Working paper

The economics of climate change adaptation in Africa's water sector

A review and way forward

Julian Doczi and Ian Ross

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Abstract

This working paper summarises existing work on the costs and benefits of climate change adaptation for the water sector in Africa. It reviews adaptation cost estimates for the continent and the main economic appraisal methods used, then summarises results. It focuses on adaptation to climate impacts *on* the water sector, such as damage to water infrastructure, rather than impacts *from* water on other sectors, such as agricultural drought. The paper finds that the literature is limited and identifies two key priorities for future appraisals:

1) greater focus on the costs and benefits of 'soft', non-infrastructure adaptation interventions
2) use of appraisal techniques that are better-suited to dealing with the uncertainties and time horizons associated with climate change in ways that are useful for decision makers

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Table of contents

Abbreviations

ADB	Asian Development Bank
AfDB	African Development Bank
BCR	Benefit-cost ratio
CBA	Cost-benefit analysis
CEA	Cost-effectiveness analysis
CER	Cost-effectiveness ratio
CGE	Computable general equilibrium model
CUA	Cost utility analysis
DEFRA	UK Department for Environment, Food and Rural Affairs
DFID	UK Department for International Development
ECA	Economics of Climate Adaptation Working Group
GDP	Gross domestic product
GRI-CCE	Grantham Research Institute on Climate Change and the Environment
IDB	Inter-American Development Bank
IFF	Investment and financial flow analysis
IIED	International Institute for Environment and Development
IPCC-AR5	Intergovernmental Panel on Climate Change Fifth Assessment Report
MCA	Multi-criteria analysis
MDG	Millennium Development Goal
MPT	Modern portfolio theory
NEEDS	National Environmental, Economic and Development Study
NPV	Net present value
OECD	Organisation for Economic Co-operation and Development
SEI	Stockholm Environment Institute
TEEB	The Economics of Ecosystems and Biodiversity
UNDP	UN Development Programme
UNEP	UN Environment Programme
UNFCCC	UN Framework Convention on Climate Change
USD	US Dollar
WASH	Water, sanitation and hygiene
WRM	Water resources management

Executive summary

This paper summarises existing work on the costs and benefits of climate change adaptation interventions for the water sector in Africa, as well as key critiques of that literature. The impacts of climate change on humanity will be felt mainly through water. This includes impacts *from* water on other sectors (e.g. flood impacts on agriculture) and impacts *on* the water sector itself (e.g. damage to water infrastructure). We focus only on the latter here, and define the 'water sector' in this context as consisting of water supply, sanitation and hygiene services (WASH) and water resources management activities (WRM).

The water sector in many African countries is particularly vulnerable to climate change impacts. They will serve as an additional pressure on top of the significant vulnerability to existing climate variability that water systems are facing throughout the continent. This is due to poor basic service levels from the sector's 'development deficit' in these countries.

The challenge facing African water sector decision makers is to adapt and build resilience to climate variability and impacts, but to do so in a context of significant uncertainty and constrained international funding for adaptation. To make informed decisions, they need a better understanding of the costs and benefits of adaptation interventions in different contexts. There is a growing body of work on the 'economics of adaptation', but relatively little on water. This paper summarises what there is, with recommendations for extending and strengthening research in this area.

This working paper begins with a general discussion of previous adaptation cost and benefit estimates, key challenges, and a review of economic appraisal methodologies. It then reviews the literature for studies that specifically estimate the costs and benefits of adaptation interventions to climate impacts within the African water sector. Thirteen existing studies of significance are reviewed, highlighting the relative dearth of published research in this area.

The studies reviewed employ a limited number of economic appraisal methods, focus more on WRM than WASH, and cover only a few countries in Africa. Studies are also skewed towards infrastructure-based ('hard') adaptation, and have struggled to deal with the uncertainties inherent in attributing climate and intervention-specific costs and benefits. New appraisal methods such as real options analysis show promise in their ability to better tackle this challenge.

Overall, more work is needed that spans different country and decision making contexts, and employs a wider variety of methods. In addition, the current bias towards appraising 'hard' rather than 'soft' adaptation interventions needs to be addressed.

1 Introduction

"Climate change presents a unique challenge for economics … it must be global, deal with long time horizons, have the economics of risk and uncertainty at centre stage, and examine the possibility of major, non-marginal change." (Stern, 2006)

"Adaptation spending is Africa's climate investment priority. … Adaptation investments have the potential to substantially reduce the hardship from climate change in Africa" (AfDB, 2011)

The Intergovernmental Panel on Climate Change (IPCC) and Stern Review conclude that the impacts of climate change on humanity will be felt 'mainly through water', via shifts in rainfall and extreme events, and that the poor and vulnerable – particularly in Africa – will suffer most (Bates et al., 2008; Stern, 2006). These climate impacts include both impacts *on* the water sector (e.g., damage to water supply and sanitation infrastructure from floods) and impacts *from* water on other sectors (e.g., flood damages to agriculture). This paper focuses only on impacts *on* the water sector.

Climate change will not alter the basic nature of weather-related impacts on the water sector, but is likely to change the severity and magnitude of those impacts (Bates et al. 2008; Howard and Bartram 2009). These impacts include losses and damage to, and reduced operational efficiency of, the infrastructure and services in both main 'sub-sectors' of the water sector: water supply, sanitation and hygiene (WASH) and water resources management (WRM). These can be driven by, for example, more frequent and intense droughts and floods. In many low and middle income countries, however, climate trends will remain moderate compared to existing levels of natural variability, highlighting the importance of addressing the current vulnerability of systems and services (Batchelor et al., 2010; Calow et al., 2011).

African water sector decision makers are therefore facing the need to adapt and build resilience to climate variability and future impacts, but are doing so in an uncertain context. The predicted costs of adaptation in the water sector are high. For example, the World Bank's (2010) *Economics of Adaptation to Climate Change* study concludes that the net annual costs of adaptation in developing countries for water supply and riverine protection alone are between $13-17 billion USD. This is much larger than the $2.7 billion USD pledged for adaptation so far, globally and across all sectors, through the various international climate funds (Schalatek et al., 2012). Given this uncertainty and limited availability of funds, the challenge is to better understand the costs and benefits of adaptation interventions in different contexts. This would better enable African water sector decision makers to efficiently use these limited funds on the most appropriate interventions.

