. Full briefing notes are available for each sector, and more detailed reviews are available for coasts, agriculture and ecosystems.

Integrated Assessment Models

Many of the cited estimates of the economics of climate change are derived from global Integrated Assessment Models (IAMs). These provide aggregated estimates, assessing costs in a single iterative framework. However, to make analysis manageable, they involve assumptions and simplifications, and they have been the subject of considerable debate. The AdaptCost project commissioned two leading global IAMs, the FUND and PAGE models, to provide results for Africa.

The first important conclusion from the model runs is that the economic costs of climate change in Africa are likely to be significantly higher in relative terms than in many other world regions and that they could be significant even in the short-term. The models indicate that the central net economic costs of climate change could be equivalent to 1.5-3% of GDP each year by 2030 in Africa. These costs include market and non-market sectors and are subject to assumptions and uncertainties.

The FUND model estimates that under a business as usual scenario, net economic costs could be equivalent to 2.7% of GDP each year in Africa by 2025. The model reports large costs from water resources, health impacts, and energy costs for cooling, but some potential benefits from agriculture. Note that positives and negatives are combined in the results. It shows relatively similar levels of economic costs in future years through to 2100. A separate analysis with the FUND national model has provided net estimates for each African country. This shows strong distributional patterns of economic costs by country (and region) and strong increases in economic costs in all regions over future years.

The PAGE2002 model estimates that economic costs could be equivalent to around 2% of GDP each year in Africa by 2040 (central value, market and non-market sectors, A2 scenario), with a 5-95% confidence interval of 0.4-4%. The model shows that economic costs rise rapidly in future years, so that by 2100, they could be equivalent to 10% of GDP each year, i.e. too high for a sustainable economy.

The PAGE model has been run with adaptation included, which reduces costs significantly. Under the A2 scenario, the (mean) economic costs of climate change drop from 0.8% of GDP in 2020 and 1.7% in 2040 (with no adaptation) to 0.5% and 1.1% respectively (with adaptation included). The benefits of adaptation are far in excess of estimated costs, with mean benefits of $17 billion in Africa in 2020 compared to mean costs of $4.5 billion, and they increase significantly in future years. However, the model shows high residual costs in Africa even with adaptation, estimating that these are around 50% for market sectors and around 70% of total impacts.

Finally, the PAGE model has been run with a mitigation scenario for a 2 degrees (450 ppm) scenario. This shows highly reduced costs from climate change in later years (post 2040), such that annual economic costs of climate change to Africa

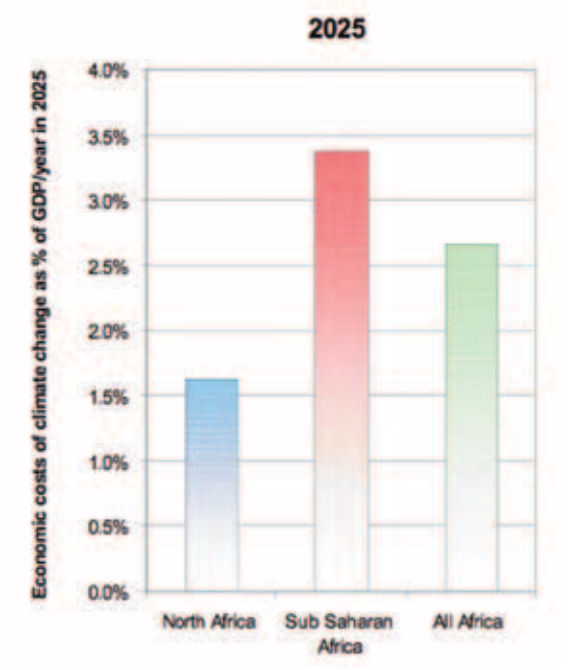
While there is high uncertainty, the integrated assessment models indicate that the central economic costs of climate change for Africa could be equivalent to 1.5-3% of GDP each year by 2030.

are limited to just over 2% (mean value) of GDP by 2100 – this is dramatically below the business as usual scenario. Adaptation reduces these economic costs further, leaving low residual impacts. The modelling shows that in the absence of mitigation, economic costs from climate change in Africa could be extremely large, even in the short-term. Impacts will be unevenly distributed across countries, and between sectors. Moreover, high economic costs are likely even with adaptation. Mitigation reduces longer-term impacts significantly, but there will still be significant adaptation needs and residual economic costs. Adaptation needs are similar in early years in all scenarios, due to the change already locked into the system.

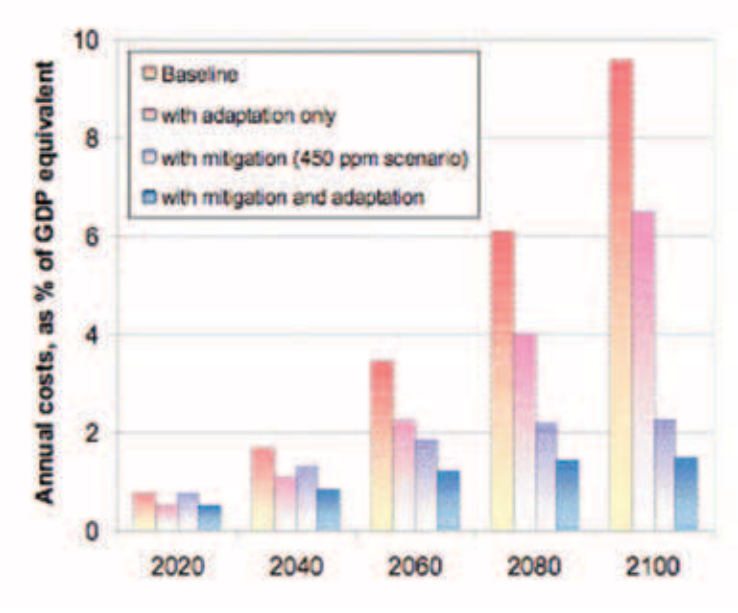
All these estimates are only indicative. They provide some insight into signals, size and patterns of effects. They can provide information on the potential economic costs, which are useful in the context of adaptation financing requirements. However, the models only reflect a partial coverage of the effects of climate change, and do not capture extreme events (including flooding and droughts), cross-sectoral links and socially contingent effects, or the cumulative effects on adaptive capacity, all of which may be important for Africa.

Aggregated Approaches of Investment and Financial Flows

Much of the existing evidence focuses on the costs of enhancing climate resilience in future investment ('climate proofing'). This investment and financial flows (IFF)



Annual Costs of Climate Change as an Equivalent % of GDP in 2025
Source FUND model (Tol and Antoff) See IAM briefing note.

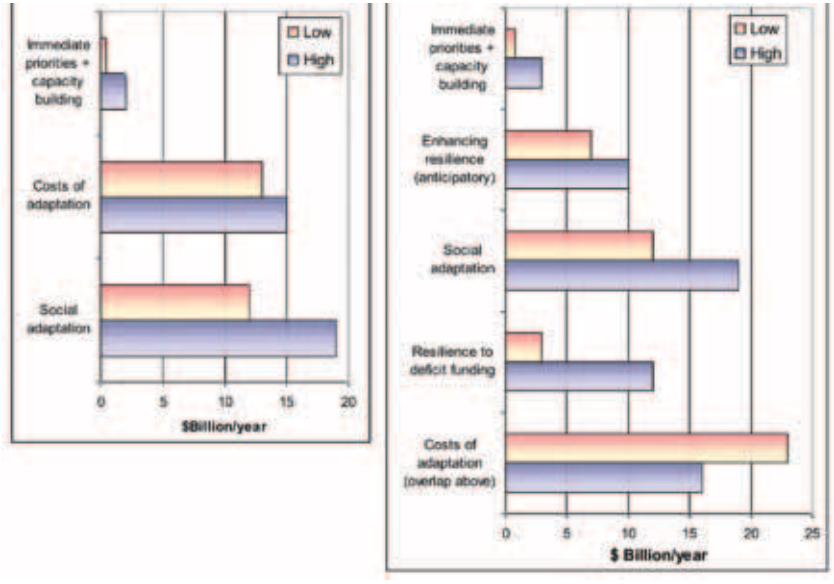


Annual Mean Economic Costs from Climate Change as a Fraction of GDP in Africa
With mitigation and adaptation. (Source PAGE model), see IAM briefing note.

