The Cost of Adaptation to Climate Change in Africa

October, 2011

Key Conclusions

Africa is arguably the most vulnerable region in the world to the impacts of climate change. The majority of both bottom up and top down ('integrated assessment') studies suggest that damages from climate change, relative to population and GDP, will be higher in Africa than in any other region in the world. This is corroborated by the analysis using the Regional Integrated model of Climate and the Economy (RICE) model in this review: this suggests that climate damages in Africa, as a percentage of GDP, may be 10% higher than the next most exposed region (India) and more than twice as high as in the US, Russia, Eurasia and Latin America. Breaking these impacts into specific sectors or components further illustrates these vulnerabilities, with recent studies into health, agriculture and water all demonstrating that Africa is often more vulnerable to climate change along these dimensions than any other region.

This vulnerability, coupled with the continent's negligible contribution to current and/or historic emissions, means that adaptation spending is the continent's climate investment priority. Africa accounts for less than 7% of total emissions and its emissions per capita are less than half the global average. Given this, it is not surprising that last year's report by UN Secretary General's High Level Advisory Group on Climate Change Finance concluded that adaptation spending was a priority in Africa.

We conclude that the most relevant studies suggest adaptation costs in Africa in the region of US$ 20-30 billion per annum over the next 10 to 20 years. A wide number of estimates of the costs of adaptation in Africa have been made, using a variety of approaches. This generates considerable uncertainty with the full range of estimates spanning US$ 2 billion to US$ 60 billion per annum. However, most recent studies, especially those that factor in and attempt to address Africa's existing adaptation deficit (see below) converge on a range between US$20- 30 billion over the next 10-20 years. This represents a reasonable 'approximate' estimate that can be used in the purposes of discussions on raising and allocation of international climate finance. This amount is on top of existing development and poverty alleviation needs, which could be in the order of US$ 70 billion to meet the Millennium Development Goals. To place this in context, to date, there has been approximately $350m of adaptation funding approved for spending in Africa, of which just $130m has been disbursed.

In Africa, there is a pressing need to mobilise resources to address the continent's *current* limitations to deal with climate events, as well as resources to deal with *future* climate change. Most studies implicitly assume that the current ability of Africa to respond to climate extremes and variability are sufficient and resources only need to be mobilised to provide additional adaptive capacity for future changes in climate. This approach is understandable, since the objective of studies like the World Bank's 'Economics of Adaptation to Climate Change' was to estimate the financing needed for the incremental adaptation to deal with *future* climate change. However, for a continent like Africa, it provides an underestimate of the costs that Africa needs to incur to reduce its overall climate vulnerability to an acceptable level.

Adaptation investments have the potential to substantially reduce the hardship from climate change in Africa. A series of global modelling analyses show that the benefits from undertaking adaptation may outweigh the costs by a factor of about two and that this ratio may be higher in non-OECD countries than OECD countries. Sectoral specific studies in agriculture and health, two crucial sectors for Africa's adaptation efforts, provide further evidence on the cost effectiveness of adaptation spending. However, it should be stressed that cost-effectiveness is not the only criterion for determining allocation spending – developed countries have an obligation, acknowledged in the UN Framework Convention on Climate Change, to support adaptation in developing countries that are particularly vulnerable to climate change – nor should this cost-effectiveness be taken to mean that efforts to cut emissions can be reduced.

The potential benefits of adaptation spending need not be undermined by concerns about absorptive capacity. The analysis presented in this paper suggests that, on average, the absorptive capacity of African countries i.e. their potential for countries to effectively use money allocated to adaptation in an effective way is broadly similar to that of other countries at a similar level of development. In cases where absorptive capacity is lower, partnerships with development institutions can provide assurance that money is spent in a way that delivers the benefits expected.

Africa's immediate adaptation priority is to improve its current adaptive capacity, much of which will be operationally indistinguishable from – and needs to be fully integrated with – traditional development activities. A growing evidence base supports the idea that general development is a crucial pre-requisite for strengthening a country or region's ability to deal with climate change and that more obviously explicit 'adaptation investments' are best implemented when a base level of development (or adaptive capacity) has been achieved. With more than 45% of Africa's population living in countries with the lowest adaptive capacity in the world, investments here are crucial. These will include investments in the health and education systems in African countries, as well as building institutional capacity. There is likely to be a strong comparative advantage for existing development institutions in helping to deliver these investments.

Beyond this a series of more targeted adaptation investments are required and it is crucial that African decision-makers factor climate change into all long term strategic decisions starting immediately. In particular, Africa has a large infrastructure deficit and will want to catch up over the coming decades. The design and location of this infrastructure, which will have a lifetime of decades, needs to accommodate changes in the climate. Studies like the World Bank EACC suggest that achieving this will be particularly costly in relation to water and sanitation measures. Softer adaptation measures i.e. zone planning and building codes will also need to complement these structural adaptation measures.

Adaptation needs to be complemented with global emission reductions. Although the policy focus in Africa is rightly on adaptation, the global need to reduce greenhouse gas emissions remains unchanged. Practically all adaptation studies analyse the cost of dealing with "moderate climate change" of maybe 2 – 3°C, associated with substantial emissions cuts by 2050. The costs of dealing with more aggressive climate change are less well understood but likely to be substantially higher.

Contents

List of Tables

List of figures

1 Introduction

This paper provides a synopsis of the potential impacts of climate change on Africa and draws out implications for the resources the Continent may require to enable it to adapt to climate change. Its intention is to assist African negotiators and policy-makers in understanding the latest research on these topics to inform their discussions and negotiations at national, regional and international fora. In particular, questions about how much money needs to be raised for international climate finance and how any such money should be allocated between competing demands continue to be a crucial aspect of the international negotiations. This paper is particularly intended to ensure that Africa's needs for adaptation spending – given its vulnerability to climate impacts - are fully accounted for in these discussions.

The paper summarises the recent literature on climate impacts and adaptation - although some new modelling results are also provided. Researchers have undertaken a lot of useful and robust research on these topics in recent years – although important research gaps still remain – but this research uses a number of different methodologies, provides a large range of estimates and is collected in a variety of disparate sources. The aim is to synthesise some of this thinking in an easily accessible document and, specifically in relation to the costs of adaptation in Africa, to identify the reasons for the wide range of estimates and narrow the range according to an assessment of which methodologies are stronger and weaker. The review is not intended to be exhaustive but rather to illustrate some of the most recent evidence from both a 'top-down' and 'bottom-up' perspective. To complement this review of existing evidence, the paper also presents new modelling analysis on some of the potential impacts of climate change in Africa, relative to other regions, using the Regional Integrated model of Climate and the Economy (RICE) and the Climate Framework for Uncertainty, Negotiation and Distribution (FUND) Integrated Assessment Models.

Following this introduction, the paper is divided into three further sections:

- Section 2 presents evidence on the impacts of climate change in Africa, using both top-down Integrated Assessment Models (IAMs) and bottom-up sectoral studies to capture aspects of climate change impacts that are particularly relevant to Africa.

- Section 3 presents evidence on the costs of adaptation in Africa again drawing on both top-down and bottom-up assessments.

- Section 4 looks at the investment case for adaptation spending in Africa and identifies some of the likely priority investments.

- Section 5 concludes.

2 Climate change impacts

Africa is one of the most heavily exposed regions in the world to climate change

It is generally recognised that Africa is among the most vulnerable regions in the world to climate change. This section explores the most recent evidence relating to climate change damages in Africa. It is split into two sections:

- Section 2.1 looks at **aggregate** (or ‘top-down’) assessments of the economic damages that climate change might cause in Africa, including new analysis making use of the so-called ‘Integrated Assessment Models’ (IAMs)
- Section 2.2 analyses some of the most recent case study (or ‘bottom up’) evidence on the damage that climate change might cause in Africa in **specific sectors and/or dimensions**. It looks in particular at the possible impacts on agriculture, health and water availability.

2.1 Top-down modelling results

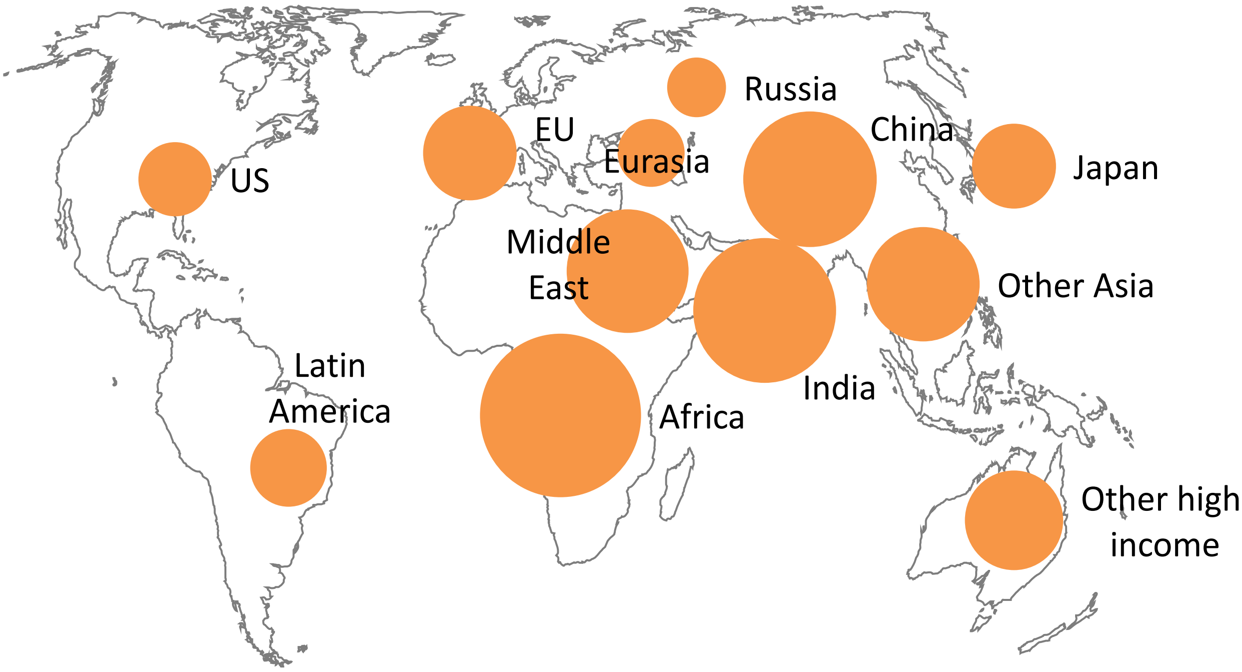
Our top-down modelling analysis is based on new model runs from two of the most influential IAMs. We have undertaken new analysis to look at the aggregate damages that climate change might cause in Africa, compared to other regions, using two IAMs: the Regional Integrated model of Climate and the Economy (RICE) developed by Professor William Nordhaus of Yale University and the Climate Framework for Uncertainty, Negotiation and Distribution (FUND) developed by Professor Richard Tol and Dr. David Anthoff.

Despite their utility, results from such models need to be treated carefully. IAMs can give a flavour of the relative exposure and vulnerability of African countries, compared to other world regions, which can be very helpful in making comparative assessments and understanding, at a high level, where policies should be prioritised. However, due to their aggregate nature, these models are fairly simplistic in the way they portray and measure climate change impacts. They are incomplete and sensitive to assumptions. There are also conceptual (and ethical) challenges associated with trying to place a monetary value on all climate impacts (Vivid Economics, 2011).

Other top down models tend to show that Africa is more exposed to climate change damages than any other region in the world. A cross-model comparison undertaken by Bosello et al. (2010) uses five different models that provide a regional break-down of overall climate change impacts as a percentage of GDP, at a temperature increase of 2.5°C. In two models Sub-Saharan Africa is the region which suffers the highest climate damages, in a further two models it is the second most detrimentally affected region and is the third most detrimentally affected region in the fifth model. Similarly, a study by Barr et al. (2010) also showed African countries to be the most vulnerable in the world – with the highest expected impacts of climate change and the lowest capacity to adapt.