To help tackle this challenge, this paper summarises existing work on the costs and benefits of adaptation interventions for WRM and WASH services, as well as key critiques. We focus on the African context, though also draw on relevant work from other regions. Chapter 2 introduces the topic by reviewing research on the aggregate, cross-sectoral costs of climate change adaptation in Africa. It also highlights some of the methodological and policy issues that have arisen. In Chapter 3, we then examine the various methods these studies have applied. We then focus on African WASH- and WRM-specific adaptation estimates in Chapter 4. Throughout we focus on methods and studies that compare both costs *and benefits* of adaptation interventions, though few yet exist that analyse both. We conclude by highlighting remaining research needs and ways forward.

This paper focuses only on reviewing these cost and benefit estimates for African water sector *adaptation interventions*. It does not discuss the costs and benefits of climate *impacts* on the water sector. It also does not investigate the broader macro- and microeconomics of water sector adaptation, focusing only on the economic appraisal of these adaptation interventions. Finally, the paper does not pass judgement on the suitability or value-for-money of the reviewed adaptation interventions and cost estimates.

This paper is based on a review of literature and methodologies. It is not a fully systematic review, but we did undertake extensive manual searching in academic databases and on Google during 2013. We supported this with forward and backward citation tracking and with consultation on the collected literature with climate economists. There are other reviews of the costs of adaptation overall and in specific sectors (discussed below), but a review focusing specifically on the economic appraisal of adaptation interventions for the water sector in Africa was lacking, except for an initial piece by Dyszynski (2010). This working paper builds on this earlier work, with greater focus on the relevant methodologies and a wider range of estimates reviewed.

2 Aggregate costs of adaptation in Africa

2.1 The costs of adaptation to climate change in Africa

This chapter addresses the broad, cross-sectoral work that has been done on the economics of adaptation in Africa. A significant body of research already considers the various interventions for adaptation, ways to mobilise finance for those sectors that are most vulnerable to climate impacts, and who should pay. Much less research has been carried out on issues around *how much* adaptation interventions might cost in different countries and sectors – and whether long-term benefits exceed their costs. This is a trickier question and perhaps more important for immediate adaptation planning.

As Kumar et al. (2010) detail, research on the costs of adaptation interventions is evolving, and consensus on overarching cost estimates is still lacking. This stream of research originally began with studies that simply determined the economic cost of climate impacts themselves. This was then refined by accounting for the costs of adaptation, though initially these were simply considered as the value of avoided future climate damages.

However, an early review by OECD (2008) saw this as insufficient, emphasising instead a focus on the financial costs of the adaptation *interventions* needed to adapt to a certain degree of unmitigated climate change. The review noted that work on this approach had only advanced in earnest from 2006. Since then, global, regional, and local estimates of adaptation costs have advanced. Significant knowledge gaps remain however, especially in the African context and for individual sectors such as water (AfDB, 2011).

While several of the studies cited in this chapter consider the water sector to some degree, they mainly do so in an aggregated manner. That is, they include the water sector as just one of many sectors in contributing to a broad adaptation cost estimate. Nevertheless, the magnitudes of these general estimates – and the problems they encounter – will be useful to remember when focusing on the water-specific analyses in Chapter 4.

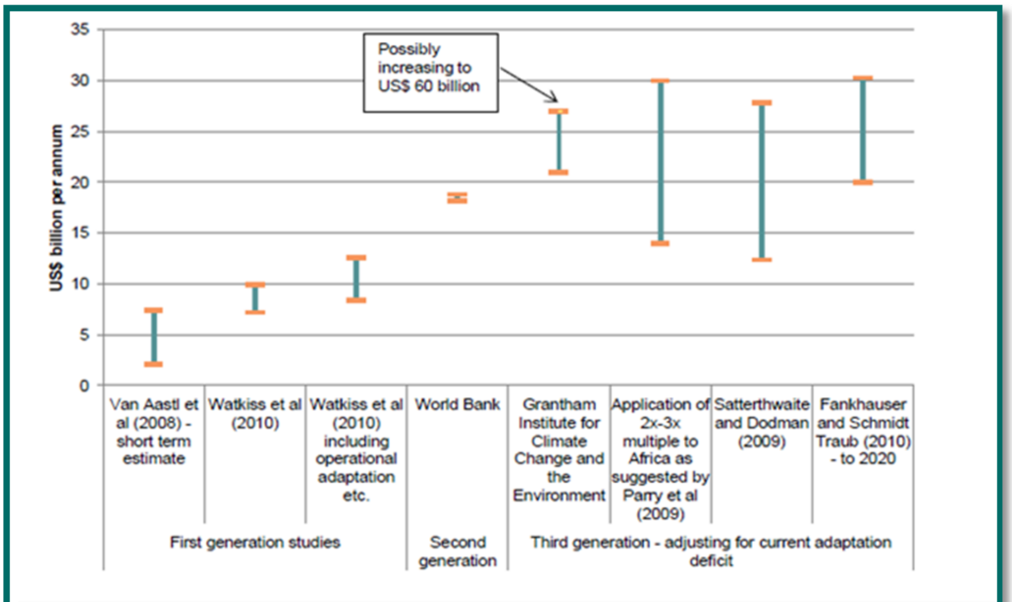
Summary of the AfDB (2011) review of cost estimates

A useful overview of the current state of knowledge on the economics of adaptation in the African context was published by AfDB (2011). Drawing on the research of Fankhauser (2009), the report summarises the cross-sectoral costs of essential adaptation interventions in Africa for the next 10 – 20 years. It concludes that the range of $20 – $30 billion USD per year is the most likely estimate for the continent, with this amount being *additional* to existing development needs. It also highlights the favourable benefit-cost ratios of interventions, with global models suggesting that their long-term benefits may outweigh their short-term costs by a factor of at least two.