Adaptation cost estimates are strongly influenced by what is included or excluded.

The top-down and IFF studies indicate immediate adaptation financing needs of at least several billion dollars a year now for Africa to build capacity and start building resilience. Although this will potentially be a lot more if additional categories are included.

These adaptation costs will rise over time, with plausible estimates of around tens of billions of dollars a year by 2030.



Estimates of Adaption Costs 2010-2015 **Estimates of Adaption Costs 2030**

Summary of Estimates of the Costs of Adaptation for Africa
See IFF briefing note.

approach has mostly been undertaken on a global scale. However, it is possible to separate the African component of these studies. These approaches and other top-down analysis have been reviewed.
In the short-term (up to 2012) estimates of the immediate adaptation financing needs for Africa are $1-2 billion a year, to undertake vulnerability assessment, build capacity, pilot adaptation, and tackle immediate hazards (SEI, 2008); these costs will rise in the future, possibly to $3 billion/year by 2030.

The additional costs of 'climate proofing' investment is typically estimated at $7-10 billion/year by 2030 for Africa, based on UNFCCC (2007) estimates. However, a recent review (Parry et al., 2009) considers that this may be a major underestimation, not least because of an 'adaptation deficit' to the current climate in Africa. This deficit needs to be erased and the costs of doing this in Africa has been estimated at $60-several hundred billion/year, although this deficit is associated with current development rather than climate change. If such a deficit was addressed, there would need to be a further $3-12 billion/year by 2030 to make it climate resilient (which would be attributed to climate change). Overall,

Parry et al. estimate the total attributable costs of climate proofing investment to future climate change could be a factor of 2 to 3 higher than the UNFCCC estimates, estimated in this note as $12-28 billion/year by 2030 for Africa.

There are also some studies that count the additional costs for social protection, to protect livelihoods and health related to climate. A study by the Grantham Institute (2009) estimates an additional $12-17 billion/year is needed for Africa currently (2015), with this number potentially increasing in future years up to 2030.

These aggregated (top-down) studies provide useful information and the range cited appears reasonable. However, there is low confidence in these estimates for a number of reasons. The methods do not directly address the uncertainty in future climate scenarios and subsequent impacts. Actual adaptation strategies and measures are not evaluated, nor are the benefits of adaptation. Adaptation to future climate change is not separated from future socio-economic change. The estimates do not include the additional costs of residual damage after adaptation. These points are important when comparing these estimates to others and for the adaptation negotiation and financing discussions.

In conclusion, the total adaptation costs for Africa are strongly influenced by their boundaries. The lowest estimates here are associated with the additional costs needed to address future climate change, with immediate (current) needs estimated at several billion/year, rising to a minimum of $10 billion/year by 2030, although these estimates could be an underestimate by a factor of 2 to 3.

Higher estimates are derived when additional costs are included to address the adaptation deficit and to increase social protection. However, these upper estimates are based on current deficits to the existing climate, and are associated with current development, rather than future climate change (though they are essential steps in enhancing future resilience).

Detailed IFF studies are emerging all the time. The UNDP has developed country and sectoral level guidance which is being trialled by six African countries. This will allow a more accurate estimation of likely adaptation financing needs by country (bottom-up) and allow a more accurate African-wide estimation in the future.

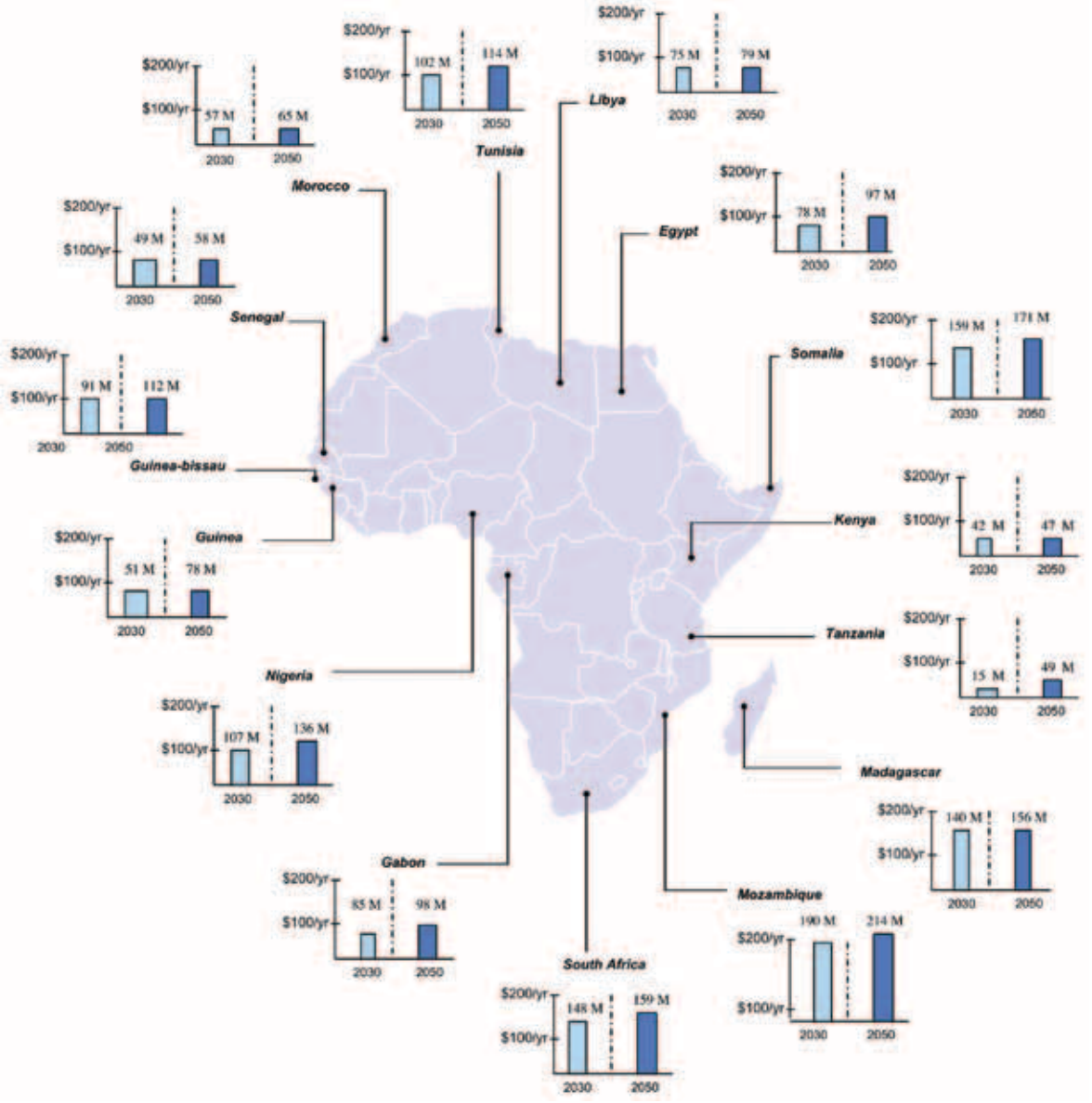
Coastal Adaptation

The coastal zones of Africa are highly populated, have significant economic activity and important ecosystems. They are at risk from future sea level rise and storm surges. With a large and growing population in coastal zones and a low adaptive capacity, many African countries are highly vulnerable.