These results are substantiated by the RICE model. The figure below plots the damages caused by climate change (before adaptation) across all of the regions in the world in 2100 assuming a 4°C increase in temperatures from pre-industrial times which may be consistent with sea level rises of just over 35cm. As a percentage of GDP, climate damages in Africa are expected to be higher than in any other region in the world, more than 10% higher than the next most exposed region (India) and more than twice as high as in the US, Russia, Eurasia and Latin America.

Figure 1. **Climate damages (as a percentage of GDP) are higher in Africa than any other region in the world**

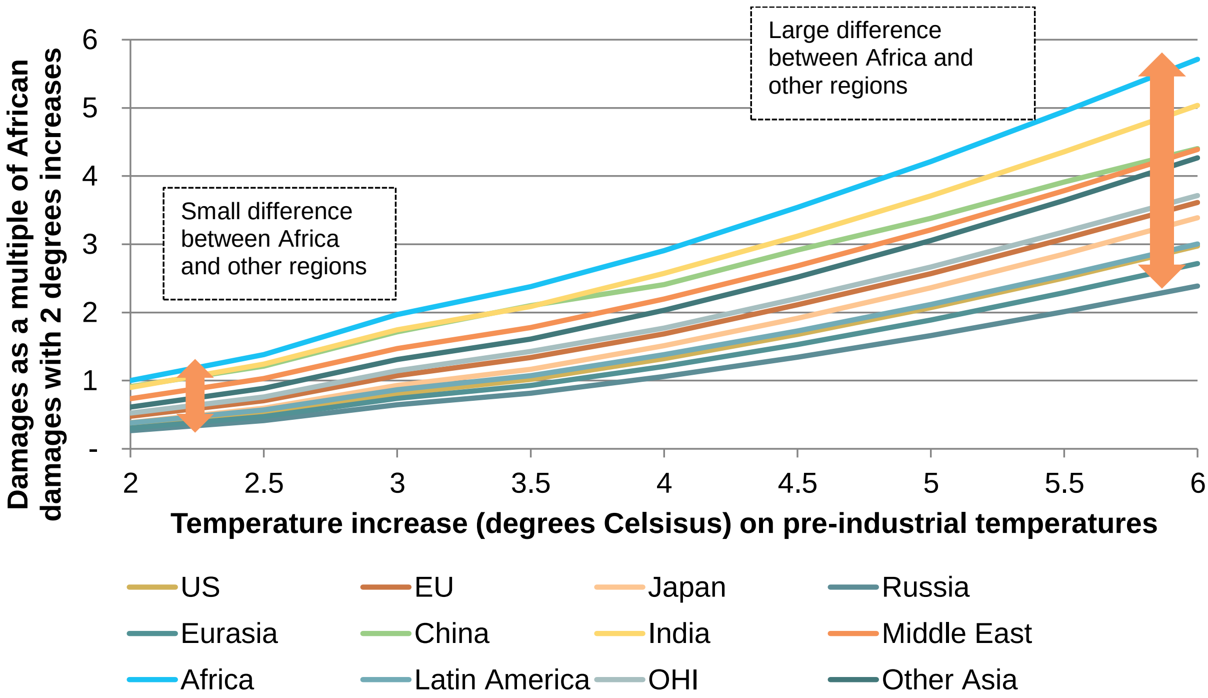


Note: *Damages assessed at temperature increase of 4°C and consistent SLR in 2100. Circle width proportional to climate damages. Damages assessed before adaptation*

Source: *Vivid Economics using RICE and MAGICC*

Africa's relative vulnerability increases for higher temperature increases. Not only is Africa expected to be more vulnerable to climate change than any other region in the world (according to RICE), this vulnerability increases with higher temperature increases. This is shown in Figure 2 below, where climate damages at different temperature increases are plotted, relative to the climate damages that Africa is projected to experience if temperatures increase by 2°C. Africa is the most exposed region at all temperature increases but the absolute gap between Africa and other regions increases for more extreme temperature increases.

Figure 2. **Africa is particularly exposed to the most dangerous climate change**



Note: MAGICC used to identify sea level rises consistent with different temperature increases

Source: Vivid Economics using RICE and MAGICC

This analysis is broadly corroborated by a second IAM, FUND. This suggests that in the event that temperatures increase by four degrees, North Africa and Sub-Saharan Africa will be two of the three most detrimentally affected regions[1]. This model also provides for greater decomposition of causes of economic damage from climate change than most other models, allowing further insights. It suggests for instance, that by 2100:

- human mortality costs will be higher in Sub-Saharan Africa than in any other region of the world (inflicting damage almost twice as great, as a percentage of GDP, than in any other region of the world);

- damages from water resource losses will be greater in North Africa than in any other region of the world except the Former Soviet Union

2.2 Bottom-up analyses

[1] Impacts of climate change in the FUND model take into account the impact of adaptation and its costs. As with RICE, the damage estimates are just those that can be attributed to climate change

To complement the aggregate top-down assessments, the sections below look at more detailed case-study evidence on the impacts of climate change across three dimensions of crucial importance to Africa: health, agriculture and water availability. This is not intended to be a comprehensive assessment of climate impacts in Africa but rather to highlight some of the region's vulnerabilities along key dimensions. Other implications of climate change that will be important for Africa include coastal zones, infrastructure and biodiversity. The advantage of assessments of this sort is that they can provide more specific analysis on particular issues of concern. The disadvantage, from the perspective of a brief synthesis paper such as this one, is that the studies are difficult to compare. They tend to use different input assumptions on, for instance, temperature increases, year of assessments, making comparable assessments across different dimensions difficult. Nonetheless the sub-sections below confirm the acute vulnerability of Africa to climate change.

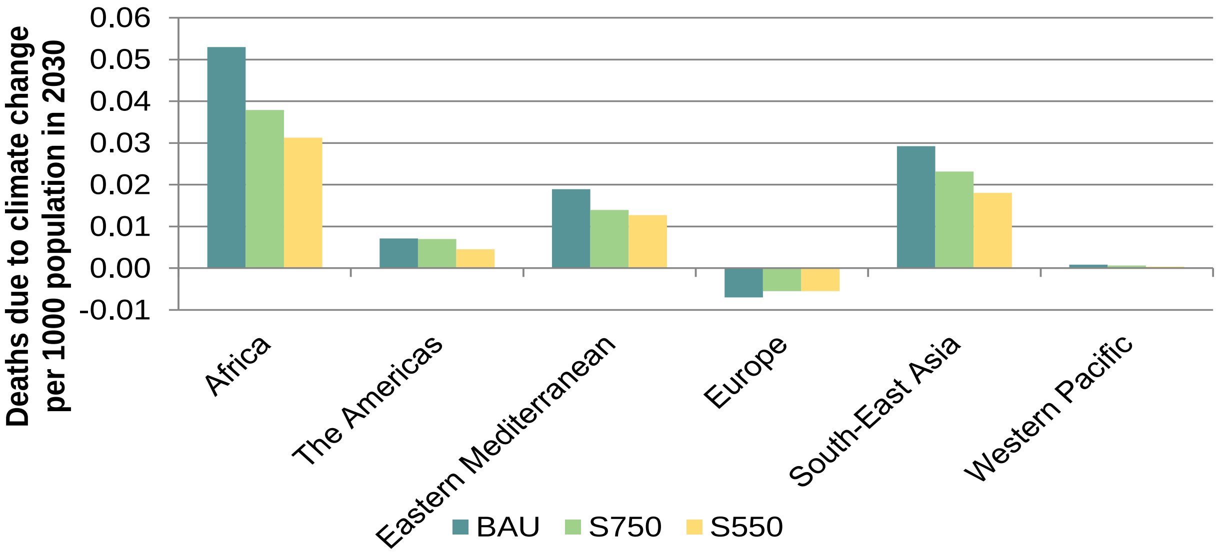
2.2.1 Health impacts

Our analysis makes use of the most recent work by the World Health Organisation (WHO, 2009; McMichael at al., 2004) to assess the likely impacts of climate change on health outcomes across the world. The study looks at the impacts of climate change on both deaths and disability adjusted life years (DALYs) from the increased prevalence of cardio-vascular disease, malnutrition, malaria and diarrhoea across three scenarios[2].

The results show that climate change is likely to have much more damaging impacts on health outcomes in Africa than in any other region of the world. Figure 3 shows that the death rate from climate change is between 60% and 80% higher in Africa than it is in the next most vulnerable region (South East Asia). The result is driven by a pre-existing exposure to these diseases coupled with an expectation that the Continent will be less able to adapt to the impacts of climate change. These results imply that there will be between 40,000 and 70,000 additional deaths in Africa in 2030 as a result of climate change with malaria and diarrhoea responsible for the largest proportions of these deaths.

[2] The BAU scenario implies temperature increases of 1.2°C by the 2020s; the S750 scenario implies increases of 0.9°C; and the S550 scenario implies increases of 0.8°C.

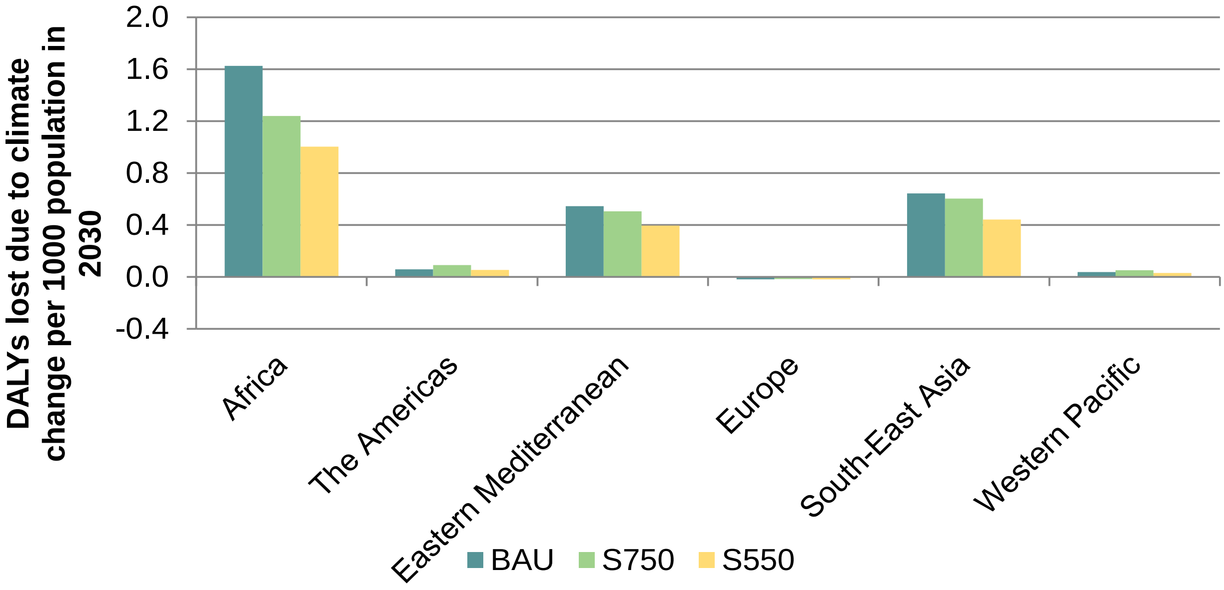
Figure 3. **Climate change is expected to increase the death rate by between 60% and 80%, more than in any other region**



Source: WHO (2008) and Vivid Economics

Figure 4 shows a similar picture in terms of the impact of climate change in terms of disability adjusted life years (DALYs) i.e. the number of years lost to ill-health, disability or death as a result of climate change. Indeed, on this metric, the relative exposure of Africa is even greater: the number of DALYs lost per 1000 of population is expected to be at least twice as great in Africa as in any other region.