The report reviews the current state of knowledge by classifying existing assessments as either ‘top-down’ or ‘bottom-up’, then classifying the former into three ‘generations’ of work. The 'top-down' classification distinguishes those studies that develop regional/national estimates of adaptation intervention costs using investment modelling and large-scale datasets. Conversely, 'bottom-up' studies are those that sum and extrapolate cost estimates from individual, small-scale case studies. The classification of three 'generations' of top-down studies is then used to cluster studies of similar sophistication, with the third generation being the most sophisticated.[3]

It is useful to distinguish between top-down and bottom-up studies. The latter can provide better estimates of adaptation intervention costs to inform local budgeting and decision making, but are usually too context-specific to allow for broader comparison. For example, a local case study in a coastal area may include a focus on adaptation interventions against sea-level rise or typhoons in its cost estimates, which would not be transferable to inland areas.

Figure 1: Three generations of top-down, continental cost estimates for adaptation interventions in Africa



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

Source: AfDB 2011

Considering first the top-down estimates, the summary of the AfDB's review of its three generations of estimates is displayed in Figure 1. The range and magnitude of cost estimates increases for each generation. Their increasing sophistication allows them to include a broader range of increasingly difficult-to-estimate costs, discussed in more detail in Section 2.2 below.

The 'first generation' (i.e., least sophisticated) includes global reviews by the World Bank (2006) and the UNFCCC (2007). Their data are then analysed by Van Aalst et al. (2007) and Watkiss et al. (2010) to produce estimates specifically for the African continent, ranging from approximately $2 – $13 billion USD per year. These costs are reported as broad, continental figures without any significant regional or sectoral analysis. They are produced by estimating the proportion of current continental investment flows that are climate-sensitive, then applying a 'mark-up' factor to estimate the cost of climate-proofing

[3] The review justifies these classifications with a variety of reasons, which will be elaborated further in the following section below.

future capital investments. This relatively crude method, focusing mainly on infrastructure, results in the low cost estimates as compared to the more holistic second- and third-generation studies.

The AfDB review's second generation focuses on the significant new global update (both top-down and bottom-up) produced by the World Bank in 2010. This study estimates the cost of necessary adaptation interventions for Africa at approximately $18 billion USD per year from 2010 to 2050. It uses more complex methods (including a statistical study and cost-benefit analysis) and analyses African regions and sectors in greater detail. The study generates a cost estimate for the African water sector[4] of around $8 billion USD per year from 2010 to 2050. These water sector costs thus contribute to over 40% of the total estimate. This illustrates the sector's importance even when represented in a simplified manner. While a stronger overall study, it has a number of key shortcomings, described further in section 2.2 below.

The review's third generation then consists of four studies by GRI-CCE (2009), Watkiss et al. (2010), Satterthwaite and Dodman (2009), and Fankhauser and Schmidt-Traub (2010), which advance various aspects of the methodologies to include more costs. They produce fairly consistent estimates for the African continent, ranging from approximately $12 – $30 billion USD per year by 2030. It is these four that AfDB draws on for its $20 – $30 billion USD per year estimate to 2030, noted previously. The GRI-CCE review goes into particular sectoral depth, and its water sector analysis is discussed further in Chapter 4. The other three do not, however. Despite using more advanced methods (as discussed further in section 2.2, below), they do not report water sector-specific cost estimates.

Considering next the bottom-up estimates, AfDB (2011) discuss several specific, local case studies from OECD (2005), SEI (2009a), and the World Bank (2010). For example, SEI (2009a) estimates the costs of adaptation for Kenya to be $500 million USD per year in 2012, rising to $1 – $2 billion USD per year by 2030. It examines the costs related to coastal protection, health, water, agriculture, energy, and extreme events in detail. Its water sector estimates are discussed further in Chapter 4.

Not included in the review was a useful SEI (2009b) report on the economics of adaptation for Rwanda and a series of country-led cost assessments facilitated by the UNFCCC (2010). Some of these latter assessments generate some significantly different cost estimates. The water sector estimates for both of these studies are discussed in Chapter 4.

Finally, the AfDB review also discusses the benefit-cost ratios of spending on adaptation interventions. It highlights work from Bosello et al. (2010) and Agrawala et al. (2010), who both estimate that benefit-cost ratios of key adaptation interventions are at least 2:1, and likely higher in poor and vulnerable countries in Africa.

2.2 Critiques and policy issues

While both the underlying data and methods used to estimate costs have improved, studies face a common set of problems. The first is their omission of 'soft' costs in favour of easier to quantify 'hard' infrastructure costs. The second is their handling of the 'adaptation deficit' in terms of the costs of existing, unmitigated climate variability. The third is their approach to decisions around acceptable levels of 'residual damage' from climate impacts.

Incorporating 'soft' costs as well as infrastructure

Most first, second and third generation studies have focused on the more tangible costs of building and maintaining the physical assets that help protect people from the impacts of

[4] which here consisted of adaptation costs for industrial/municipal water supply and flood protection infrastructure, though the former contributed to the vast majority of the cost

climate change. For example, it is easier to estimate the costs of building sea walls than it is to estimate the costs of 'softer' coastal protection measures such as mangrove conservation, relocation initiatives or erosion control. Some advances have been made, such as an attempt in the World Bank (2010) study to statistically link climate scenarios and infrastructure demand. However, these attempts have still been largely unable to account for more complex 'soft' concepts like ecosystem adaptation and social adaptation, described further in Box 1. Likewise, none of the reviewed studies yet attempt to quantify more context-specific soft costs like capacity building and adaptation planning/training with local decision makers. Nor do they consider the costs of activities that might generate the foundation for future 'hard' costs, such as the improvement of local weather stations to generate better climate data.

Box 1: Ecosystem adaptation and social adaptation

Ecosystem adaptation

The concept of ecosystem adaptation in this context relates to the maintenance or rehabilitation of ecosystem services as adaptation interventions. This requires estimating the financial costs of adaptation interventions in the form of ecosystem services. While much of the early work on this topic focused on adaptation as simply 'climate damages avoided', The Economics of Ecosystems and Biodiversity reports (TEEB) have been advancing research on the costs of ecosystem adaptation interventions themselves. The reports promote the idea of investing in 'ecological infrastructure' as adaptation interventions and illustrate their positive benefit-cost ratios. Some of the interventions (such as those for lakes/rivers and inland wetlands) are related to WRM and, by extension, WASH. However, these reports (the first of which was published in 2008) are not referenced at all in the World Bank (2010) report or by the third-generation studies, even though they are highlighted by Parry et al. (2009) as a key consideration for those producing future cost estimates.