In the absence of adaptation, the physical, human and financial impacts of climate change on coastal zones will be significant. Coastal adaptation is therefore likely to be a priority area. To investigate this, the AdaptCost study commissioned new analysis using the DIVA model to provide aggregated African-level analysis and separated outputs by country to highlight impacts and adaptation costs.

This modelling indicates that without adaptation, the impacts and economic costs to coastal zones could be a significant risk for Africa, with over 2 million people suffering from flooding every year by the year 2030, rising to 5 million/year by 2050 (A1B mid-range scenario). In the longer-term these risks increase significantly with an estimated 16 million people flooded/year in 2100 (A1B, 43 cm sea level rise).

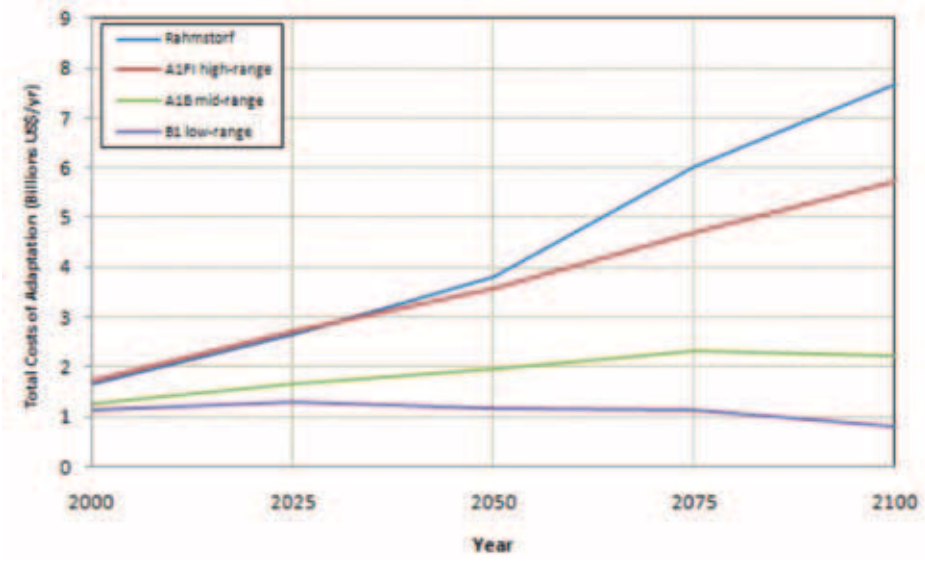
Analysis of sea level rise in Africa using the DIVA model suggests large impacts and economic costs in coastal zones. Adaptation can reduce these significantly and has high benefits when compared to costs. Nonetheless, adaptation costs are estimated at $1-4 billion/year by 2050, increasing significantly later.



Costs of Adaptation ($million/year) to Sea Level Rise and Socio-Economic Changes for Selected Countries in Africa – A1B Mid-Range Scenario for 2030 and 2050.
Source: DIVA model, see coastal briefing note.

The model has also estimated the economic costs associated with the impacts of flooding and the loss of ecosystems. Without adaptation, the total costs for the A1B mid-range scenario are estimated at $1.6 billion/year in 2030, rising rapidly to $7.5 billion/year by 2050. In the longer-term, impacts rise significantly, up to $38 billion/year in 2100. Note that a large proportion (around 50%) of these future costs is due to socio-economic change and population growth. The economic costs increase with higher sea level rise scenarios, and using higher scenarios from the literature, the model reports a plausible upper estimate of $50 billion/year by 2100.

The model also looks at adaptation costs and benefits for two protection measures. The costs of adaptation are estimated at approximately $2 billion/year for Africa in the period 2030-2100 (A1B) and the benefits are significant: with adaptation, residual damage costs are reduced to around $1 billion/year. The analysis shows that adaptation can significantly reduce the risk of flooding and the economic costs of sea level rise, at relatively low cost. However, the costs of adaptation rise significantly with higher sea level rise scenarios. Using plausible scenarios from the recent literature, the costs of adaptation for Africa could increase to $5-8 billion/year by 2100. It is stressed that these values do not address all categories of impact and they do not include the additional current deficit to better cope with coastal flooding. They could therefore be considered an underestimation. However, they are primarily based on technical measures.



Costs of Adaptation due to Sea Level Rise and Socio-Economic Change in Africa
Figure shows four sea level scenarios studied employing a risk based and cost-benefit approach. 1995 prices. Source DIVA model, see coastal briefing note.

The national DIVA results show impacts and adaptation costs in particular countries to be the most important. Based on the number of people flooded, Mozambique, Cameroon, Tanzania, Morocco and Egypt are at particular risk. For economic damage Egypt (in particular), Algeria, Morocco, South Africa, Tunisia, Libya and Cameroon are the most at risk. In absolute terms, the highest adaptation costs occur in Mozambique, Guinea, Guinea-Bissau, Nigeria, Somalia and South Africa. Note that high impact costs and adaptation costs are not automatically connected.

The study has also reviewed other estimates. The recent World Bank study also applies the DIVA model, but adds some additional adaptation costs, and considers a higher sea level rise scenario (A2, higher SLR). It estimates costs for Africa at $4-6 billion/year for the period 2010-2050.

There are also a number of national studies, including analysis in Benin, Egypt, Kenya, Nigeria, Senegal, Tanzania and South Africa, as well as emerging studies in a much larger group of countries which will be available by the end of 2010. Comparing the aggregated estimates

for Africa with these individual country studies is difficult. Results for some parameters are of the same size, while others show significant differences. These differences arise from the difference in defining coastal and wetland areas and the level of spatial detail the analysis and framework adopted, i.e. whether existing and future protection costs are included, and whether action is to pre-defined levels or within an optimal analysis.

Finally, further work is required to better understand the implications of sea level rise for Africa in a broad sense, but also to move to national and sub-national assessments. These can address adaptation in a local context and the linkages with development, as well as considering more realistic adaptation measures.

Health Sector Adaptation

Health has been identified as one of the key sectors for adaptation in Africa. A range of potential impacts could occur from climate change, including an increase in cases of malaria, diarrhea, schistosomiasis, heat related mortality and morbidity, and an increase in incidences of deaths/injuries/disease linked to coastal and inland flooding. There are also indirect effects associated with climate change such as the risk of undernourishment and malnutrition, and wider gaps developing between economic and development levels and health. Finally, there are also risks to public health systems and infrastructure.

There are existing continental studies on the potential impacts of climate change on health, as well as several national studies. These show increased health risks with climate change, particularly for sub-Saharan Africa, although the level of impact is strongly influenced by future development and economic growth, with assumptions of higher development (and lower baseline incidence) impacts and therefore adaptation costs are lower.

On a continental scale, a number of studies have estimated short-term adaptation costs, using estimations of future health impacts and combining these with prevention costs.

The costs of adaptation associated with malaria and diarrheal disease have been estimated for Africa at between $2.2-3.3 billion/year by 2030 (UNFCCC, 2007),

Adaptation appears highly cost-effective for reducing the threat of many climate related burdens, significantly reducing potential impacts at relatively low cost.

$2-9 billion/year by 2030 (Markanya and Chiabai, 2009) and most recently, around $1 billion/year in the period up to 2050 (World Bank, 2009). The range is determined primarily by assumptions of development baselines and incidence rates. There are some estimates of the costs of adaptation for malnutrition, but these are much lower, and also overlap with the agriculture sector, considered later.