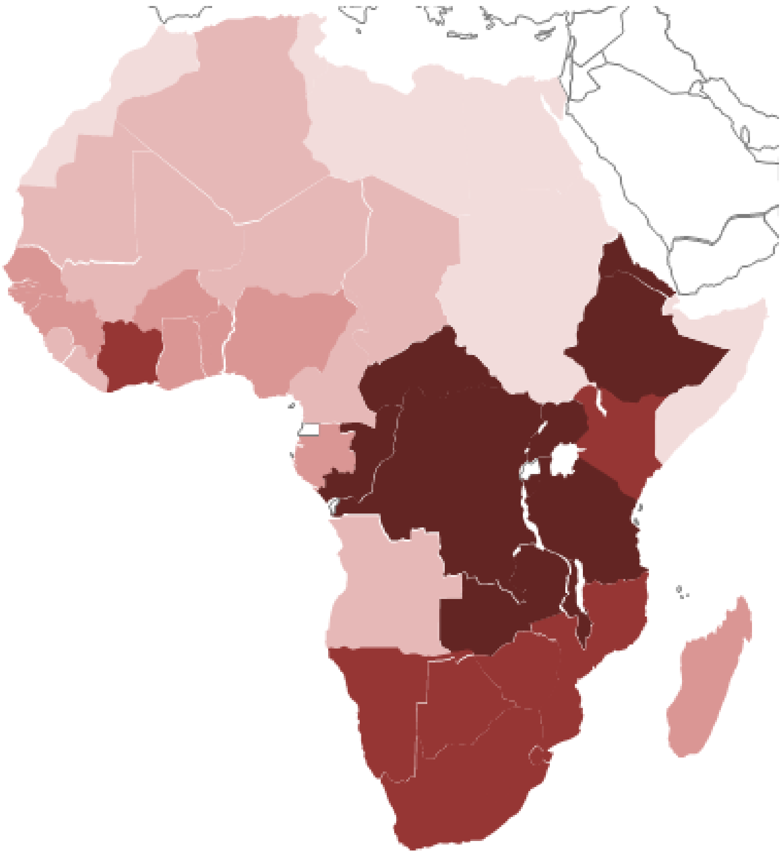
Figure 4. **The impact of climate on disability adjusted life years is expected to be higher in Africa than in any other region**



Source: WHO (2008) and Vivid Economics

Other studies have attempted to provide an indication of how these health impacts may be distributed across Africa. Unfortunately, the WHO data does not provide a country-by-country break down of potential health impacts from climate change. Other studies have attempted this analysis, although the challenges associated with undertaking this assessment given the current state of knowledge on the links between climate change and health impacts mean that these results must be used cautiously. Nonetheless, as Figure 5 below shows, the greatest health impacts may be expected in Central and Southern Africa, reflecting, to a large extent, where the current burden of disease is greatest.

Figure 5. **The health impacts from climate change are expected to be particularly serious in Central and Southern Africa**



Note: Darker shading represents countries where deaths resulting from climate change are highest, lighter shading where they are lowest. In order to illustrate the range of impacts within Africa, we use a relative measure which splits countries within Africa into one of five categories depending on their exposure relative to other African countries. Even in the case of the African country with the smallest expected health impact, Tunisia, there are a further 20% of developing countries outside of Africa who are expected to experience a smaller increase in burden of disease from climate change.

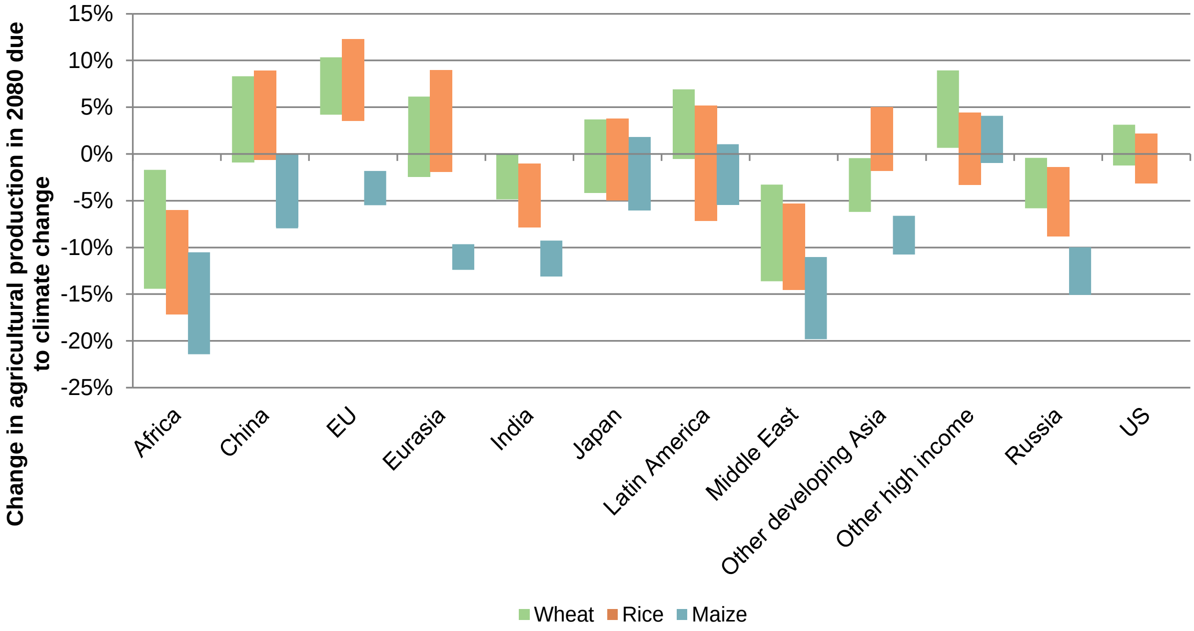
Source: Barr, Fankhauser and Hamilton (2011) and Vivid Economics

2.2.2 Agriculture impacts

We use a recent, comprehensive study to look at potential climate impacts on agriculture. Iglesias and Rosenszweig (2010) provide estimates of the potential impacts of climate change (temperature changes, precipitation changes and carbon fertilisation impacts) on yields for wheat, rice and maize in the period 1990-2080. It contains one of the most detailed and up-to date data sets for assessing agricultural impacts and by considering impacts across the full range of IPCC emissions scenarios (SRES scenarios) it takes account of some of the major uncertainties in future climate outcomes. The study also factors in the expected impacts of farm-level adaptation. As such, it provides an update to the work reported in the IPCC Fourth Assessment Report on the impact of climate change on agricultural production in Africa (Boko et al., 2007).

Figure 6 shows that this study anticipates that agricultural yields (and hence production) in Africa are expected to be far more threatened by climate change than any other region, with the possible exception of the Middle East. The worst case scenario for production declines is worse in Africa than in all other regions across all three staples. Africa, the Middle East and India are the only three regions where there appears to be no likelihood that future changes in the climate could stimulate an improvement in yields.

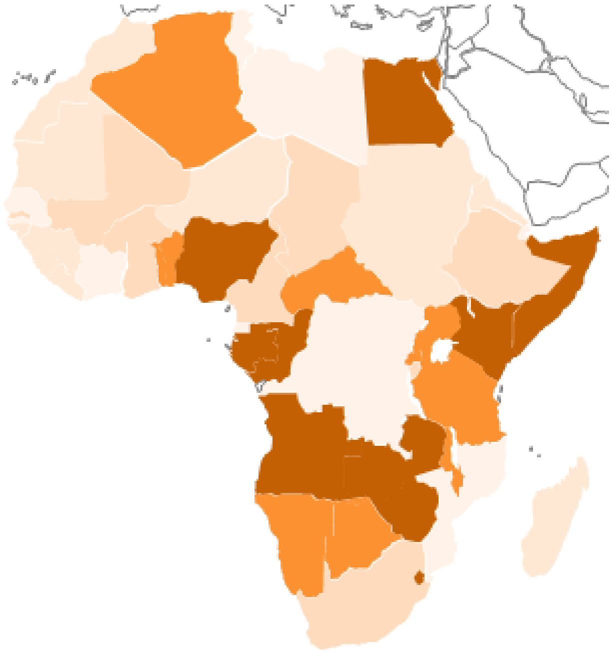
Figure 6. **Climate change is expected to have a worse impact on agricultural yields in Africa than in any other region of the world**



Source: Iglesias and Rosenszweig (2010) and Vivid Economics

Notes: Following authors, production changes calculated as yield changes applied to average 2000-2006 production levels

Figure 7. **The largest declines in agricultural yields within Africa are anticipated in central Southern Africa (Zambia, Zimbabwe, Angola)**



Note: A1F1 SRES scenario and the overall yield change is the weighted average yield change across the three crops with the weights determined by current production levels. Darker shading represents countries where productivity reductions resulting from climate change are highest, lighter shading where they are lowest. In order to illustrate the range of impacts within Africa, we use a relative measure which splits countries within Africa into one of five categories depending on their exposure relative to other African countries. The country with the smallest decline in yields, Côte D'Ivoire, is still expected to see a -0.1% decline in yields in the scenario.

Source: Iglesias and Rosenszweig (2010) and Vivid Economics

The impacts of climate change on agricultural productivity will vary significantly across the continent. Figure 7 shows the relative changes in agricultural yields in 2080 across Africa, with countries grouped into one of five categories depending on the percentage change in yield anticipated relative to other countries in Africa[3]. It suggests that coastal countries may be particularly badly affected regions i.e. Gabon, Nigeria, Egypt, Somalia and that, generally speaking, Southern and Central Africa may experience a more deleterious impact than Northern Africa.

The likely negative impact from climate change on agricultural productivity in Africa is confirmed by other studies. For instance, Dinar et al. (2008) suggest that in Burkina Faso temperature increases of 2.5°C could lead to a 46% fall in net agricultural revenues and 5°C increases would lead to a decline in revenues of 93% - the revenue metric is used to assess the economic/human impacts of the decline in yields. These impacts would be compounded if climate change also led to a

[3] This analysis uses the A1F1 SRES scenario and the overall yield change is the weighted average yield change across the three crops with the weights determined by current production levels.

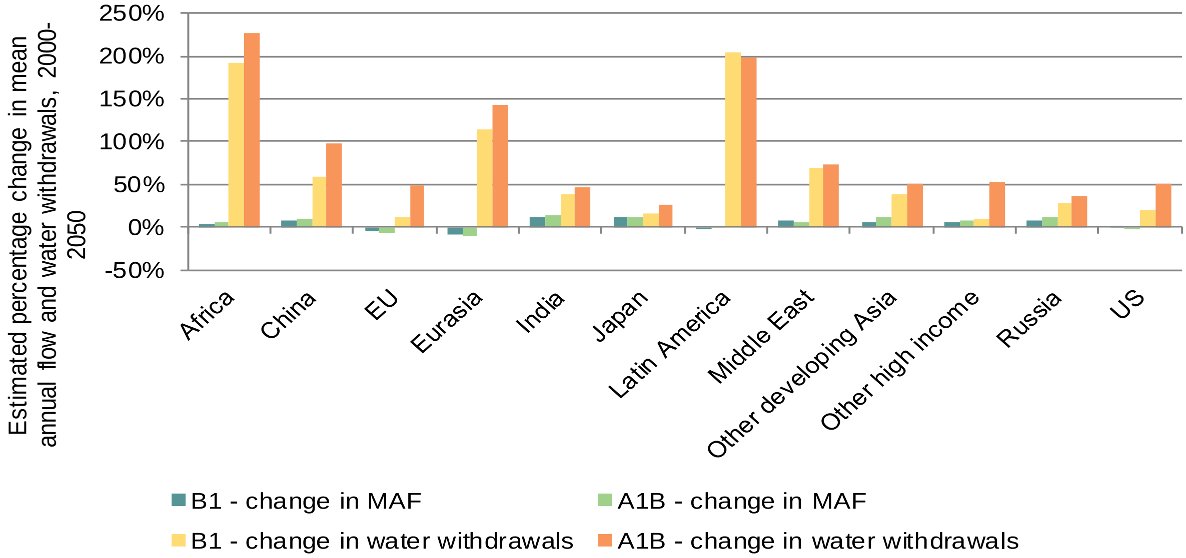
reduction in precipitation. In Cameroon, smaller impacts are reported with temperature increases of 2.5°C leading to net revenue declines of 5% and 5°C increases leading to declines in revenue of 11.3%.