Social adaptation

The concept of social adaptation in this context relates to adaptation interventions to protect livelihoods in ways that 'hard' infrastructure investments cannot address, such as crisis insurance and relocation initiatives. Accounting for social adaptation involves the challenge of accounting for elements of government social protection policy as adaptation interventions, while disaggregating these types of measures from other ongoing 'development'. This relates closely to the 'adaptation deficit' challenge described below. Some work on this has already been attempted, most notably by GRI-CCE (2009) and by SEI (2009b). The former advances the issue by explicitly considering the costs of adaptation interventions to: protect livelihoods, financially support the poor in areas hit by climate impacts, and undertake proactive or reactive relocation initiatives. With these considerations, the study estimates adaptation costs for Africa of $21 – $27 billion USD per year by 2030. These social adaptation interventions account for the majority of this estimate, at between $12 – $17 billion USD per year. The latter study likewise estimates the cost of social protection measures as adaptation interventions for Rwanda, via livelihood protection through programmes like cash transfers. It is unable to isolate these costs from other 'development', however. Nevertheless, it estimates these costs for Rwanda of potentially $120 – $170 million USD per year by 2030. These are in addition to their 'baseline' costs of adaptation for infrastructure-related interventions of $50 – $300 million USD per year (i.e., $170 – $470 million USD per year in total). There is no consensus yet on whether such interventions can be truly classified as adaptation, even though they build resilience and contribute to reducing the 'adaptation deficit' (see below).

The adaptation deficit

The second key issue is the 'adaptation deficit' (as coined by Burton (2004)), also known as the 'development deficit'. This relates to the idea that many parts of the developing world still lack the capacity to deal with current climate variability. It implies that the investment needs for future adaptation are therefore additional to the need for investment to adapt to current variability (AfDB, 2011). As Parry et al. (2009) note, most of AfDB's first- and second-generation studies fail to account for this issue. Instead, these studies implicitly argue that current adaptive capacity is sufficient and that only future costs need be determined.

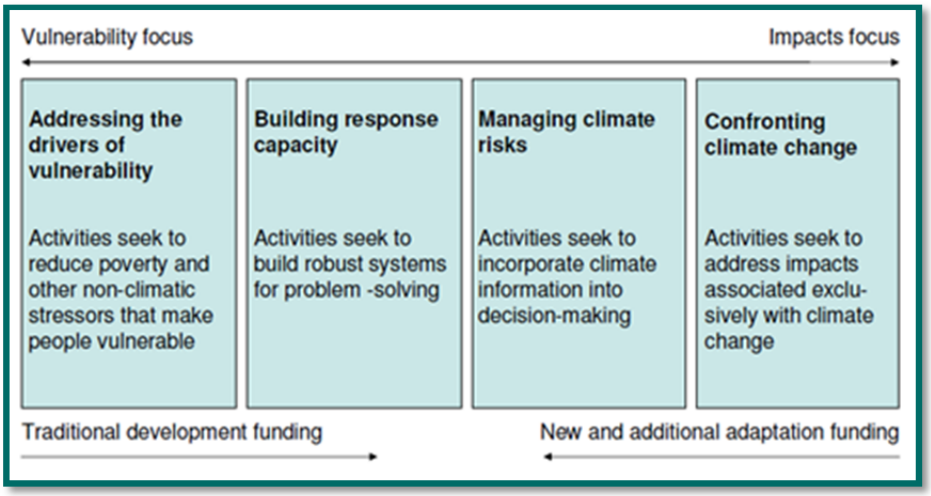
Third-generation studies attempt to address this issue by including elements of deficit accounting into their cost estimates. For example, both GRI-CCE (2009) and SEI (2009b) address the problem through accelerated infrastructure development.[5] Likewise, Fankhauser and Schmidt-Traub (2010) tackle the issue by using the Millennium Development Goals (MDGs) as their cost reference point. They estimate the cost of meeting the MDGs in the absence of climate impacts, then the additional cost of 'climate-proofing' this achievement. With this, they estimate a climate-proofing cost of $20 – $30 billion USD greater per year (by 2030) than the cost of the MDGs alone: $100 billion compared to $70-80 billion. This represents a 40% premium on MDG financing needs. Of course, the MDGs are themselves modest development goals, so the costs of any additional development and resulting climate adaptation beyond them are not included.

This issue can also be viewed through the slightly different lens of 'climate-resilient' development. This perspective emphasises that, in economic analyses like these, adaptation should not be treated as an additional activity that is separate from development, since, in practice, investment into one often brings about gains in the other. This is illustrated by the World Resources Institute's (McGray et al., 2007) 'development-adaptation continuum' (Figure 2). It is also reflected in the difficulty of classifying social protection measures as **either** social adaptation **or** development when, in practice, they achieve **both** at once.

In addition, there may be trade-offs between climate-resilient development and 'fast' development. In the WASH sector, for example, one response to the uncertainty of future climate could be to build lower-quality and shorter-lived infrastructure quickly, in the expectation that it will fail in the medium-term. This would defer decisions about incurring large adaptation costs until more is known about future climate, and avoid 'locking in' to a certain development path.

[5] This then raises GRI-CCE's (2009) estimate to $60 billion USD per year by 2030 for Africa and SEI's (2009b) to $600 million USD per year by 2030 for Rwanda. See annotation to Figure 1 above.