Other studies (Parry et al., 2009) highlight that this focus on only two or three health endpoints implies that total health adaptation costs will be much higher, and reports that the current estimation above might therefore reflect only 30-50% of total health adaptation costs.

Nonetheless, a general finding is that health adaptation is extremely cost-effective, and that adaptation can significantly reduce potential impacts, at relatively low cost. In many cases, measures that are effective for preventing future climate risks also have more general benefits in relation to the current adaptation deficit and accelerating development.

There are also a number of national studies that have assessed the costs of adaptation, such as recent work in Kenya on malaria (SEI, 2009), a wide coverage of health protection for Ghana, and health protection against extreme events (droughts) in Tanzania (ECA, 2009).

The Ghana study estimates the incremental cost of adaptation in the health sector to be $350 million by 2020 and a similar amount from 2020 through to 2050 (total, not annually), whilst the Kenya study assesses the annual costs of adaptation at around $23 million/year by the 2050s. These more localized studies tend to reinforce the findings that health adaptation costs will be relatively low compared to some other sectors, and that action is cost-effective. Nonetheless, there is still a need for further analysis to cover the full range of potential health outcomes from climate change, to develop the analysis of socio-economic baselines and development, and to further the development of effective practical adaptation policy and options for health in Africa, including cross sectoral links.

Ecosystem Based Adaptation

Biodiversity and ecosystems provide multiple benefits to society, which in turn have economic benefits, although these are rarely captured by markets. These benefits are known as 'ecosystem services' and include provision of food, supporting services such as nutrient recycling, regulatory services including flood protection and recreational and cultural services.

Ecosystem services are integral to the African economy and underpin large parts of the economy, foreign revenue and export earnings, as well as sustaining a very large proportion of the population. There are many stresses on these systems already and climate change will only add to these pressures. The existing studies show potentially large impacts to ecosystems in Africa, which are already beyond their natural coping capacity. Planned ecosystem service adaptation is therefore a priority for the continent.

It is also clear that tackling these impacts requires the management of ecosystems within interlinked social-ecological systems, to enhance ecological processes and services that are essential for resilience to multiple pressures, including climate change. This is termed Ecosystem based Adaptation (EbA) and combines the management of ecosystems and biodiversity into an overall strategy to help people and ecosystems adapt to the adverse impacts of global climate change.

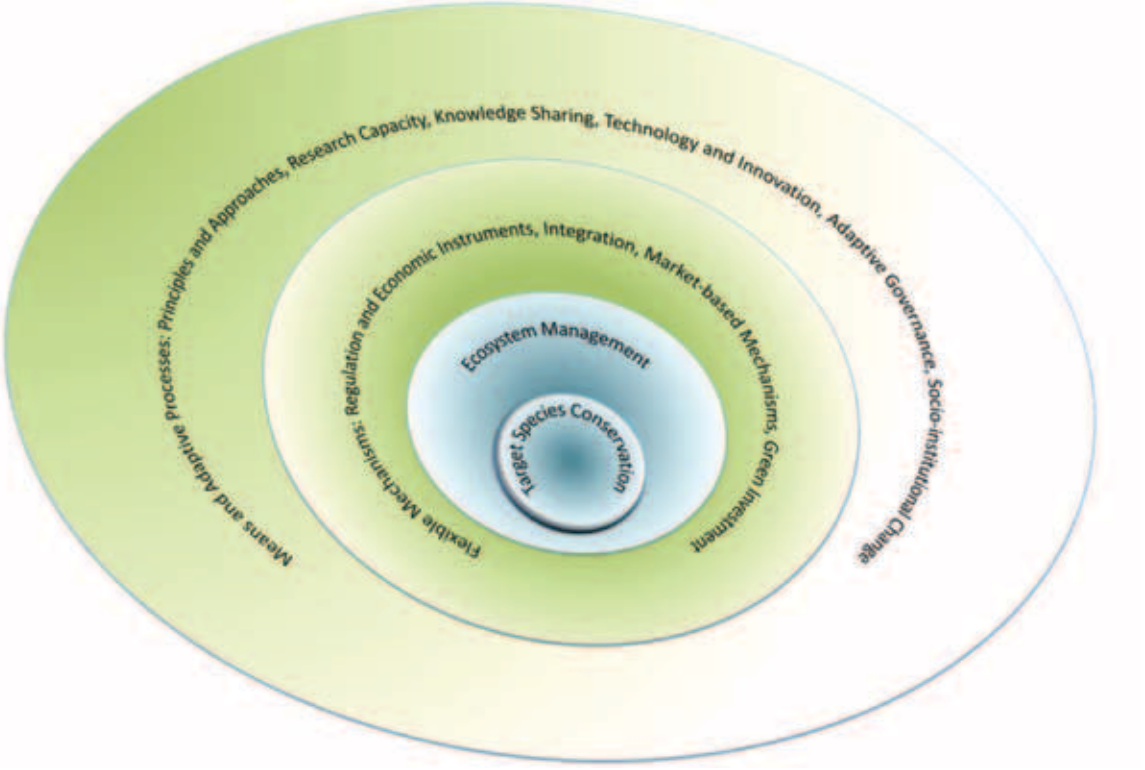
At the aggregated level, a number of studies have estimated the short-term adaptation costs, using estimates based on extending protected areas, wider conservation and off reserve measures, although these responses are primarily targeted at addressing current vulnerability and could be more accurately described as good practice and accelerated development, rather than specific options targeted towards tackling climate change (although of course these measures would enhance future resilience).

The additional cost of enhancing the network of terrestrial protected areas in Africa has been estimated at $4-5.5 billion/year. This would improve the core reserve system in the continent but is effectively addressing current vulnerability. Some studies increase these costs

by a factor of 3 to reflect wider conservation measures, implying annual costs of $12-17 billion, although again, these are focused on current vulnerability rather than marginal increases for future climate change.

These numbers only include the terrestrial protected area network. There are additional costs of adaptation outside this. Biodiversity and ecosystem conservation in the wider matrix of landscapes has also been estimated (including new assessments in the study) and these imply costs of approximately $20 billion/year for Africa. These costs address forest, agriculture and freshwater ecosystems in the wider landscape matrix, but do not include urban ecosystems. These are primarily associated with current vulnerability and immediate concerns, but these wider actions are seen as essential for addressing future climate change.

There are also additional costs for marine ecosystems. The recent global World Bank study has estimated the costs of adaptation for marine fishery resources to Africa at $1-2 billion/year (in the period through to 2050), though the estimates are highly uncertain.



Ecosystem Based Adaptation

To facilitate the adjustment of human societies and ecological systems to changing conditions and multiple stresses, the dynamic landscape of EbA pathways combines EbA strategies (active core, in blue), with flexible enabling mechanisms and adaptive processes (supportive milieu, in green).

A range of bottom-up costs and country estimates have also been considered. The existing African National Adaptation Programs of Action (NAPAs) include around $100 million of funding for ecosystem type initiatives, implying immediate needs of over $250 million if replicated across the continent on a per capita basis. There have also been recent studies on matrix management in South Africa, and agro-forestry in Kenya, which provide national values and have the potential for replication.

However, this remains a fairly limited area of study, and the economics of ecosystem based adaptation for Africa is seen as a key priority for future adaptation work following the AdaptCost project.