2.2.3 Water impacts

Our analysis is based upon Kirshen (2007), a study undertaken for the UNFCCC to provide guidance for the GEF[4]. The study uses two climate change scenarios to estimate the likely impacts of climate change on water supply and demand across 130 countries, taking into account adaptation options. It uses two scenarios, SRES A1b – a scenario in which emissions grow substantially – and SRES B1**-** where there is more substantial mitigation effort. It reports estimates for 2050. We report changes in two key measures of water supply and demand across 12 regions as defined by RICE. Mean annual flow (MAF) is a simple measure of the amount of water available throughout the year in a country and total country water withdrawals measures the country's demand.

The results show that on aggregate Africa is expected to benefit from a slight increase in water availability. However, in many regions water availability may worsen and relative to expected demand growth the aggregate effect is miniscule: the gap between demand and supply growth is greater than in any other developing country regions (except Latin America). In the context of an expected 200% increase in water demand by 2030 (driven by population growth and development), the joint highest increase in any region, as shown in Figure 8, this could result in the region facing acute water shortages.

Figure 8. **Although Africa is likely to experience a small increase in mean annual flow of water, it will also experience a 200% increase in demand, exacerbating existing pressure on water availability**

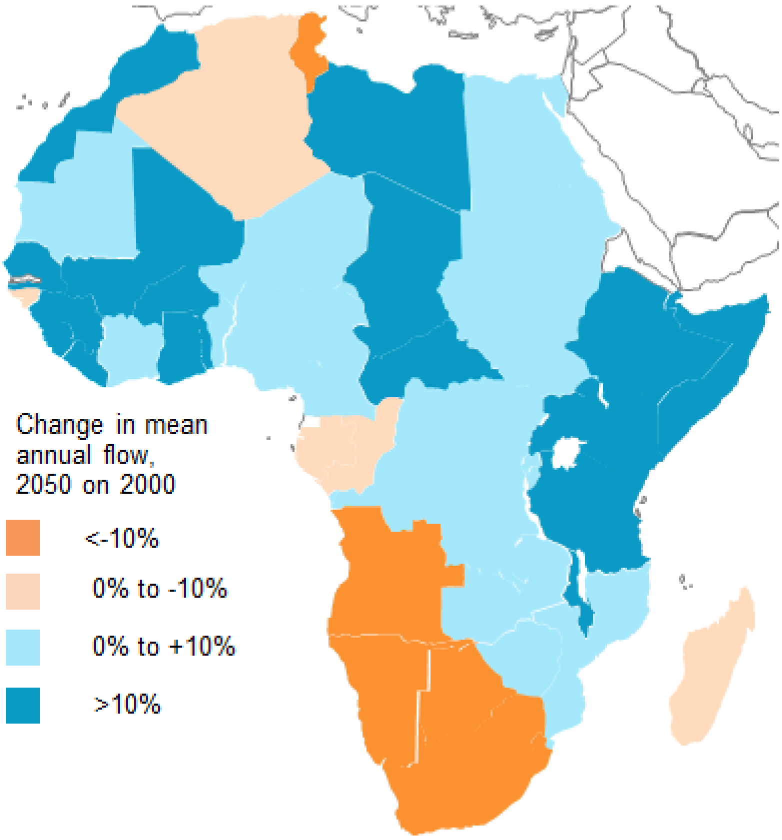


Source: Vivid Economics analysis of Kirshen (2007)

[4] Although there are some inconsistencies in the predictions made by different models on the impacts that climate change will have on the geographic distribution of water availability, the fact that this study is relatively recent and the audience for which it was prepared enhances it credibility

Furthermore, while Africa on an aggregate basis may benefit from increased water availability, some countries will have reduced availability. In general terms, southern Africa will experience reduced rainfall and hence reduced overall water availability, with Botswana, Swaziland, Lesotho and South Africa all expected to experience around a 20% reduction in water availability (mean annual flow). West Africa and the Horn of Africa are estimated to benefit from increased overall water availability as rainfall increases. This is shown in Figure 9 below. The socio-economic impacts of this change in water availability will depend on a large number of country-specific factors including the existing level of water resources and the efficiency with which the country manages its water resources.

Figure 9. **South Western Africa is expected to see a decrease in water availability of more than 10 per cent as a result of climate change**



Source: Vivid Economics analysis of Kirshen (2007) A1B scenario

Furthermore, as the IPCC (2007) notes, 'one of the impacts of climate change will be an acceleration of the hydrologic cycle', leading to increased variance in rainfall in most nations of the world. This will increase the incidence of extreme rainfall patterns. Consequently, although the analysis shows that the *mean* annual flow of water may increase in 36 out of the 46 African countries studied, in no less than 39 African countries, the water availability in the worst-case scenario[5] is expected to be lower in 2050 than in 2000. This is likely to increase the prevalence of droughts. Some of the worst affected regions on this basis include countries in the Horn of Africa which, as current events demonstrate, are already heavily exposed to drought.[6]. Other countries where this may be an acute problem include Burundi, the Republic of Congo, Gabon, Rwanda and Swaziland.

2.3 Summary

This brief review of climate impacts confirms that Africa is arguably the most vulnerable region in the world to the impacts of climate change. The RICE model shows impacts, as a percentage of GDP, which may be 10% higher than the next most exposed region (India) and more than twice as high as in the US, Russia, Eurasia and Latin America. This is broadly confirmed by FUND and also by the prior academic literature. Breaking down these impacts into specific sectors or components further illustrates these vulnerabilities, with recent authoritative studies into health, agriculture and water all demonstrating that Africa is often more exposed to climate change impacts along these dimensions than any other region of the world.

This vulnerability arises, despite the continent making a negligible contribution to current and/or historic emissions. Africa accounts for less than 7% of total emissions (WRI CAIT, 2011) and its emissions per capita are less than half the global average. Given this, it is not surprising that last year's report by UN Secretary General's High Level Advisory Group on Climate Change Finance (AGF, 2010) concluded that adaptation spending was a priority in Africa. The following section provides estimates of how much this adaptation spending may cost.

[5] Measured as the mean annual flow minus the standard deviation multiplied by 1.96.

[6] The worst-case (low) mean annual flow in Ethiopia in 2050 may be 73% lower than the worst case in 2000 and in Somalia it could fall by 42% In Djbouti the mean annual flow could fall to zero. The study does not include Eritrea.

3 The costs of adaptation in Africa

Africa is likely to require between US$ 20-30 billion per annum over the next 10 to 20 years to reduce its climate vulnerability to an acceptable level.

This section provides an overview of the current estimates of adaptation costs in Africa and reaches conclusions on a plausible range. Adaptation can be a powerful way of reducing the impacts of climate change, (as discussed in section 4). However, it is not cost-free, and African countries in particular will need financial assistance to help shoulder the adaptation burden. It is therefore important to understand its likely costs.

We conclude that adaptation costs in Africa are likely to be in the region of US$ 20-30 billion per annum over the next 10 to 20 years. There is considerable uncertainty around these figures. The full range of estimates is between US$ 2 billion and US$ 60 billion per annum, although the figures at the lower end of the range are clearly incomplete and do not account for Africa's adaptation deficit, for example. While generating a more precise estimate is not possible, the US$20-30 billion range should be sufficiently robust to be used in the context of the ongoing debate over how much money needs to be raised for international climate finance and where it should be allocated.

Estimating the costs of adaptation in Africa is a challenging exercise and the resulting literature provides a wide range of estimates. These differences stem from differences in the assumed level of climate change, different decision rules on how much adaptation should take place, different years of assessment, as well as differences in methodologies i.e. whether adaptation costings are constrained to 'hard' (technical) engineering solutions, or also include 'soft' (non-technical, behavioural or other) adaptation options; how studies assume that people and governments make decisions given the uncertainty over future climate impacts; and, critically, especially within Africa, how studies disentangle development spending from adaptation spending. These factors all hamper cross-study comparison and highlight the substantial challenges in deriving a precise estimate on adaptation costs. Nonetheless, an understanding of the likely future requirements for Africa is crucial in order to ensure an adequate scale of resource mobilisation.

A range between US$20 – US$30 billion per annum compares with a cumulative total of US$ 350m of adaptation funding approved for spending in Africa to date, of which approximately US$ 130m has been received. The vast majority of this funding has come since 2008, from a handful of international sources. Table 1 summarises the sources of adaptation finance received by Africa to date.

Table 1. **Africa has received just US$132m of adaptation funding to date**

Source of funding	Funding approved (US$ m)	Funding received (US $m)
Least Developed Countries Fund	95.7	64.5
MDG Achievement Fund – Environment and Climate Change thematic window	20.0	15.6
International Climate Initiative	12.1	12.1
GEF Trust Fund - Climate Change focal area (GEF 4)	3.3	3.3
Strategic Priority on Adaptation	9.6	9.6
Special Climate Change Fund	28.2	20.5
Global Climate Change Alliance	51.6	1.0
Pilot Program for Climate Resilience	113	1.5
Adaptation Fund	15.1	3.8
Total	**349**	**132**

Source: Climate Funds Update (2011)

Note: This table only relates to funding with an explicit geographic focus within Africa. Funds have also been committed to projects with a global focus that are likely to have some benefit to Africa,

The section divides the evidence into two parts:

- ‘top down’ studies which develop regional/national estimates for the costs of adaptation based on aggregate information
- ‘bottom-up’ studies which are typically less holistic in scope, but, by using individual case studies, offer both increased accuracy and examples of how climate change may impact on the studied populations.

3.1 Top-down modelling

We distinguish three ‘generations’ of studies that estimate the costs of adaptation in different regions, each of which builds upon preceding analysis. While these have been increasing in their sophistication, it is important to note that even the best studies have their deficiencies and produce estimates with a large range, in part due to the vast uncertainty inherent in making such predictions.

3.1.1 First generation studies

The first generation of studies focused on adapting physical capital (e.g. buildings and infrastructure) and imply costs of US$2-13 billion for Africa (in the context of global estimates of US$4-110 billion). However, they are narrow in scope and are based on a methodology with substantial weaknesses which may underestimate the costs of adaptation several times.

The first generation studies share a broadly similar methodology. This was first developed by the World Bank (2006) and calculates adaptation needs by estimating the fraction of current investment flows that is climate sensitive and then uses a 'mark- up' factor that estimates the cost of 'climate-proofing' future capital investment. The UNFCCC study is the only first-generation study that went beyond infrastructure adaptation, covering a total of five sectors. It also provided disaggregated information for different world regions. However, infrastructure costs, calculated in the traditional way, still dominate.

Table 2 presents the results from these studies for developing countries/globally.

Table 2. **The estimates for adaptation costs in developing countries in the first generation of studies ranges from 4-109 billion**

Study	Methodology (decision rule)	Time period	Region	Sectors	Estimate (US$ billion per annum)	Notes
World Bank (2006)	Top-down, investment flow mark-up	Short term	Developing countries	All	9 – 41	
Stern Review (2007)	Top-down, investment flow mark-up	Short term	Developing countries	All	4 – 37	
UNDP HDR (2007)	Top-down, investment flow mark-up & additional adaptation estimates	2015	Developing countries	All	86 – 109	Include adaptation costs for poverty reduction strategies and disaster response systems. No clear distinction between development and adaptation
Oxfam (2007)	Top-down, investment flow mark-up & additional adaptation estimates	Short term	Developing countries	All	50 +	Further new cost items
UNFCCC (2007)	Various, sector specific	2030	Developing countries	5- Agriculture, water, health, coastal zones, infrastructure	28 – 67	
UNFCCC (2007)	Various, sector specific	2030	Global	5- Agriculture, water, health, coastal zones, infrastructure	44 – 166	

Source: Agrawala and Fankhauser (2008)

Follow-up studies based on this methodology provide specific estimates for Africa. One of the significant weaknesses of these initial studies was that they failed to provide a regional disaggregation of adaptation costs. However, a couple of follow-up studies have attempted to use these studies to identify what the implication from these approaches would be for Africa.