Figure 2: The development-adaptation continuum



Source: McGray et al. (2007), adapted by Klein and Persson (2008)

Residual damage

The third key issue relates to the handling of 'acceptable' levels of 'residual damage', arising from climate impacts that cannot be mitigated or adapted to because of the prohibitive costs of doing so. Parry et al. (2009) examine this, as does Fankhauser (2009) in his critique of the World Bank (2010) report. In this Bank report, adaptation costs are simply estimated as the interventions needed to restore pre-climate change levels of societal welfare. However, the two studies point out that cost-effective action on climate change would not reduce the costs of climate impact damages to zero. Instead, it would balance and jointly minimise the costs of climate impacts, mitigation and adaptation to an optimal level. In other words, it would find the balance point between the marginal costs and marginal benefits of mitigation, adaptation, and an agreed amount of residual damage. Returning to Fankhauser's critique, he suggests that the result of omitting residual damage is that the reported 'adaptation intervention costs' are overestimates, instead representing 'total climate change costs' (i.e., adaptation costs plus the costs of residual damage).

That said, this balance point is a complex ethical and economic policy area, and needs to be agreed both at a global level and within each country. In the global UNFCCC negotiations, no clear agreements on this topic have yet been made, with the so-called 'loss and damage' negotiations remaining highly contentious. The UNFCCC secretariat itself (2007) attempted to account for these residual damage costs, but only for its analysis of coastal zone risk, and with its estimates self-professed as conservative. Meanwhile, Parry et al. (2009) assert that one-fifth of all projected climate impacts on the agriculture sector by 2030 could end up being residual impacts, though this is highly uncertain.

From the macroeconomic perspective, in certain contexts, some of the costs of mitigation / adaptation / residual damage could be avoided by developing the economy in a different way. For example, avoiding construction in vulnerable flood plains in the first place would then avoid the need to adapt or accept damage to these areas later on. Likewise, the timing of mitigation/adaptation interventions also affects costs (e.g., early, cheap prevention or late, costly response) (Parry et al., 2009).

3 Economic methodologies for comparing adaptation interventions

3.1 Overview of methodologies for comparing adaptation interventions

In this chapter, we consider some specific methodologies for estimating both the costs *and benefits* of adaptation interventions. We also discuss the issues that can arise when using any of these methods, and issues to consider when selecting methods for use. Examples for the water sector are noted wherever possible, but the focus of this chapter is on the methodologies themselves. As discussed in Chapter 2, approaches to estimate adaptation costs have evolved in the past decade. However, there is still far less literature on the economic *appraisal* of specific adaptation interventions (i.e., *comparing* costs and benefits), especially for the African water sector. Those studies that exist mainly focus on adapting existing methodologies for economic appraisal, such as Cost-Benefit Analysis (CBA). However, others propose completely new approaches to appraising adaptation interventions. Table 1, below, lists the main methods used to date, drawing on various sources, including an overview of approaches by UNFCCC (2011).

Table 1: Methods used to compare adaptation interventions based on costs and benefits

	Method	Description	Output used to compare options	Advantages	Disadvantages	Example of its use in the water sector, where available (not necessarily Africa)
Methods making a comparison based on a specific metric (e.g., BCR)	Cost-Benefit Analysis (CBA)	CBA assesses benefits and costs of adaptation intervention options in monetary terms. Outputs include net present values, internal rates of return or benefit-cost ratios (BCRs). An adaptation cost curve (a ranked bar chart resembling a parabolic curve) can be used to visualise and compare BCRs for different adaptation interventions.	Benefit-cost ratios (BCRs)	- Quantitative output provides ease of comparison - Well-used and understood across many sectors	- Difficult to include non-monetised costs/benefits - Focuses on efficiency (i.e., ignores uncertainty and equity) - Method breaks down under deep uncertainty - Discounting has huge influence with long time horizons	- Irrigation and flood risk reduction in Nepal (Willenbockel, 2011) - Water management in Bolivia (IDB, 2011) - Adaptation cost curves in ECA (2009) for drought risk in China, India, Mali and Tanzania
	Cost-Effectiveness Analysis (CEA)	CEA identifies the least-cost option of reaching an identified target or risk reduction level, or the most effective option within available resources.	Cost-effectiveness ratios (CERs), e.g., cost per outcome	- Quantitative output provides ease of comparison - Can include non-monetised benefits	- Metric differs if outcome differs, so not comparable across projects - Focuses on effectiveness (i.e., ignores uncertainty and equity)	- Community water management in four Pacific island states (Kouwenhoven and Cheatham, 2006)
	Multi-Criteria Analysis (MCA)	MCA assesses adaptation intervention options against a number of criteria, which can be weighted, to arrive at an overall score	Weighted MCA scores	- Can include all benefits, whether monetised or not	- Scoring and weighting are subjective	- WRM in Yemen (Miller and Belton, 2011)

	Method	Description	Output used to compare options	Advantages	Disadvantages	Example of its use in the water sector, where available (not necessarily Africa)
	Cost Utility Analysis (CUA)	CUA is similar to CEA, but the denominator is not an outcome, rather a measure of utility (i.e., economic welfare). Utility scores of interventions are calculated, then turned into BCRs using the costs of each intervention. CUA is most commonly applied in health economics, but water management examples exist.	BCRs or cost-utility ratios	- Quantitative metrics allow ease of comparison - Increasing welfare is often a key policy objective	- Focused on utility of individual, therefore excludes benefits to society - Abstract nature of utility metrics can be confusing for non-experts	- Marinoni et al. (2011) apply CUA (and MPT, below) to a catchment in Australia
	Stakeholder-Focused CBA	A form of CBA that considers the distribution of costs and benefits among various stakeholders and the different weightings that they ascribe to them	Schedule of costs & benefits disaggregated across stakeholders	- Allows equity analysis of cost and benefits - Participatory	- Quite a time and resource-intensive process - More appropriate for single case studies than broad analysis	- Water case studies from Bolivia, Morocco, Malawi, Bangladesh and Nepal (IIED, 2013)
Other methods for comparing interventions	Risk Assessment	Risk assessment analyses current and future risks and identifies options to address the greatest threats	Subjective risk scores	- Can include uncertainty - Can use alongside CEA to bring a quantitative dimension	- Assumptions about likelihood are crucial - Not that immediately useful for comparing options	- Climate-proofing in six Pacific island states using an Integrated Risk Reduction framework (ADB, 2005)
	Modern Portfolio Theory (MPT)	MPT is an asset management methodology, which allows different feasible portfolios of assets to be compared on the basis of risk and expected return	Expected returns	- Integrates uncertainty and quantifies returns	- Strong and contested assumptions around rationality and complete information	- Marinoni et al. (2011) apply MPT (and CUA, above) to a catchment in Australia