Agriculture Sector Adaptation

Agriculture underpins economic development in all of Africa. With more than 200 million chronically hungry people, and 60% of the labour force in agriculture, climate risks pose significant threats to development (FAO, 2002). Previous work has identified a potentially wide range of (positive and negative) impacts at regional and national levels (Boko et al., 2007). Studies highlight the high level of vulnerability of Africa's agriculture sector compared to other world regions, due to a large dependence on rainfed farming, low levels of development and limited adaptive capacity to existing climate variability.

Africa's expansive and agroclimatically diverse landscape and agricultural systems pose a challenge to aggregating losses and prescribing 'catch-all' adaptation to secure economic welfare. Uncertainty surrounding climate change impacts and social development over the next century compounds these challenges. A range of economic methods has been applied to assess the impacts of climate change on African agriculture, and costs and benefits of adaptation (see table).

Economic method	Scope		Adaptation focus	Scale	Model structure	Uncertainty and climate scenarios
	Impacts	Adaptation				
Ricardian	Net revenue changes per ha	Autonomous	NA	Farmer	Top-down	Selected uniform or GCM
Coupled crop-CGE modeling	Crop production and welfare changes	Planned	Hard	Sectoral	Top-down	Selected uniform or GCM
CGE	National welfare changes	Planned	Hard	Economy	Top-down	Selected uniform or GCM
IFF	Percentage markup, inventory, discounting	Planned	Hard	Sectoral	Top-down	Modeling with scenarios optional
CBA	Net present value changes	Planned	Hard and soft	Sectoral	Top-down or bottom up	Selected uniform or GCM

CGE = Computable General Equilibrium; IFF - Investment and Financial Flow; CBA = Cost Benefit Analysis

High potential risks of negative climate change impacts on agriculture justify adaptation investments.

Each approach involves advantages and tradeoffs that make different outputs appropriate for different users. Highly aggregated, top-down methods have been the focus of work to date for impacts and adaptation costing at regional and national levels.

These results are useful for illustrating the wide range of positive and negative impacts of climate change. For example, Ricardian economics studies estimate that net revenue per hectare impacts range from losses of $23.2 billion to gains of $90.5 billion for Africa by 2020, increasing to $48.4 billion and gains to $96.7 billion by 2100, respectively (Dinar et al., 2009). The wide range of economic impacts is attributed to different climate scenarios being used, and highlights the uncertainty behind study results.

National-level impact studies illustrating the already high costs of current climate variability and extreme events (floods, droughts) further highlight the need to adapt. For example, in the case of Zambia, climate change and variability compound each other, raising the number of poor people to 74,000 under the most negative scenarios by 2016 (Thurlow et al., 2009).

Most assessments of the economics of adaptation in Africa are highly aggregated with few regional studies, although there are an increasing number of national level studies. Primary methods consist of IFF and agronomic models linked with general equilibrium economic models.

Based on UNFCCC (2007) estimates, adaptation investments above baseline (BAU) total $781 million by 2030 for agricultural research, extension and capital formation. Work by the World Bank (2010) suggests that public investment needs in sub-Saharan Africa account for about a third of global needs, with $3.2-3.3 billion mostly going into rural infrastructure investments.

These investment estimates do not account for overlaps in spending with business as usual growth or with adaptation costs for other sectors. Grantham Institute (2009) results highlight that Official Development Assistance (ODA) commitments to meet the Millennium Development Goals (MDGs) (estimated at $72 billion/year for Africa, compared to the $29 billion delivered in 2004) should also be met because without them adaptation will be much more costly.

Emphasis on 'hard', capital-oriented, versus 'soft', socio-institutional investments, with particular focus on rural roads and irrigation infrastructure was echoed in both regional and national-level studies. The need for current agricultural development needs to be met as part of a robust adaptation strategy is highlighted by findings of national-level studies.

The project identified the need for future work (see figure below). Key recommendations include the need for more information on agriculture impacts and adaptation:

- More bottom-up national and sub-national impacts and adaptation economics
- Improved analysis of 'soft' costs of climate impacts and adaptation
- Emphasis on adaptation-development synergies as a primary adaptation strategy to increase resilience to uncertain future risks
- Use of analytical methods balancing economic and social investment prioritisation

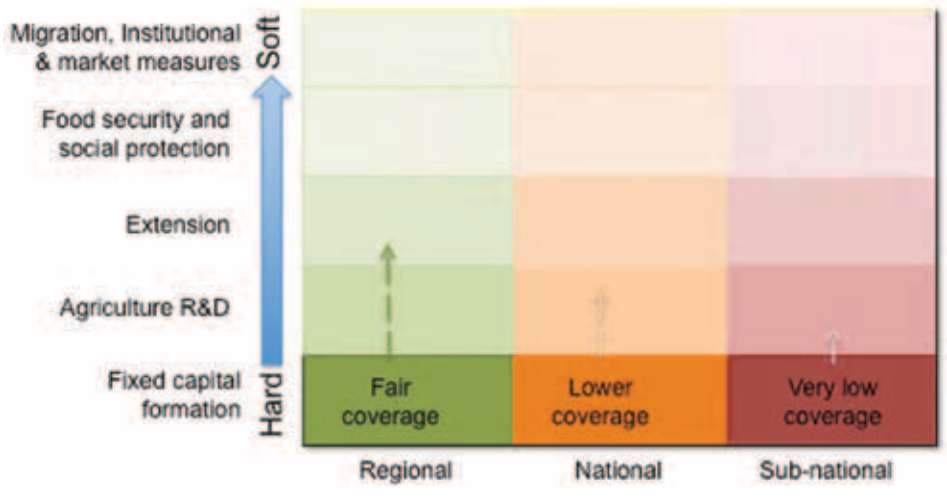
Water Sector Adaptation

Climate change impacts have far reaching implications for traditional water managers. Increased demand from municipal, agricultural and industrial consumers, and ecosystems, compounds these challenges. As a result, basing future water management on past hydrological trends does not protect against a range of uncertain future climates. Hydrological modelling suggests that both low and high ranges of inter-temporal stream flow will widen under climate change, increasing risks of more frequent droughts and floods in many African countries (Strzepek and McCluskey, 2006).

Studies investigating the costs of climate impacts and adaptation options on Africa's water sector are extremely limited. Initial global level studies employ top-down approaches and simplified economic methods using limited information for Africa (e.g. Kirschen/UNFCCC, 2007).

Identified adaptation investment needs are especially dependent on which cost categories are included in the analysis. For example, inclusion of infrastructure for flood protection increases adaptation costs significantly. The World Bank (2010) estimates that with flood protection and water supply considerations costs reach between $6.2-7.1 billion annually by 2050. In comparison Kirshen/UNFCCC, 2007 estimates costs between $4.5-4.7 billion annually, not including flood protection.

Case study work involving climate impacts and cost benefit analyses for adaptation options has helped inform top-down studies. Cost benefit analysis for South Africa's Berg River Basin indicates that increased reservoir storage capacity appears to meet future urban water demand more cost effectively than using water markets and marginal cost pricing to allocate water under climate change scenarios (Callaway et al., 2009).