- Van Aalst et al. (2007) use the World Bank (2006) study to derive a 'short-term' Africa estimate of US$2.1 billion -US$7.4 billion per annum with a further US$0.3 billion required to safeguard the effectiveness of AfDB investments.

- Watkiss et al. (2010) break down the UNFCCC global estimates to derive an Africa specific range of US$7.2 - US$9.9 billion in 2030. They also note that these numbers largely relate to investment needs and that there would be a further US$0.8-1.2 billion in 2012, rising to US$1.2-2.7 billion in 2030 required for assessing vulnerability, building capacity and operational adaptation. The authors note that these costs are largely separate from the investment cost figures numbers and that although there may be some overlap in certain areas, 'we consider these estimates should be added to the estimates of climate proofing investments.'

Although this approach has been widely adopted, it has significant flaws, especially in an African context. Of particular importance is that the methodology is based on a 'mark-up' applied to existing investment flows. Since past investment in Africa has been very low, both in absolute terms and relative to investment needs, the method dramatically underestimates future adaptation costs. The approach is heavily reliant upon, and sensitive to, assumptions regarding international capital flows, and typically neither the time horizon nor the underlying climate scenario is specified. Empirical information regarding the proportion of capital flows that are climate sensitive and the size of the mark-up needed to 'climate proof' these investments is also poor.

The sectoral composition of these studies is a further weakness. In addition, the sectoral coverage is extremely limited and focused on infrastructure adaptation. Even the most comprehensive of the first generation studies, that by the UNFCCC, excludes, for instance, the impacts on ecosystem as well as energy, mining, tourism, retailing and manufacturing. Within the health sector, which was covered by the UNFCCC study, attention was restricted to the effect of climate change on diarrhoeal diseases, malaria and malnutrition in low and middle-income countries, as these were the only areas where sufficient estimates were available.

As a result, Parry et al. (2009) conclude that this first generation of studies were not sufficiently substantive. They also observe that the studies were not independent of one another and were not subject to peer review in the scientific or economics literature.

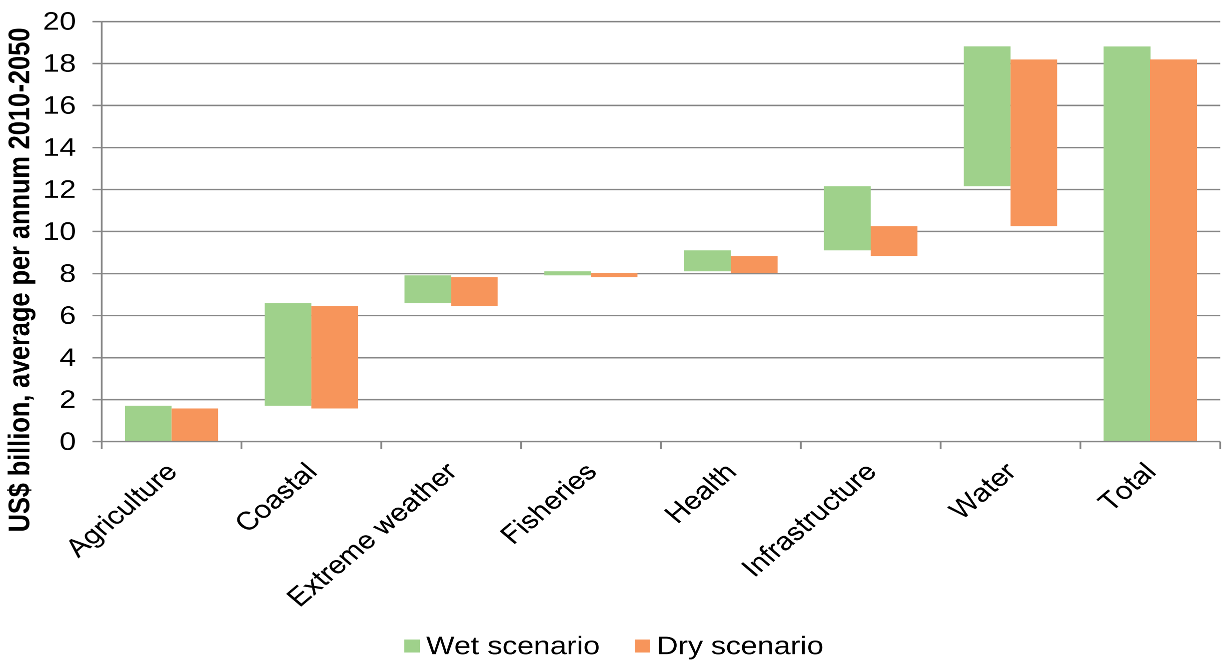
3.1.2 Second generation studies – the World Bank Economics of Adaptation to Climate Change (EACC) study

The World Bank's EACC study provides an estimate of around US$ 18 billion per annum for Africa. It corrects some of the weaknesses of the first generation studies, but excludes measures needed to close the existing adaptation deficit in Africa.

Recognising the weaknesses of these initial studies, the World Bank (2010) undertook a more detailed assessment of adaptation needs across the developing world. Its approach was similar to the UNFCCC for sectors like agriculture and coastal protection, but more detailed analysis was undertaken to overcome some of the deficiencies associated with the first generation of studies. For instance, the estimate of the costs of climate-proofing infrastructure included a statistical study of the link between climate and demand for infrastructure, while the coastal investment costs included a cost-benefit analysis of the building of sea walls versus the value of land. It also covered additional sectors/impacts including fishery, and the investments needed to deal with extreme weather events. This supplemented a bottom-up analysis looking at particular countries (discussed in part in section 3.2 below). The study assumed a 2°C warmer world by 2050[7] and considered two different scenarios consistent with this temperature increase which vary according to the implications for precipitation.

The country level data collected in this study suggests that the costs of adaptation in Africa might be around 18 billion per annum in the period 2010-2050 (US$2005 prices, no discounting)**.** This average over the period reflects a steady build up over time with estimates for spending in the period 2010-19 approximately 50% lower than in the period 2040-49. The data also suggests that the bulk of the costs will be incurred in improving coastal defences and in water supply infrastructure (Figure 10).

Figure 10. **The World Bank's EACC study suggests that annual average adaptation costs in Africa will be USD 18 billion per annum over the period 2010-2050, with most costs in the water sector and for coastal protection**



Source: World Bank Economics of Adaptation to Climate Change country level data and Vivid Economics calculations

Notes: Based on country level estimates of gross costs i.e. excluding any benefits from climate change

[7] The assumption that the temperatures will be 2°C warmer by 2050 is broadly consistent with existing modeling analysis for this date. However, such models also show that current commitments and efforts would imply substantially greater temperature increases beyond this date. This could further increase adaptation costs.

As a percentage of GDP, Africa's adaptation estimates are higher than in any other region of the world at around 1.3-1.4% (with Sub-Saharan Africa at 1.7-1.8% of GDP). This confirms a similar ranking provided by Agrawala et al. (2010) who present regional adaptation cost curves plotting the proportion of climate damages that are avoided by adaptation and the proportion of GDP that must be spent to avoid these damages. These show Sub-Saharan African and the Indian sub-continent as having the greatest adaptation needs relative to GDP[8].

The World Bank study is substantially more robust than the first generation of studies. In particular, it provides a more rigorous analysis based on a consistent set of climate models to link impacts to adaptation costs, as well as improvements in relation to methodologies used in particular sectors i.e. coastal flooding. However, it is still not a complete assessment of adaptation needs, with areas such as ecosystem adaptation still missing[9].

A further key deficiency of this study from Africa's perspective is that it treats adaptation as an additional activity that is separate from development. In reality, the two activities are strongly intertwined, particularly in least-developed countries. Adaptation and development consist of a suite of measures that address to various degrees both poverty alleviation and climate vulnerability (McGray et al. 2007). Projects in, for example, agriculture, health, water and sanitation deal simultaneously with urgent development and adaptation needs and address a well-recognised current adaptation deficit – that is difficulties in dealing with current climate events.

In Africa, there is a pressing need to mobilise resources to address the continent's *current* limitations to deal with climate events, as well as resources to deal with future climate change. The EACC study implicitly assumes that the current ability of Africa to respond to climate extremes and variability, for example, in terms of its institutional capacity, are sufficient and resources only need to be mobilised to provide additional adaptive capacity for future changes in climate. This approach is understandable, since the objective of the study was to estimate the financing needs for the incremental adaptation needed to deal with *future* climate change. However, for a continent like Africa, it does not provide a reliable estimate of the overall costs that Africa needs to incur to reduce its climate vulnerability to an acceptable level.

3.1.3 Third generation studies - adaptation as climate resilient development

Attempts to integrate adaptation needs into Africa's current development challenges provide the most robust assessment of Africa's overall needs if climate impacts are to be reduced to an acceptable level: most of these studies suggest a figure between US$ 20 and 30 billion per annum, but possibly as high as US$ 60 billion. The most recent generation of studies have begun to address the challenge of estimating the costs of adaptation in Africa taking into account its current gap in adaptive capacity and, in doing so, have begun to frame the adaptation debate in terms of climate resilient development. Four estimates are of particular importance.

[8] These results, do not utilise a 'decision rule' for the extent of adaptation, but just give the cost in terms of GDP for any given level of adaptation. Indeed, the paper does not provide a numerical estimate, or range, of costs of adaptation for different regions, recognising the degree to which these rely on arbitrary assumptions by noting that 'specific numerical estimates on adaptation costs should be interpreted with caution'.

[9] This exclusion is despite the fact that they are crucial for poverty alleviation (Chomitz, 2007).

A study by the Grantham Research Institute for Climate Change and the Environment (2009) estimates that the total requirement might be US$ 13-17 billion per annum in the period to 2015 and potentially US$ 21-27 billion by 2030. This study explicitly includes the costs of 'social adaptation' which can be thought of as, in part, dealing with existing problems of climate vulnerability in Africa. This includes protecting long-term livelihoods from the impacts of climate events through such actions as crisis-transfers, financial support for the poor in regions affected by climate events, and relocation initiatives for severely affected communities. These costs are not well researched and are particularly difficult to estimate and disaggregate from other development measures. In this study, social adaptation in fact accounts for the bulk of the total adaptation estimate (US$12-17 billion) with the remainder consisting of US$ 1 billion for capacity building and US$8 – US$9 billion for climate proofing investments The study also notes that the total adaptation costs in Africa might increase to up to US$60 billion if Africa's infrastructure develops more quickly than projected in earlier studies.

A second, very simple, if somewhat crude, approach is to take the findings from Parry et al. (2009) that the first generation of studies (reported in section 3.1.1 above) may provide estimates that are 2x to 3x too low. A significant reason underpinning the conclusion from Parry et al. (2009) was that the first generation studies failed to take account of the continent's current adaptive capacity gap, that is, shortcomings in dealing with current climate events. Watkiss et al. (2010) report a range of US$ 14 -30 billion for 2030 from this method.