Method	Description	Output used to compare options	Advantages	Disadvantages	Example of its use in the water sector, where available (not necessarily Africa)
Computable General Equilibrium (CGE) models	CGE models are a series of equations used to estimate how the economy could react to changes in independent variables. Commonly used in macroeconomics, they have also been used to model impacts of adaptation interventions.	Simulated changes in GDP and welfare at national or sector level	- Can model inter-sectoral linkages	- Omits nonmarket effects - Data-intensive and requires significant modelling skills that may not be available in developing countries - Not suitable for comparing multiple interventions	- Modelling the welfare and GDP implications of coastal protection in the face of sea-level rise (Bosello et al., 2007)
Investment and Financial Flow (IFF) Analysis	IFF estimates the fraction of current investment flows that are climate sensitive, then estimates the cost of 'climate-proofing' future capital investment using a mark-up factor	Gross adaptation costs at global or national level	- Relatively easy to apply	- Economy-wide analysis, not specific interventions - Mark-up is subjective - No analysis of benefits or residual impacts, only measures costs	- Adaptation costing for the 2007/8 Human Development Report (UNDP, 2007) - A complete IFF methodology guidebook, including specific guidance for the water sector, by UNDP (2009)

3.2 Practical issues related to methodology

This section highlights some key practical issues related to methodology, which could be relevant either in assessing existing studies or informing study design.

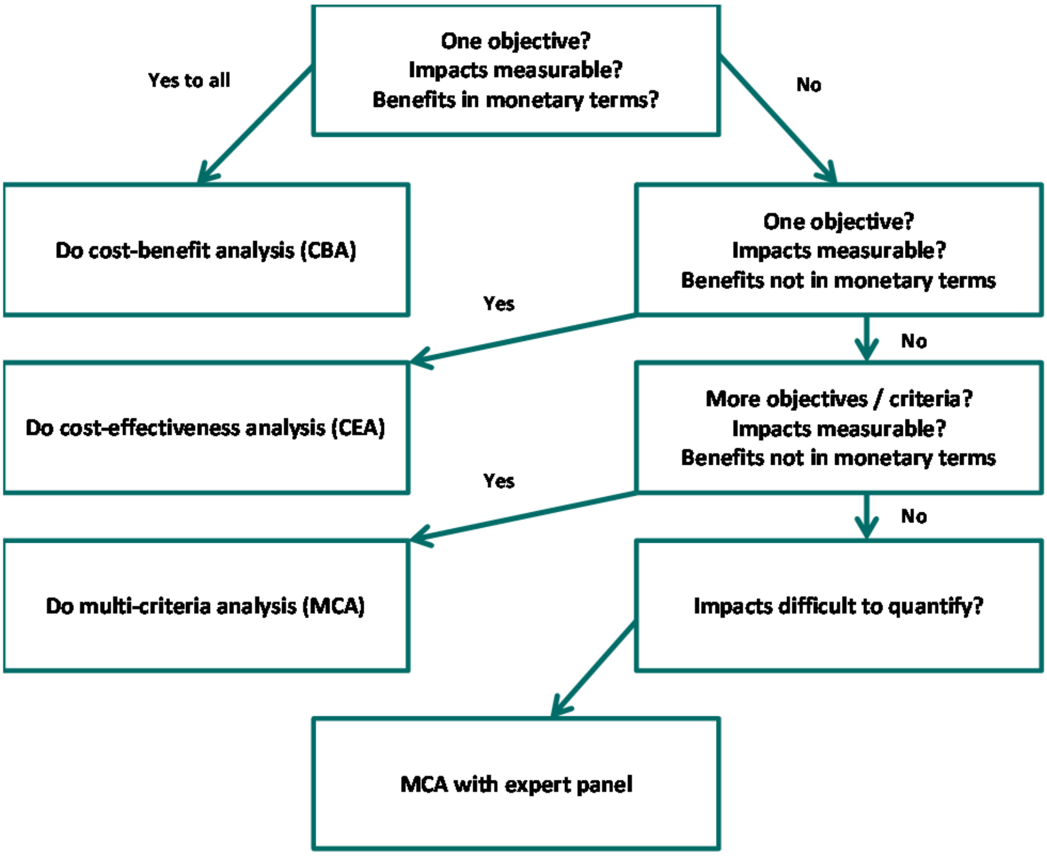
Issues to consider when selecting methods

As evident from Table 1, there is no universally 'perfect' economic appraisal method, with each having its own advantages and disadvantages. Identifying the most appropriate method for a particular context involves the following considerations:

1. **Study objectives**, for example whether the output will be used for investment planning or project design, and whether it focuses on adaptation, risk or vulnerability
2. **Level of analysis**, for example whether it is national, sectoral or at the project level
3. **Time-scale**, for example whether it focuses on a 5-year project or 50-year horizon scanning (which may need multiple climate scenarios)
4. **Resources available**, as some methods are data-intensive and therefore more expensive if data have to be collected
5. **Political context**, for example, what or whom the study is trying to influence and what approach will be most convincing, as well as an understanding of the value judgements and assumptions underlying each method

One example of how to structure these factors for decision making is illustrated in Figure 3, below. The figure displays a decision tree from the UNFCCC (2011) that provides guidance on how to select between CBA, CEA and MCA for most contexts. Creating a similar decision tree for all nine of the methods detailed in Table 1 would be a more difficult undertaking, but would rely on the same four basic decision criteria above.