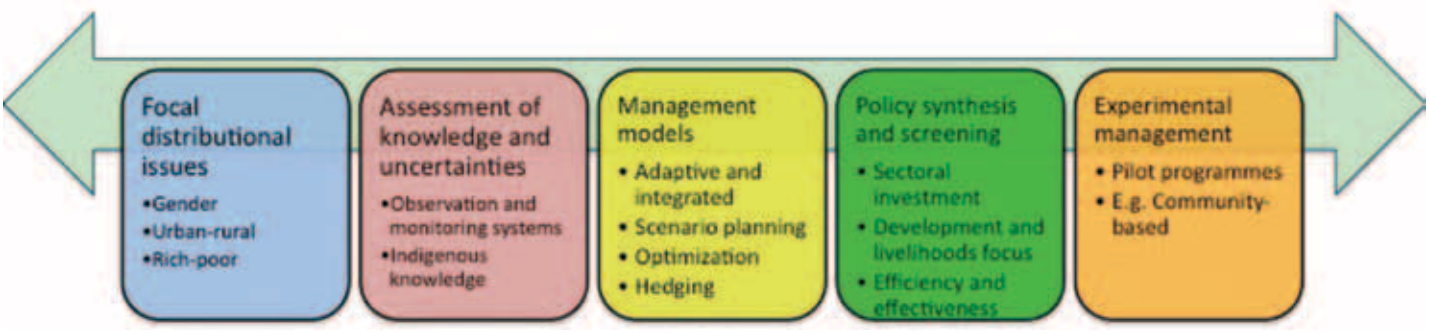
Key gaps in adaptation economics work

Economic adaptation assessments for Africa's water sector are especially important as they provide the first steps towards managing the effects of climate change on water supplies. However, there is a need for more economic analysis involving comprehensive methods capturing more holistic, adaptive management approaches. Particular attention should be given to both 'soft', management-related, and 'hard' investment options. For example, a range of options are needed to address basin and floodplain-level planning, ecosystem resilience, distributional and cross-sectoral (e.g. water-agriculture-energy linkages) issues affecting the sustainability of supply and demand.

Achievement of MDGs related to improving water supplies by 2015 aligns with adaptation options (Mahta et al., 2005, Banerjee et al., 2008). Differentiating between different socioeconomic groups, the structure of formal and informal water markets, and technological investments within urban and rural contexts is also necessary for mapping vulnerability and prioritising areas for public and private intervention (Kessides, 2006). Significant gaps in data, modelling and the overall understanding of potential climate impacts on Africa's hydrological systems and future water resource supply and demand dynamics, warrant more investment in monitoring and basic research.

Adaptive management techniques are illustrated by Tunisia's approach to water management, which has evolved beyond traditional systems to physical and institutional engineering in the face of highly variable and declining water supplies. Current management systems imbed flexibility based on a dynamic combination of data collection, scenario modelling and close stakeholder engagement to promote robust, process-based management (Jagannathan, Mohamed and Kremer, 2009).

A framework of adaptive management, supported by more local-scale economical analysis and stronger development orientations, is suggested as a way forward for adapting Africa's water sector to climate change.



Stylized framework for adaptive management framework for Africa's water sector
Source: Adapted from Molden, 2007, see water briefing note.

Synthesis of the Costs of Climate Adaptation in Africa

The analysis in the previous sections is brought together here in a number of key conclusions.

A sample of national and sectoral studies for Africa is shown in the diagram to the right; the AdaptCost project is developing a database of impacts and adaptation studies in Africa using weADAPT.org and Google Earth.

Key conclusions are:

- The economic impacts of climate change in Africa are likely to be significantly higher than in many other world regions and they could be significant in the short-term, with estimates that the costs could be equivalent to 1.5-3% of GDP/year by 2030. Impacts (and benefits) will be unevenly distributed across countries and between sectors.

- Adaptation can reduce these costs, but it cannot remove them completely, particularly under a business as usual scenario. Global mitigation is needed as well as African adaptation.

- A number of estimates of the costs of adaptation for Africa are available. These include estimates by the UNFCCC, World Bank and others. These estimates include different categories of adaptation, including capacity building and immediate priorities, enhancing climate resilience in new investment (anticipatory adaptation) and social adaptation to protect livelihoods. There are also major financing needs to enhance the capacity to cope with the current climate adequately (the adaptation deficit), which are essential in enhancing resilience for the future, although these needs are associated more closely with development than future climate change.

- The various studies provide a large range of estimates due to differences in approach but also due to what is included or excluded in the analysis.

- There is a large range ($5-30 billion a year) around these numbers. Estimates at the lower end of the range only include immediate needs. Estimates in the central and upper range include social adaptation and some accelerated development. A key conclusion is that the numbers are defined by the categories of adaptation and development included.

- The cost of adaptation is likely to increase in future years. Adding the adaptation components together leads to a range of estimates that vary from $10-60 billion a year. Again the variation depends on what is included, notably in relation to the categories of capacity building, enhancing climate resilience, social adaptation and accelerated development.

To illustrate, the estimates are brought together in the figure below. A number of categories of adaptation are presented.

The first of these – in pink at the top – is the specific actions to tackle future climate risks (the marginal action specific to future climate change), i.e. enhancing climate resilience, such as infrastructure design and flood protection measures.

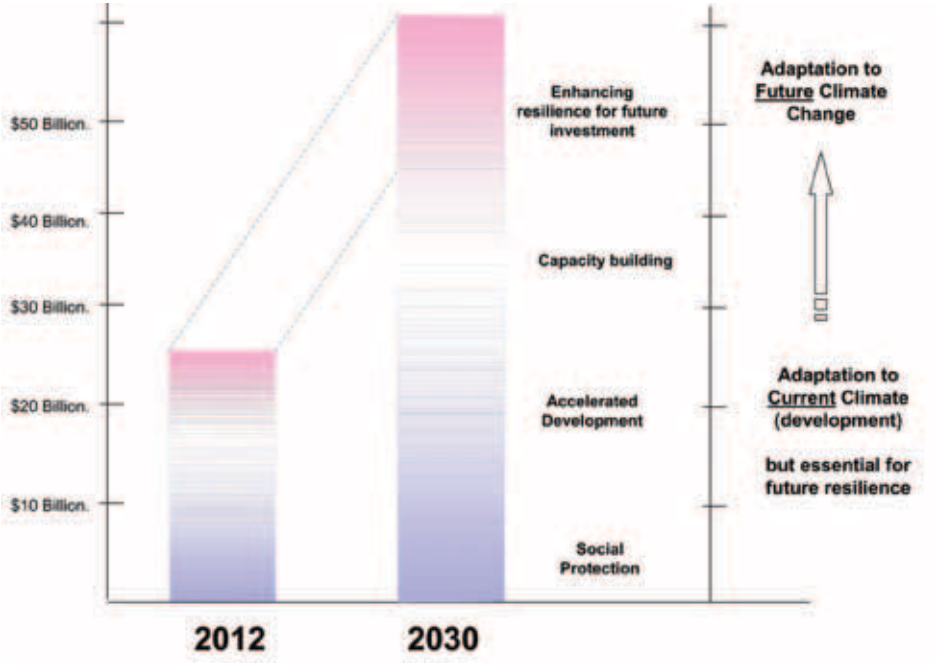
The second category comprises building adaptive capacity and institutional strengthening, for example developing meteorological forecasting capability, information provision and education. While this is primarily needed to provide the necessary information and data to allow adaptation to future climate change, it also has strong benefits in providing coping capacity against current climate variability.

The third category represents accelerating development to cope with existing impacts, for example integrated water management, electricity sector diversity, natural resources and environmental management, but these also provide the necessary investment to build future resilience, i.e. they are key to ensuring effective future adaptation, and without this, future investment may well be wasted.

Finally, there are other categories, primarily associated with existing climate variability, and categorised in terms of increasing social protection, for example cash transfers to the most vulnerable following disasters, safety nets for the most vulnerable.

The overall costs of adaptation vary according to which of these categories is included. Sources of finance and the balance of public and private costs of adaptation differ between these four categories, but the overall finance needs are dominated by which categories are included.

Most of the categories involve difficult attribution issues between future climate change and existing climate variability (some of which may be a result of observed climate change), and also difficult attribution issues between what is climate change adaptation and what is development. Understanding these issues and the linkages and conditionality is a priority for future work.