A third approach by Satterthwaite and Dodman (2009) estimates total African adaptation requirements in 2030 as US$ 12.4 – 27.8 billion. This methodology adopts the 2x-3x multiple above to most categories of adaptation expenditure identified by the UNFCCC but separately itemises the adaptation cost for African infrastructure. This reflects that infrastructure flows will have to increase substantially in order to realise the Millennium Development Goals (MDGs) on the continent and hence looking at current infrastructure flows will substantially underestimate adaptation needs given future elevated infrastructure investment levels. This yields an estimate of between US$ 3 and 12.1 billion per annum by 2030 for infrastructure adaptation on the continent (compared with a baseline estimate for infrastructure adaptation in Africa that yields an estimate of less than US$ 0.4 billion).

A study by Fankhauser and Schmidt-Traub (2010) explicitly takes climate-resilient development, rather than adaptation, as the starting point. It estimates the additional costs of meeting the Millennium Development Goals that will result from a changing climate in the period 2010-2020. It finds that the annual cost of 'climate proofing' the MDGs is between US$20 billion and US$30 billion greater than the cost of meeting the MDGs alone (Table 2). That is, climate change might increase the cost of meeting the MDGs from US$72 billion per annum to around US$100 billion per annum.

Even this estimate may not be complete. This study builds upon and improves the analysis presented in previous studies, by treating development and adaptation as interlinked processes, with socioeconomic development a pre-requisite for a number of adaptation options. However, it is important to note that this study only quantifies the adaptation cost of meeting the MDGs – any costs of adaptation to achieve development over and above these relatively modest goals is not included in this cost estimate.

Table 3. **Fankhauser and Schmidt-Traub estimate that the cost of 'climate proofing' the MDGs is in the range of US$ 20- 30 billion per annum in the period 2010-2020**

	ODA needs for MDGs (US$bn)	Adaptation needs (US$ bn)
MDG costs:		
- Agriculture and nutrition	8.8	1.6 - 2.7
- Nutrition and school feeding	4.0	0.0
- Education	8.3	0.0
- Health	28.0	1.2 - 2.3
- Infrastructure	22.9	3.6 - 8.4
- Statistics	0.3	0.0
Sub-total: MDG cost	**72.3**	**6.4 - 13.4**
Social Adaptation:		
- Capacity building/planning		0.2 - 0.4
- Coastal protection		1.4 – 4.0
- Disaster response		12.0 – 12.5
Sub-total: social adaptation		**13.6 – 16.9**
Grand total		**20.0 – 30.3**

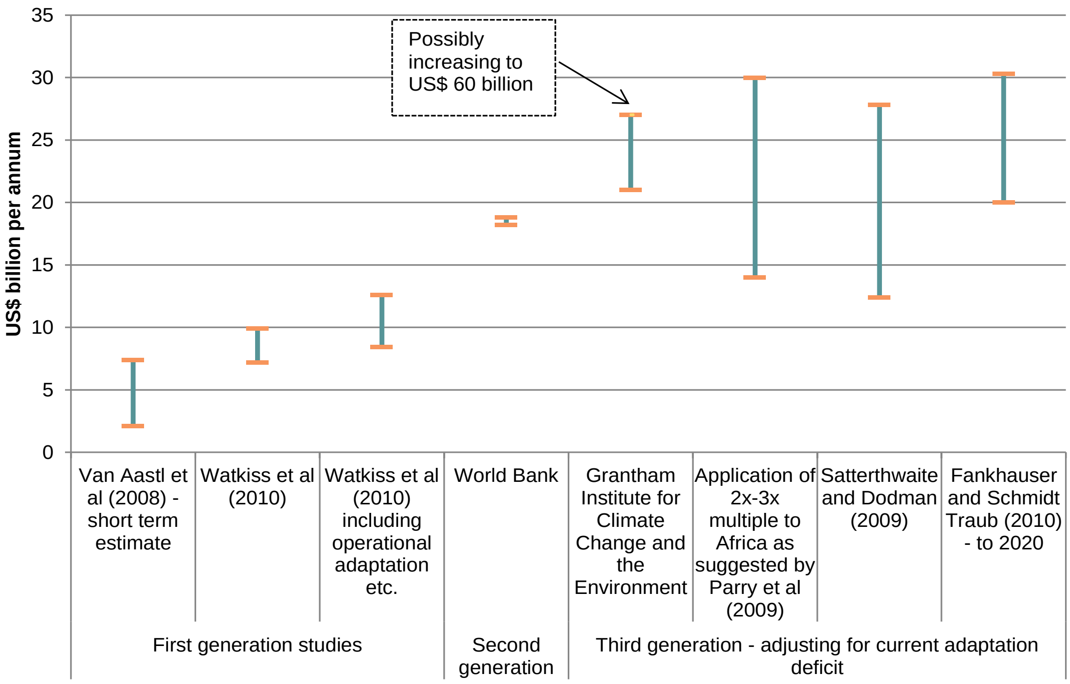
Source: Fankhauser and Schmidt-Traub (2010)

3.1.4 Summary

Figure 11 shows that the latest studies on adaptation costs (which try to account for Africa's current adaptation deficit) all broadly suggest a range of US$ 20- 30 billion per annum by 2030 at the latest and, in the case of Schmidt-Traub and Fankhauser (2010) in the 2010-2020 period. There is no rigorous or scientific way in which to synthesise the findings from different studies into one number but the convergence of all of the estimates that have attempted to account for current difficulties in dealing with climate events (Africa's current adaptive capacity gap) lends confidence that it is broadly correct.

Current flows of adaptation money to Africa are massively lower than US$ 20 – 30 billion. This US$ 20 -30 billion range compares with the current (cumulative) resources that have been committed for adaptation spending in Africa of US$ 350m, of which around US$ 130m has actually been disbursed. While there would be expected to be a gap between current commitments and future requirements, the fact that total current **cumulative** commitments have been approximately one hundredth of the future **annual** requirements demonstrates the scale of the challenge. It also demonstrates the urgent need for African leaders to engage in the debate on the sources of future climate change finance, for instance, in following up on the findings from the UN Secretary General's High Level Advisory Group on Climate Finance (AGF). This is discussed in more detail in a recent AfDB/Vivid Economics (2011) brief on the implications of the AGF report for Africa.

Figure 11. **Most of the preferred studies that account for Africa's current adaptation deficit suggest that adaptation costs of between US$ 20 and 30 billion may be required on the continent by 2030, and possibly earlier**



Notes: all estimates for 2030 unless otherwise stated. World Bank estimate is annual average over the period 2010-2050

Source: Vivid Economics based on sources discussed in text

3.2 Bottom-up, sectoral analysis

Bottom-up analysis can provide important additional insights to top-down results. It provides a more detailed flavour of adaptation challenges and costs in different localities or sectors of the economy. As such it can indicate more accurately where spending should be prioritised**.** In some cases it is possible to extrapolate some of these studies to estimate regional economy-wide adaptation costs, although such analyses are unlikely to be reliable in isolation and are more useful to supplement and guide top-down approaches (World Bank (2010) and Watkiss et al. (2010)).

3.2.1 OECD case studies

The OECD 2005 report 'Bridge over troubled water' presents six country case studies reviewing climate change impacts and vulnerabilities, analyses national plans and examine areas of

natural resource management where climate change is closely linked with development in six countries. Among the six countries chosen were case studies on the Nile and on Mount Kilimanjaro in Tanzania.

– The study found that 20-30% of donor projects in Tanzania are in sectors potentially affected by climate risks and so will have to be adapted to account for this. A second feature in Tanzania is that certain sectors, such as agriculture and water resources, are projected to experience both negative and positive impacts under climate change – for example, while production of maize is projected to decline, the production of two cash crops (coffee and cotton) is projected to increase – these changes will require significant adaptation. (Agrawala et al., 2003)

– In Egypt, it found that around 25% of development assistance projects are in sectors potentially affected by climate change. Among the adaptation projects and investments it suggests as most important are water demand management strategies (requiring capacity building across institutions and society), improved rain-harvesting techniques, increasing extraction of ground water, water recycling, desalination, and improving water transportation. (Agrawala et al., 2004)

3.2.2 NAPAs and PPCRs

National Adaptation Programs of Action (NAPAs) and the Pilot Programmes for Climate Resilience (PPCRs) provide evidence on current practice in adaptation spending which, in Africa, is mainly being directed at preparatory measures and capacity building, most of it in the agriculture and water sectors. In 2001 the 7th COP decided that least developed countries should be 'assisted in preparing National Adaptation Programs of Action (NAPAs) to address urgent and immediate needs and concerns related to adaptation to the adverse effects of climate change' (UNEP, 2011). NAPA teams were funded by the Global Environment Facility (GEF) and were to include government and civil society in efforts to identify key climate-change adaptation measures and to initiate a process of planning, preparation and implementation in vulnerable developing countries. Some forty NAPAs have been completed to date although most have not been, or only very partially, implemented.

PPCRs were designed to build upon the findings of the NAPAs and other relevant country studies to demonstrate ways to integrate climate risk and resilience into development planning. PPCRs support the funding of technical assistance and the funding of public and private sector investments identified in national plans and place particular emphasis on integrating climate resilience into development plans.

These plans show the current dominance of preparatory measures and capacity building, especially in the agriculture and water sectors. For instance, some of the key aspects of the Niger's PPCR, which has had USD 110m allocated to it[10], include: scaling-up investments in sustainable land and water management and in irrigation development (representing the most costly element of the programme); improvement of meteorological prediction and climate forecasting tools and spreading of the information; piloting schemes of weather-based risk insurance and inventory guarantee for

[10] In addition Zambia and Mozambique have each received a grant of USD 1.5 million to support the preparation of their PPCR investment plans.

crops; and piloting social protection measures targeted at the most vulnerable. One of the three underlying 'pillars' of the programme is the *'mainstreaming of climate resilience into poverty reduction and development planning strategies'* (CIF, 2010).

3.2.3 World Bank case studies

The World Bank (2010) study provides bottom-up evidence on adaptation needs in a number of countries including in Mozambique, Ethiopia and Ghana. Although such case studies cannot provide an overall picture of the costs of adaptation, the three countries represent nearly the full range of agricultural systems in Africa and hence provide a significant diversity of potential climate change impacts and adaptation responses. For each country, adaptation options are identified and costed for the key sectors, although the costs of private (autonomous) adaptation are excluded. As such, the true costs of adaptation are likely to be higher.

– The country study for **Mozambique** estimates investment costs of around US$ 400 million per year over 40 years for the adaptation options identified. One adaptation option – sealing unpaved roads, a 'low regret option' likely to yield significant benefits no matter the extent of climate change – would restore about one fifth of the welfare loss owing to climate change. The remaining welfare losses could be regained with better agricultural productivity or through the improvement of education, each at a similar overall cost. Irrigation investments are found to be a poor adaptation option.

– Adaptation costs in **Ethiopia** are estimated to be far higher, at US$ 1.22 billion in the wet climate scenario and US$ 5.84 billion in the dry scenario[11]. These adaptation measures include increased use of irrigation, paving roads, improving hydropower projects and 'soft' adaptation measures such as changes in transportation operation and maintenance and the development of new design standards. Without adaptation, Ethiopia's GDP in 2025 would be lower by 2 - 8% as a result of climate change. The adaptation measures studied can reduce this welfare loss by roughly 50%.

– The report considers similar measures for **Ghana**, where it estimates that climate change will cause a reduction in real household consumption of 5 - 10% in 2050, with an economy wide reduction in real GDP of 1.9 - 7.2%. However, although the report discusses various adaptation measures at length, and analyses their strengths and weaknesses, it does not provide an overall cost estimate.

3.2.4 Other recent studies

An SEI (2009) study identifies immediate adaptation needs in Kenya for current and future climate change of $500m by 2012, rising to $1-2bn a year by 2030. The sectors examined in the

[11] Note that the two extreme scenarios used in World Bank (2010) are the same for the country studies and the global study – the 'extreme dry' scenario uses CSIRO and the 'extreme wet' scenario is modelled on NCAR.

bottom up assessments included: coastal protection, health, water, agriculture, energy and the responses to extreme events. Four types of adaptation are identified and costed[12]:

- accelerating development to cope with existing impacts;
- increasing social protection through transfers to those most vulnerable to climatic changes;
- building adaptive capacity and strengthening institutions;
- enhancing climate resilience through infrastructure development.