Figure 3: A decision tree for the informed selection of CBA, CEA or MCA[6]



Source: Adapted from UNFCCC (2011)

Challenges in economic appraisal of adaptation interventions in the water sector

There are a number of challenges inherent in the economic appraisal of adaptation interventions in the water sector, many of which are challenges common to other aspects of climate change policy. Firstly, the deep uncertainty surrounding projected future climate and societal scenarios means that methodologies based on assigning probabilities are shaky. This issue is discussed in more detail in the next section. Secondly, the time horizons for economic appraisal of adaptation interventions may or may not be longer than those usually used. If they are longer, it affects discounting, as Box 2 explains. Finally, existing climate variability is influential in all scenarios (i.e., different programme designs and counterfactual) and the impact of weather on outcome variables is difficult to model even without climate change. Work by Oates et al. (2014) aims to provide better tools for risk screening and economic analysis that support WASH programme design.

The causal chain between changing climate variables and water sector outcomes is long, with increasing uncertainty along the chain (Figure 4). Even if we are relatively certain about predicted temperature increases, we are generally less certain about the impact this will have on rainfall. Furthermore, the knock-on effects of changes in rainfall (amount, timing, intensity, duration, distribution) on surface water flows and groundwater recharge

[6] A more detailed diagram is available in DEFRA (2013) *Economics of the National Adaptation Programme*, an annex of the UK government's *National Adaptation Programme Report*

are even less certain (Calow et al. 2011; Taylor et al. 2013). This affects the assumptions we can make in economic appraisal about different future scenarios, impacts on systems and services attributable to climate change specifically, and hence the impact of adaptation interventions.

The kinds of impacts that are predicted are damage and reduced operating efficiency of WASH and WRM infrastructure, e.g., through flooding, drought or increased pollution from warmer water temperatures. The vulnerability of these systems to future impacts is an additional pressure on top of their significant vulnerability to existing climate variability. The *Vision 2030* report (Howard and Bartram, 2009) summarizes evidence for climate impacts on water and sanitation infrastructure in the near- to medium-term.

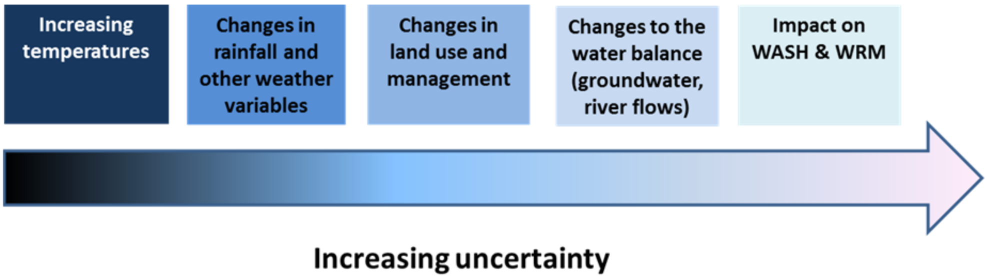
Box 2: Discount rates under climate change

Discounting is a key element of economic appraisal. It incorporates the principle of 'time preference' (we prefer to receive goods and services now rather than later) and the fact that future wealth is expected to be higher than the present. Essentially, a set of discount rates are applied to costs and benefits each successive year into the future. Discount rates are usually about 10% for developing countries, and 4% for richer countries, with the rationale being based on the rate of return on long-term government bonds. To illustrate using an example, at a discount rate of 10% in a country like Malawi, a benefit received in 10 years is worth only about 42% of what it would be valued at today. In 20 years, this falls to 16%. There are three problems with this approach when considering climate change

- **Welfare of future generations** – climate change brings *existential* risk, and the potential to significantly reduce the welfare of future generations. However, the above example shows that their welfare is rapidly valued at close to zero under usual discounting practices. This is ethically problematic. Conversely, if we set the discount rate very low, we risk over-valuing future generations at the expense of reducing poverty today.
- **Timing of benefits** – in a related but separate point, many adaptation interventions may bring large benefits, but only far into the future. Other measures may bring smaller benefits but closer to the present. The estimated timing of benefits is therefore very important, in addition to *who* benefits.
- **Tipping points** – modern economics is mathematically wedded to the idea of investigating small smooth changes at the margin. This is not well-suited to analysing tipping points, feedback loops, or other non-marginal effects predicted to occur from climate change. Again, this could under-value future benefits linked to the protection against future mega-floods.

Academic debates are unresolved, but policy is coalescing around the idea of a declining discount rate, which is one way of balancing current costs and distant benefits. For example, the UK government's preferred rate starts at 3.5% and declines steadily to 1% for more than 300 years into the future. Nevertheless, there is still no consensus, and the idea of *negative* discount rates is also gaining support (meaning that future welfare is valued higher than present welfare). For the moment, most development interventions (and appraisals thereof) continue to use short time horizons and fixed discount rates.

Figure 4: The cascade of uncertainty



Source: Adapted from Richard Carter (unpublished presentation)

It is important to recognise the difficulties of distinguishing between existing climate variability and future climate change, though this matters little for those already suffering the effects of both. Many African countries already experience high inter-annual (and intra-seasonal) variability in rainfall, for example, affecting both WASH services and WRM. While hydrology is part of a global system, subsystems display a high degree of heterogeneity at more local levels. This means that a wide variety of context-specific scenarios are possible and tipping points can exist – for example, with flooding, once a certain river level bound is exceeded. Furthermore, climate is only one of the risks to the water sector. Other challenges such as population growth, urbanisation and environmental degradation may be more important in both the short and medium term. For example, Tanzania's population is predicted to nearly triple between 2010 and 2050. The implications of this for water demand and land use are arguably more important than any predicted changes in the climate. Patterns of development and macroeconomic factors (such as the composition of GDP) are therefore important. Historically, changes to these have only taken place over the medium to long-term.

Alternative methodologies – adaptation decision-making under uncertainty

A recent DFID topic guide (Ranger, 2013) tackles the issue of adaptation decision making under uncertainty. It emphasises that accounting for the changing and uncertain climate need not be complicated and should not paralyse action, and introduces a range of concepts and tools for incorporating uncertainty into project appraisal.

Ranger builds on the work of Hallegatte et al. (2012), emphasising the importance of *deep* uncertainty – a situation in which we agree neither on which are the best models, nor on how the probabilities attached to key variables are distributed.