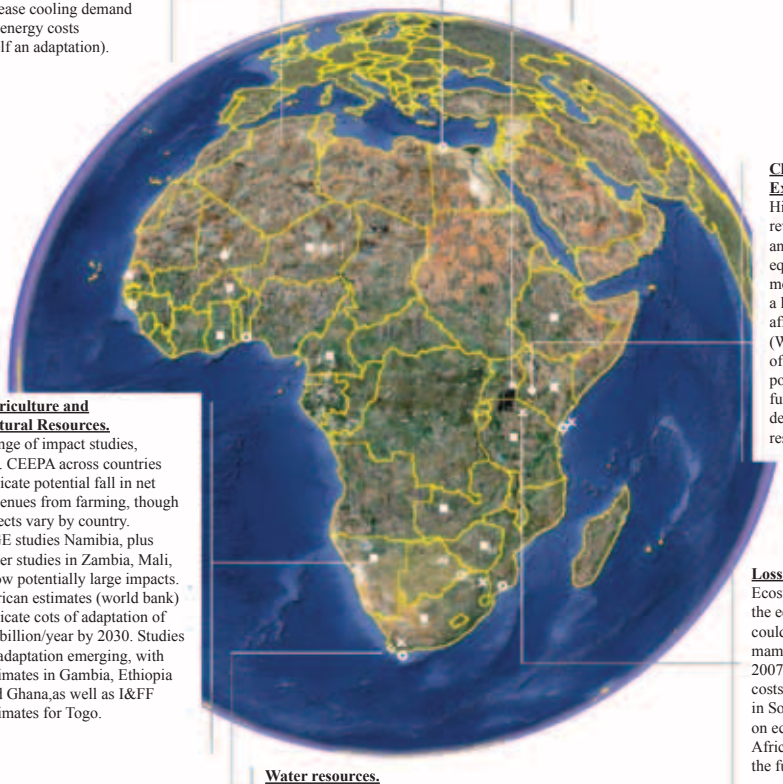


Potential Costs of Adaptation to Current and Future Climate in Africa $billion/year

Coastlines. Sea level rise.
Up to 5 million of people at risk of coastal flooding by 2050 (DIVA) with costs of $7.5 billion/year. Adaptation costs to reduce these estimated at $1 to 4 billion per year by 2050. National/local impact/ adaptation cost studies in Egypt , Kenya, Benin, Mozambique, Guinea Bissau and Western Cape.

Health. Burden of disease.
55000 deaths + 2 mill. DALY / year due to climate change with increases in vector and diarrhoeal disease by 2030 (WHO, 2004) with costs of adaptation of $1.9 to 9.2 billion (Markandya and Chiabai (2009). National/ local adaptation cost studies in Kenya/Ghana/S. Africa (malaria), Tanzania (water borne disease). Health adaptation appears highly cost-effective.

Cooling demand / Energy.
Rising temperatures will increase cooling demand and energy costs (itself an adaptation).



Climate variability/ Extremes.
Historic data in East Africa reveals costs of major flood and drought years are equivalent to 5 - 10% or more of GDP, and represent a long-term liability affecting economic growth (World Bank, 2006). Costs of extreme events could potentially intensify in future. Addressing current deficits is key for future resilience.

Agriculture and Natural Resources.
Range of impact studies, e.g. CEEPA across countries indicate potential fall in net revenues from farming, though effects vary by country. CGE studies Namibia, plus other studies in Zambia, Mali, show potentially large impacts. African estimates (world bank) indicate cots of adaptation of $3 billion/year by 2030. Studies of adaptation emerging, with estimates in Gambia, Ethiopia and Ghana,as well as I&FF estimates for Togo.

Loss of ecosystem services.
Ecosystem services underpin much of the economy of Africa. Climate change could potentially endanger 25 to 40% of mammal species in national parks (IPCC, 2007). National/local studies on economic costs in in Kenya (coral), wildlife, biomes in South Africa. Some emerging studies on ecosystem based adaptation (South Africa) and a key priority for research in the future .

Water resources.
25% of Africa's population (200 million people) currently experience high water stress, and could increase to 75-250 million by the 2020s and 350-600 million people by the 2050s (IPCC, 2007). Nationallocal adaptation cost studies in South Africa, Kenya.

Examples of Potential Economic Effects of Climate Change across Africa
Source: Watkiss et al. SEI, Oxford using weADAPT.org in Google Earth.
Individual symbols represent sector or national studies.

Moving the Adaptation Framework Forward

The methods for assessing the costs – and benefits – of adaptation are still evolving.

It is important to distinguish action over time. Current climate variability in the context of immediate vulnerability is a key concern for Africa. The near-term policy window is now, to prepare for adaptation in the years preceding 2030. Beyond 2030, impacts of climate change may be far more significant. The full spectrum of plausible climate change scenarios may affect investment decisions with long lifetimes (e.g. infrastructure). At the same time, short-term actions may increase or decrease future resilience or cut off future options.

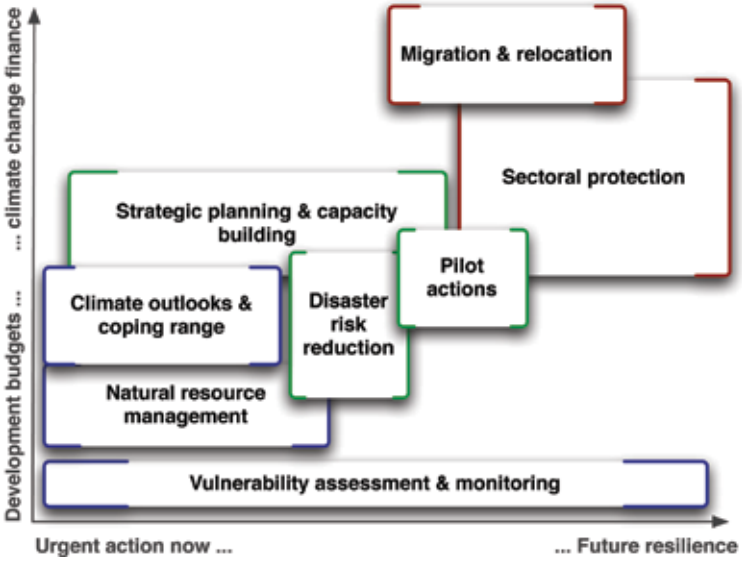
Action also needs its own timescale. Not all adaptation decisions need to be taken now. In many cases, it is difficult to plan effective and efficient responses over the long-term for infrastructure, due to the long lifetimes involved, the potentially high costs, and the high uncertainty in the climate projections, especially in relation to extremes. This makes the application of formal project appraisal techniques problematic.

The figure on this page portrays adaptation as a progression of urgent action in:

- Building adaptive capacity (e.g. season climate outlooks);
- Focusing on win-win, no regret or low cost measures which are justified in the short-term by current climate conditions (i.e. addressing current climate resilience and disaster risk reduction), or based on projected climate change, but involving minimal cost, or positive opportunities;
- Encouraging pilot actions to test promising responses; and
- Identifying long-term issues including areas where there are long lifetimes (infrastructure) or potentially high risks that require early pro-active investigation, even though there might be high uncertainty on specific options. It is important to consider programmes that investigate these and consider short-term options that allow flexibility for future information to be incorporated.

There are a number of areas of high vulnerability that are associated with non-market sectors, the informal economy or have strong distributional effects. There is a need to make sure these are not omitted, and they are a particular focus in Africa.

The AdaptCost study has considered these adaptation responses as a series of steps, together forming an 'adapta-



An Ensemble of Adaptation Strategies is Required

tion signature'. These identify actions in each of the strategies by sector. The broad outline of steps is the same in each case. However, the exact activities vary, hence the use of a 'signature' concept that considers options on a case by case basis. These signatures have been used to develop sector strategies, key actions and indicative adaptation costs. These have been complemented by case studies which include examples of adaptation projects and costs.