The study paid particular attention to the sequencing of adaptation measures. It found that the early adaptation measures that were found to be effective were: building adaptive capacity, the implementation of pilot actions and pro-active investigation of long-term threats. The study also notes that the costs of adaptation are still emerging, and that residual impacts of climate change are to be expected.

3.2.5 Summary

A number of conclusions can be drawn from this brief review of bottom-up adaptation studies in Africa. First, they further demonstrate the critical importance of adaptation within Africa with for instance the World Bank studies showing that Ghanian GDP could fall by more than 7% without adaptation efforts and the OECD studies showing that around a quarter of all development projects could be affected by climate change. Second, they suggest that water, agriculture and health will be particular areas of focus for adaptation spending in Africa. Third, in keeping with the spirit of the 'third-generation' studies, the PPCRs and the Kenya SEI study highlight the close interrelationship between adaptation and development and, as a closely related point, the need to build up adaptive capacity as a matter of priority. Finally, as the World Bank's Ethiopia study demonstrates, adaptation will consist not just of 'hard' engineering solutions such as paving roads and irrigation but also 'soft' measures such as transportation operation and maintenance and the development of new design standards.

[12] The first two categories of spending are found to account for the the bulk of the requirement in 2012 - $500m compared with $100 -$150m for the latter two categories. By 2030, the split is more even with $500 - $1000m estimated to be needed for the first two categories and $250- $1000m for the latter two categories.

4 The case for adaptation spending in Africa

There is a strong investment case for adaptation spending in Africa: this investment should prioritise building adaptive capacity.

This section considers the emerging evidence on the effectiveness (of different types) of adaptation spending in reducing climate damages and on this basis identifies the likely key adaptation priorities in Africa in the short-medium term. Section 4.1 considers evidence on the cost-effectiveness of adaptation spending both generally and specifically within Africa. As in sections 2 and 3, this evidence is split into the evidence from top-down models and bottom-up assessments. Section 4.2 then briefly considers whether this cost-effectiveness might be undermined by a lack of absorptive capacity within Africa. Finally, section 4.3 considers the priority investments in Africa, highlighting the crucial need to build adaptive capacity, with the implication that adaptation spending needs to be integrated into existing development activities.

4.1 The business case for adaptation investment in Africa

4.1.1 Top down findings

A series of modelling results show that the benefits of undertaking adaptation at a global level may be more than twice as great as the costs of that adaptation. Bosello et al. (2010) estimate the benefits and costs of adaptation investment in a range of scenarios which differ according to the level of mitigation effort, the amount of damage that climate change causes without adaptation and the choice of discount rate. As Table 4 illustrates, the consistent results across these scenario is that the benefits of undertaking adaptation investment substantially outweigh the costs, on occasion by a factor of two or more. These results are broadly consistent with those from Agrawala et al. (2010) who report benefit cost ratios for adaptation spending (in a no-mitigation scenario) of between 1.8 and 2.0.

Table 4. **High returns to investment in adaptation for each of four scenarios**

3% discounting, 2010 – 2105	Low damage, high discount rate	High damage, high discount rate	Low damage, low discount rate	High damage, low discount rate
Benefit cost ratio without significant mitigation	1.67	2.41	1.69	2.57
Benefit cost ratio with substantial mitigation	1.73	2.63	1.52	2.33

Source: Bosello et al. (2010)

There are fewer top-down studies that look at the benefits and costs of undertaking adaptation at a regional level. However, the modelling results of Bosello et al. (2010) suggest that the benefit: cost ratios of undertaking adaptation in non-OECD countries tend to be slightly higher than the equivalent ratios in OECD countries (around 2.1 on average across the different scenarios in non-OECD countries compared with 1.9 for OECD countries). This may reflect that, without adaptation, climate change will cause more damage in non-OECD countries.

4.1.2 Bottom-up analysis

The case study analysis undertaken by the World Bank in its EACC study make a clear case for adaptation measures in the African countries examined.

– In all case studies examined a significant proportion of climate change impacts could be adapted to with measures that yield a positive return.
– In the Mozambique case study, it was possible to adapt to all climate related damages at a relatively low annual cost, US$ 400m. However, whilst some measures, such as sealing roads, investing in agricultural productivity and investing in education had significant positive returns, it is only cost effective to adapt to sea level rises using coastal protection in cities and ports where damages from rising sea levels are largest. Coastal adaptation in other geographical areas would likely yield negative returns.
– The most cost effective sectors to adapt in varies significantly across countries, although 'soft' measures are effective in each of the case studies and often yield a significant positive return.

These findings are consistent with a number of further studies of immediate relevance to Africa.

- The UNFCCC (2007), and the associated background paper (Ebi, 2007), has estimated that investing US$ 3.8 billion to 4.4 billion to treat additional cases of malaria, diarrhoea and malnutrition could prevent around 133 million climate-related deaths from these diseases (almost half of which would occur in Sub-Saharan Africa). At US$ 33 per life saved this would represent a highly cost-effective intervention. This total aggregates the costs of specific interventions for each disease i.e. in the case of malaria, insecticide treated bednets and indoor residual spraying.

- In the agriculture sector, there is a wide array of evidence, as reported by Easterling et al. (2007), that reasonably low-cost adaptation measures like changes in planting dates, cultivars, fertilizer use and management practices can reduce the impact on crop yields by often more than half, relative to the no-adaptation case. A recent paper examining adaptation by Ethiopian farmers (Di Falco et al., 2011) finds that farmers that chose to undertake adaptation would have produced around 20% less without adaptation while, by contrast, those farmers that chose not to adapt could have produced around 35% more had they chosen to invest in adaptation.

- Further corroboration is provided by case studies into agricultural adaptation in Mali and adaptation to deal with climate-induced health and hydropower generation resulting from drought in Tanzania presented by the Economics of Climate Adaptation team (2009). The Mali case study suggests that all of the losses caused by climate change could be averted by cost-effective adaptation measures, while the study in Tanzania found that just under half of the expected losses otherwise anticipated by 2030 could be averted by cost-effective adaptation measures.

Although cost effectiveness is important, it should not be the only factor in determining the allocation adaptation funding; equity is just as important. In particular, developed countries have an obligation, acknowledged in the UN Framework Convention on Climate Change, to support adaptation in developing countries that are particularly vulnerable to climate change. Providing sufficient adaptation funding to developing countries is a key concern that goes well beyond cost-effectiveness considerations.

Neither does the effectiveness of adaptation mean that mitigation efforts are unnecessary. Practically all the available evidence on adaptation effectiveness concerns adaptation to a “moderate” amount of climate change of perhaps 2-3°C. Very little is known about the effectiveness of adaptation to the more severe levels of change that will occur if global greenhouse gas emissions are not curtailed. It would therefore be dangerous to rely on adaptation as a large-scale substitute for mitigation.

4.2 Africa’s absorptive capacity

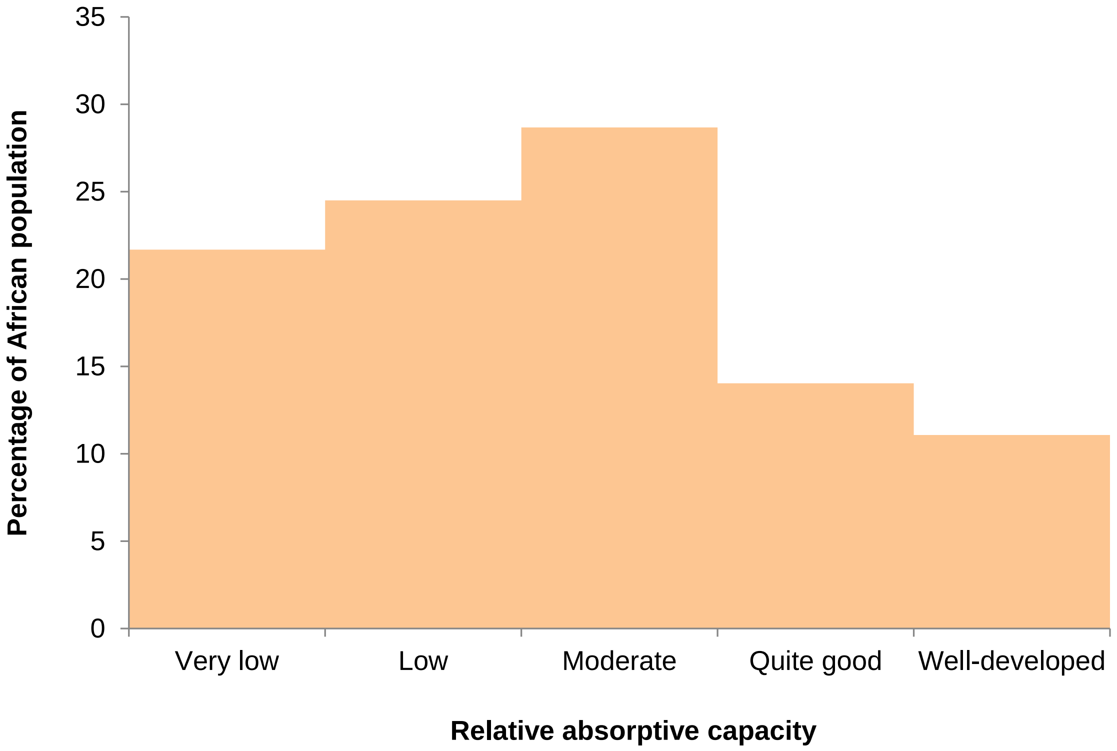
The cost-effectiveness of adaptation spending might be undermined if countries lack absorptive capacity to cope with the increase in flows. Concerns are sometimes raised that developing countries lack the absorptive capacity to manage large scale increases in adaptation funding and any scaling-up of flows should wait until these challenges have been overcome.

On average, Africa’s absorptive capacity is broadly similar to that of other countries at a similar stage of development; it need not be used as an excuse to not begin scaling-up adaptation flows. Figure 12, based on data from Barr, Fankhauser and Hamilton (2010) places Africa’s population into one of five categories depending on the current strength of their absorptive capacity relative to other developing countries[13] . It demonstrates that although there is considerable variety across the continent, a majority of Africans live in countries where absorptive capacity is no lower than the developing country average. Tanzania, Senegal and Ghana are all examples of where the capacity to absorb increased financial flows is already, in relative terms, very high.

In other parts of Africa, implementation capacity is weaker; in these cases adaptation spending may need more careful monitoring, implementation assistance and project oversight by development institutions such as the AfDB. Some of the African countries where institutional capacity is weaker include Central African Republic, Chad and Togo. In these cases, adaptation flows may need to be undertaken in partnership with development institutions. Indeed, improving this institutional capacity is likely to be one of the most effective ways of improving the adaptive capacity of these countries.

[13] Absorptive capacity is measured in this study is based on CPIA, based on CPIA, an index used by the World Bank Group to inform the allocation of concessional funding from the International Development Association (IDA). The CPIA ranks countries according to 16 indicators grouped into four clusters: economic management, structural policies, policies for social inclusion and equity and governance and public-sector management. Extra weighting is given to governance and public sector management when aggregating across the clusters.

Figure 12. **The absorptive capacity of African countries is just under the average for developing countries as a whole**



Source: Vivid Economics based on Barr, Fankhauser and Hamilton (2010)

4.3 Priority adaptation investments in Africa

Given that adaptation spending is likely to represent a good investment, it is important to try and assess what the adaptation spending priorities in Africa should be. Stern (2008, 2009) defines "good" adaptation as meeting three criteria:

– it is efficient, by achieving results at a low cost;
– it is effective in keeping down the negative impacts of climate change;
– it is equitable by targeting the countries and population groups most worthy of assistance.