The early priorities are 'no regret' strategies that address trends, existing climate signals and disaster risk reduction; all support forms of natural resource management and require additional institutional capacity. Beyond 'no regrets' strategies, pilot actions are required, testing adaptation strategies and measures before full sectoral implementation. More extreme responses to the limits of adaptation are required in some cases, for example migration to abandon settlements in hazardous zones.

Developing a conceptual and analytical underpinning to adapation planning has some way to go. Our enduring conclusion remains: uncertainty is the reason for action. Action in the sense of no regrets, sustainable development. But also in building information systems (the foundations of vulnerability assessment) and pilot actions structured to build capacity to act effectively beyond 2030.

AdaptCost Project Activities

Workshops and Capacity Building

One of the key aims of the project has been to work with researchers in Africa, and to build capacity, partnerships and consensus.

A pre-project workshop was held in Nairobi in February 2009. The workshop assembled a core group of economists and climate impacts-vulnerability-adaptation experts in Africa who will be essential for the completion of this project, and as an enduring expertise to continue work on climate adaptation. The workshop reviewed the range of methods available, linking them to the types of adaptation (an approach we are developing around the concept of adaptation signatures).

The project held an expert workshop based on the AdaptCost study on the economics of climate adaptation in Africa. The meeting was held from 21 to 25 September 2009, in Nairobi, at UNEP, Gigiri in Nairobi. This second expert workshop had the primary objective of reviewing work conducted in the past year and preparing an initial synthesis for the study. It also had the aim of developing methodological issues in relation to the economics of adaptation. Full meeting notes are available for the meeting.

The project held a roundtable in Tunis on the economics of adaptation in Africa (see the opening section for the resulting statement).

Material from the AdaptCost project has been incorporated into the curriculum of the Adaptation Academy and presented in the first Foundation Course in Cape Town, July-August 2010. The course was coordinated by the Climate Systems Analysis Group (University of Cape Town), Stockholm Environment Institute Oxford Office and Global Climate Adaptation Partnership.

Dissemination Activities

One of the key aims of the AdaptCost study was to provide policy relevant material. To this end a very large number of dissemination and policy inputs were made during the course of the project. These are summarised below.

Kigali Finance for Development (May 2009)
The AdaptCost study produced a policy brief (summarising early findings), concept note, and made a presentation at the 3rd African Ministerial Conference on Financing for Development: Climate Change, Kigali (Rwanda) 21-22 May, 2009. The policy brief was used as a key document from the event, and distributed to all high level attendees. It is available on the F4D website at <www.uneca.org/f4d/home1.htm>, and is downloadable at <http://www.uneca.org/f4d/docs/Kigali-PolicyBrief%202.pdf>.

A concept note on adaptation financing needs was also produced for the workshop, and distributed, outlining Africa-level messages. A presentation (ministerial briefing) was made at the conference, summarising the results of the policy brief and concept note.

AMCEN (May 2009)
The AdaptCost study produced a paper and gave a presentation at the 3rd Special Session of the African Ministerial Conference on Environment (AMCEN) in Nairobi, May 2009. The study also revised the AMCEN paper on Climate Change Adaptation in Africa, including adaptation financing estimates, for the conference. This was circulated as a reference document for the conference, available at <http://www.unep.org/roa/amcen/Amcen_Events/3rd_ss/Docs/Ref-4-ClimateChangeAdaptation.pdf>. A presentation (ministerial briefing) was made at the conference, available at <http://www.unep.org/roa/Amcen/Amcen_Events/3rd_ss/Docs/Presentations/Ministerial-technical/Economics-CC.ppt>.

East Africa Community (June 2009)
The study produced and circulated briefing material for an East Africa Community (EAC) meeting held in Kigali in June 2009.

African Parliamentarian Meeting on Climate Change, 12-15 October, Nairobi
A presentation summarising the study results was given at the African Parliamentarian meeting.

AMCEN (October 2009)
Briefing material and a policy synthesis was circulated for this meeting and a presentation summarising the study was given.

UNFCCC Bangkok (2010)
A presentation summarising the study was given at the UNFCCC meeting in Bangkok in 2010.

Poverty Environment Partnership (PEP), Malawi (2010)
A presentation summarising the study was given at the Poverty Environment Partnership (PEP) meeting at Lilongwe, Malawi, 1-5 March 2009, on Session 1.2: Climate Change Challenges and the African Response.

AMCEN (June 2010)
The final briefing notes and Tunis statement were prepared for this meeting. A presentation on ecosystem based adaptation was prepared and given at the meeting.

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Websites and Further Information

The briefing notes are available on the UNEP website at <http://www.unep.org/climatechange/UNEPsWork/Adaptation/tabid/241/language/en-US/Default.aspx>.

The study has set up an economics web-page on the weAdapt platform at <http://www.weadapt.org/wiki/Economics_of_adaptation>

These contain more detailed briefing notes, which provide the material summarised in this report. The briefing notes are outlined below:

- Outline of methodological issues
- Integrated Assessment Model Results on the Economics of Climate Change in Africa
- Estimates of Adaptation from Investment and Financial Flow Analysis and Other Aggregated Approaches for Adaptation Needs for Africa
- Coastal Adaptation – Africa Review and New Estimates
- Health Adaptation Costs – Africa Review
- Ecosystem Based Adaptation Costs – Africa Review
- Adaptation Costs for Agriculture
- Adaptation Costs for Water

A number of more detailed sectoral reports were also produced, which are available. These are:

- Sea Level Rise and Impacts in Africa, 2000 to 2100. Sally Brown, Abiy S. Kebede and Robert J. Nicholls, School of Civil Engineering and the Environment, University of Southampton, Southampton, October 2009. This includes the results of new DIVA model results for Africa on the costs of sea level rise and the costs and benefits of adaptation for Africa.
- Ecosystem-based Adaptation in Africa: Rationale, Pathways, and Cost Estimates. Tahia Devisscher, Stockholm Environment Institute. April, 2010. This study reviewed the concepts of EBA and assessed existing estimates.
- Economics of Climate Change Impacts and Adaptation in Africa's Agricultural Sector. Jillian Dyszynski, Stockholm Environment Institute. May, 2010. This study reviewed the evidence of impacts on agriculture and adaptation in Africa.

Jian Liu led the study for UNEP. For further information, contact Emily Massawa, UNEP, P.O. Box 3000, Nairobi, Kenya, Emily.Massawa@unep.org.

The study was conducted as part of the Collaborating Programme on Climate Change Adaptation between SEI and UNEP. For further information, contact the Project Manager, Paul Watkiss, SEI Oxford, 29 Grove Street, Oxford OX2 7TJ, paul_watkiss@btinternet.com.

The project overlapped with the establishment of the Global Climate Adaptation Partnership, which oversaw production of this final monograph. For further information, contact Thomas E. Downing, GCAP, Box 121, 266 Banbury Road, Oxford OX2 8DL, TDowning@ClimateAdaptation.cc.

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Emily Ojoo Massawa was Chair of the African Group of negotiators under the UNFCCC from 2004 to 2005. She led climate negotiations on behalf of the Government of Kenya for a decade as a senior officer in the Ministry of Environment and Natural Resources. She was elected to the first Adaptation Fund Board and helped shape its constitution and operating procedures and is currently a Programme Officer of the Division of Environment Policy and Implementation at UNEP working on UNEP support to the Adaptation Fund Board, global and African adaptation networks, policy communications, and national strategies.

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