A range of empirical studies demonstrate that advancing broader development goals is a crucial pre-requisite for meeting these criteria. These studies show that countries with low levels of development tend to experience much greater losses from a climate event or natural disaster than more developed countries, for instance:

- Raddatz (2009) finds that the GDP impact of a climate disaster is twice as high in low-income countries than in middle-income countries who, in turn, suffer twice as much as high income countries.

- Noy (2009) finds that economies with higher literacy rates, stronger institutions, higher per capita income, higher openness to trade etc. are more resilient to the impacts of natural disasters[14].

- Wheeler et al. (2009) shows that female education and empowerment can play a key role in reducing weather-related losses.

- Di Falco et al. (2011) find that access to credit and knowledge about the climate were critical determinants of whether Ethiopian farmers decided to make agricultural adaptation investments

This is further backed up by conceptual analyses. For instance, Agrawala et al. (2010) using the AD-WITCH IAM, suggests that almost 50% of the adaptation spending in non-OECD countries might optimally be in building adaptive capacity (rather than adaptation actions) in the first half of the twenty first century, with adaptation investments, although important in absolute terms throughout the century, only coming to dominate thereafter. Likewise, Vivid Economics (2010), in a report for the UK Department for International Development, explored the relationship between policies to stimulate economic growth and those to adapt to climate change. It found that of the nine key factors for strong growth, six are also associated with good adaptation. It concludes that:

> *'deficiencies in health and sanitation systems, poor levels of primary education and underdeveloped state institutions, among other factors, make it more difficult for poor countries to deal with climate risks'*

This leads to the conclusions that good adaptation spending needs to focus first on addressing current climate vulnerabilities, i.e. dealing with those factors that determine how well a society can respond to climate events today[15]. In many cases, doing this may be operationally indistinguishable from broader development activities. As Nicholas Stern has noted, climate change adaptation can be described as essentially *'development in a hostile climate'*. Building adaptive capacity is an obvious win-win option as it will yield benefits independent of the eventual climate outcome. Specific examples of such spending include health and education programmes and the creation of response capacity systems such as planning systems and building effective public institutions (Fankhauser and Burton, 2011). There is likely to be a strong comparative advantage for existing development institutions in helping to deliver these investments.

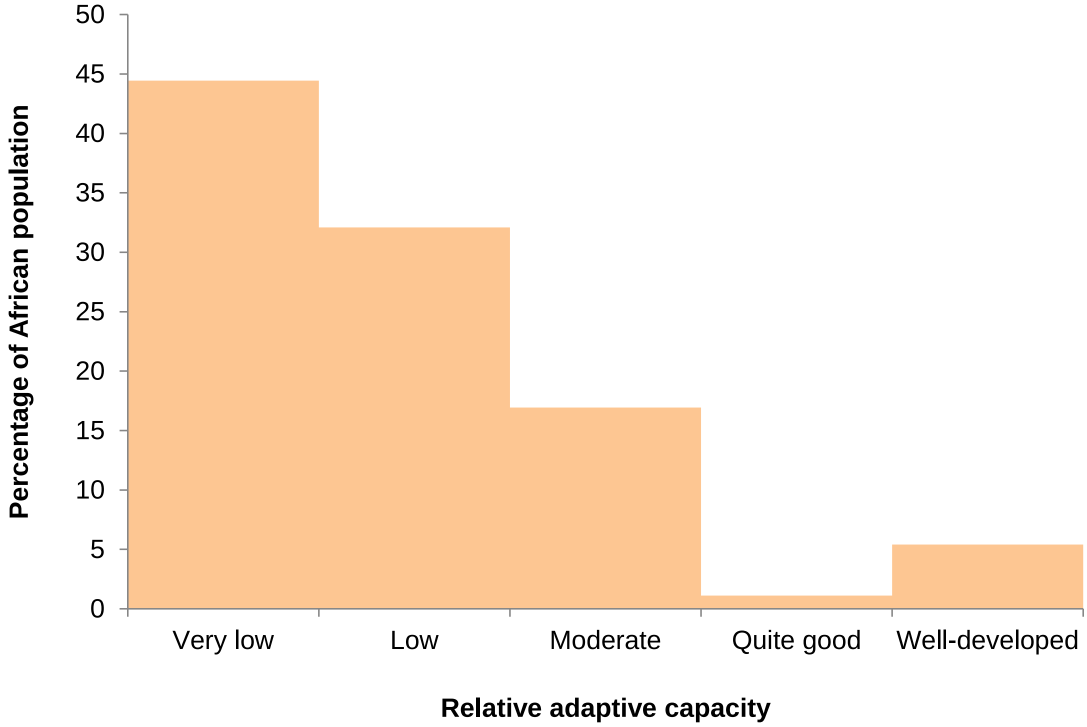
Africa's needs are particularly heavily skewed towards this form of adaptation spending. Figure 13 below places Africa's population into one of five categories depending on the current strength of

[14] Noy (2009) explicitly looks at the consequences of 'natural disasters' - high-cost but low frequency events. As such, this study does not cover the full range of possible impacts of climate change, some of which will be low-cost, high frequency events or will involve damages over a far longer time period. However, it is generally accepted that climate change will increase the incidence and severity of natural disasters and adaptation to these events is an important aspect of effective overall adaptation to climate change.

[15] More formally, Barr et al (2010) define adaptive capacity as 'the assets available, and the ability to use these resources effectively in the pursuit of adaptation. In practical terms it is the ability to react to evolving hazards which among other things requires the capacity to learn from previous experiences.'

their adaptive capacity[16]. It demonstrates that improving current adaptive capacity is a priority in Africa: just under 50% of its population live in countries with very low adaptive capacity and 75% of its population live in countries with either 'very low' or low adaptive capacity.

Figure 13. **Just under 50% of Africa's population lives in countries with the worst adaptive capacity**



Source: Vivid Economics based on Barr, Fankhauser and Hamilton (2010)

Beyond this a series of targeted adaptation investments are required and it is crucial that African decision-makers factor climate change into all long term strategic decisions starting immediately. In particular, Africa has a large infrastructure deficit that will have to be closed over the coming decades. The design and location of this infrastructure, which will have a lifetime of decades, needs to accommodate changes in the climate. As the World Bank EACC study makes clear, some existing infrastructure will also need to be retrofitted. Studies like the World Bank EACC suggest that achieving this will be particularly costly in relation to water and sanitation measures, while, along with health and agriculture, is also identified as a priority sector in the bottom-up case studies examined. Softer adaptation measures i.e. zone planning and building codes will also need to complement these structural adaptation measures.

[16] The categories for adaptive capacity are relative categories with all developing countries split into quintiles. Adaptive capacity is measured using a basket of indicators: the age dependency ratio, domestic credit available to the private sector, the gini coefficient of inequality, the World Governance Indicator score for voice and accountability, literacy and female primary school completion rates.

5 Conclusions

Africa is arguably the most vulnerable region in the world to the impacts of climate change. The majority of both bottom up and top down ('integrated assessment') studies suggest that damages from climate change, relative to population and GDP, will be higher in Africa than in any other region in the world. This is corroborated by the analysis using the Regional Integrated model of Climate and the Economy (RICE) model in this review: this suggests that climate damages in Africa, as a percentage of GDP, may be 10% higher than the next most exposed region (India) and more than twice as high as in the US, Russia, Eurasia and Latin America. Breaking these impacts into specific sectors or components further illustrates these vulnerabilities, with recent studies into health, agriculture and water all demonstrating that Africa is often more vulnerable to climate change along these dimensions than any other region.

This vulnerability, coupled with the continent's negligible contribution to current and/or historic emissions, means that adaptation spending is the continent's climate investment priority. Africa accounts for less than 7% of total emissions and its emissions per capita are less than half the global average. Given this, it is not surprising that last year's report by UN Secretary General's High Level Advisory Group on Climate Change Finance concluded that adaptation spending was a priority in Africa.

We conclude that the most relevant studies suggest adaptation costs in Africa in the region of US$ 20-30 billion per annum over the next 10 to 20 years. A wide number of estimates of the costs of adaptation in Africa have been made, using a variety of approaches. This generates considerable uncertainty with the full range of estimates spanning US$ 2 billion to US$ 60 billion per annum. However, most recent studies, especially those that factor in and attempt to address Africa's existing adaptation deficit (see below) converge on a range between US$20- 30 billion over the next 10-20 years. This represents a reasonable 'approximate' estimate that can be used in the purposes of discussions on raising and allocation of international climate finance. This amount is on top of existing development and poverty alleviation needs, which could be in the order of US$ 70 billion to meet the Millennium Development Goals. To place this in context, to date, there has been approximately $350m of adaptation funding approved for spending in Africa, of which just $130m has been disbursed.

In Africa, there is a pressing need to mobilise resources to address the continent's *current* limitations to deal with climate events, as well as resources to deal with *future* climate change. Most studies implicitly assume that the current ability of Africa to respond to climate extremes and variability are sufficient and resources only need to be mobilised to provide additional adaptive capacity for future changes in climate. This approach is understandable, since the objective of studies like the World Bank's 'Economics of Adaptation to Climate Change' was to estimate the financing needed for the incremental adaptation to deal with *future* climate change. However, for a continent like Africa, it provides an underestimate of the costs that Africa needs to incur to reduce its overall climate vulnerability to an acceptable level.

Adaptation investments have the potential to substantially reduce the hardship from climate change in Africa. A series of global modelling analyses show that the benefits from undertaking adaptation may outweigh the costs by a factor of about two and that this ratio may be higher in non-OECD countries than OECD countries. Sectoral specific studies in agriculture and health, two crucial sectors for Africa's adaptation efforts, provide further evidence on the cost effectiveness of adaptation spending. However, it should be stressed that cost-effectiveness is not the only criterion for determining allocation spending – developed countries have an obligation, acknowledged in the UN Framework Convention on Climate Change, to support adaptation in developing countries that are particularly vulnerable to climate change – nor should this cost-effectiveness be taken to mean that efforts to cut emissions can be reduced.

The potential benefits of adaptation spending need not be undermined by concerns about absorptive capacity. The analysis presented in this paper suggests that, on average, the absorptive capacity of African countries i.e. their potential for countries to effectively use money allocated to adaptation in an effective way is broadly similar to that of other countries at a similar level of development. In cases where absorptive capacity is lower, partnerships with development institutions can provide assurance that money is spent in a way that delivers the benefits expected.

Africa's immediate adaptation priority is to improve its current adaptive capacity, much of which will be operationally indistinguishable from – and needs to be fully integrated with – traditional development activities. A growing evidence base supports the idea that general development is a crucial pre-requisite for strengthening a country or region's ability to deal with climate change and that more obviously explicit 'adaptation investments' are best implemented when a base level of development (or adaptive capacity) has been achieved. With more than 45% of Africa's population living in countries with the lowest adaptive capacity in the world, investments here are crucial. These will include investments in the health and education systems in African countries, as well as building institutional capacity. There is likely to be a strong comparative advantage for existing development institutions in helping to deliver these investments.

Beyond this a series of more targeted adaptation investments are required and it is crucial that African decision-makers factor climate change into all long term strategic decisions starting immediately. In particular, Africa has a large infrastructure deficit and will want to catch up over the coming decades. The design and location of this infrastructure, which will have a lifetime of decades, needs to accommodate changes in the climate. Studies like the World Bank EACC suggest that achieving this will be particularly costly in relation to water and sanitation measures. Softer adaptation measures i.e. zone planning and building codes will also need to complement these structural adaptation measures.

Adaptation needs to be complemented with global emission reductions. Although the policy focus in Africa is rightly on adaptation, the global need to reduce greenhouse gas emissions remains unchanged. Practically all adaptation studies analyse the cost of dealing with "moderate climate change" of maybe 2 – 3°C, associated with substantial emissions cuts by 2050. The costs of dealing with more aggressive climate change are less well understood but likely to be substantially higher.

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