Most importantly for this paper, Ranger emphasises that with deep uncertainty, conventional economic tools such as CBA lose their value, because their mathematical optimisations are sensitive to uncertainty. Instead of considering only the optimisation objective (which is inherent in most neoclassical mathematical economics), we should also be focusing on *robustness* when appraising adaptation interventions. She argues that a resilient intervention is one that achieves its objectives today, but is also robust (i.e., high benefits under a variety of scenarios) and adaptive (i.e., can be altered to changing future conditions).

Ranger concludes by providing a toolbox (complete with examples) of ways to shift the focus towards robustness, including the following:

- **Low effort** – Sensitivity Testing (considering different climate scenarios and values of key variables) and Switching Values (evaluating the point at which values of key variables change the outcome, and whether these values fall within the bounds of plausibility)

- **Medium effort –** Robustness Matrix (comparing adaptation interventions based on qualitative scores for performance, average regret and maximum regret) and Qualitative Real Options Analysis (building a decision tree around different adaptation pathways, scoring them qualitatively)
- **High effort** – Robust Decision Making and Climate-Informed Decision Analysis (both more complex versions of the robustness matrix, including interdependencies and scenario plausibility respectively), and Real Options Analysis (enhancement of CBA to include timing and uncertainty, as well as incorporating flexibility in the form of future 'real' options)

It is likely that these methods will increasingly be used in adaptation decision-making although their application has been very limited to date.

4 Economics of adaptation in the African water sector

4.1 Summary of key studies on the costs and benefits of adaptation interventions in Africa's water sector

This chapter focuses on studies that specifically consider the water sector (including WASH and WRM) in African countries. Few studies focusing on the economics of adaptation have been carried out, and those that have carry the same kind of health warnings that accompany the cross-sectoral studies described in Chapter 2. Table 2 classifies and summarises 13 of the main ones.

A narrow scope was applied in selecting studies of relevance for this table. As mentioned earlier, only those that focus specifically on costing adaptation interventions to climate impacts *on* the water sector are considered, thus ignoring those studies focusing instead on climate impacts *from* water. For example, flooding and sea-level rise fall mainly into the latter category and are excluded, except where the adaptation costs are calculated for adapting to the impact of floods/sea-level rise specifically on water sector infrastructure. Note also that the inclusion of a study in this table does not signify a judgement of the quality of that study, but simply indicates that it covers something relevant to this topic.

As many of these studies consider the water sector as a whole, our table distinguishes between their WASH and WRM elements, where relevant. In addition, we classify the studies in two different ways: 1) their usefulness as a learning tool ('practical' / 'illustrative') and 2) their general focus ('sector-level' / 'project-level'). These categories are explained in more detail below the table.

Table 2: WASH and WRM in Africa – 13 significant studies on the costs and benefits of adaptation interventions

Study	Overview of the study	Area of African focus	WASH focus	WRM focus	Strengths and critiques	Classification[7]
Kirshen, 2007 *Adaptation options and cost in water supply*	Estimates the costs of adaptation interventions on water supply, including both WASH facilities and WRM measures	Continent-wide, regional, and country-level estimates for Africa	Estimates costs of groundwater use, desalination and increased use efficiency	Estimates costs of increased reservoir storage and water reclamation	Important 'first generation' study, though estimates neglect the adaptation deficit and 'soft' adaptation costs.	Illustrative Sector-level
Muller, 2007 *Adapting to climate change: water management for urban resilience*	Considers the physical and financial implications of climate impacts for urban areas in sub-Saharan Africa on water resources. Estimates the costs of adaptation interventions for urban water infrastructure.	Sub-Saharan Africa	Uses unit cost data from past projects and supply / demand assumptions to estimate costs of adapting existing urban water infrastructure (e.g., urban water storage and wastewater treatment) and the costs of new development.	Also covers water use for electricity generation	No time scale specified so costs cannot be properly compared or analysed. A basic methodology that only considers certain parts of urban infrastructure (storage, treatment and electricity generation).	Illustrative Sector-level
AEA, 2008 *Final report, Kenya: climate screening and information exchange*	Carries out a climate risk assessment to DFID's portfolio in Kenya, while also establishing the costs of adaptation via a CBA of a rainwater harvesting intervention	Kenya	Basic CBA for rainwater harvesting as an adaptation intervention	Some costing of the impact of floods and droughts, but not interventions	Project and location-specific CBA results are not easily comparable to other contexts, though the methodology is useful.	Practical Project-level
Dyszynski et al., 2009 *Climate adaptation*	Explores three methods of assessing adaptation intervention costs for the Kenyan water sector	Kenya	Investment and financial flows (IFF) analysis for the whole water sector	Case study of the Tana River Basin using integrated water modelling and	Comprehensive, top-down and bottom-up study of adaptation for Kenya's water sector, though it largely ignores 'soft' costs and	Practical Sector-level

7 The categories and methodology behind these classifications are discussed below in Section 4.2.

Study	Overview of the study	Area of African focus	WASH focus	WRM focus	Strengths and critiques	Classification[7]
economics: Kenya water sector	(including both WRM and WASH)			'adaptation signatures' – an analytical approach developed for short-term strategic decision making under conditions of long-term uncertainty	residual damage. Output cost figures specific to the Kenyan context.	
ECA, 2009 *Shaping climate-resilient development: a framework for decision-making*	Introduces a methodology to assess 'total climate risk' (using cost curves), and uses CBA to evaluate feasible (infrastructural, behavioural, technological and financial) adaptation interventions.	Case study of water in Tanzania	Tanzania case study addresses impact of droughts on human health via malnutrition and diarrhoea, based on predicted cases in 2030 under different scenarios. Calculates the costs and impacts of various interventions, including WASH infrastructure and hygiene education.	Addresses the impact of drought on power generation in Tanzania, providing a cost curve for adaptation intervention options, mainly focused on alternative power sources.	Effectively integrates the concepts of climate risk and adaptation economics across a variety of contexts, considering the adaptation deficit and many 'soft' costs. However, it omits a cost curve for WASH interventions.	Illustrative Sector-level
SEI, 2009a *Economics of climate change – Kenya*	Assesses the costs and benefits of adaptation strategies for WRM in the Tana River Basin	Kenya	Assesses demand-side economic costs of adaptation for water supply in the river basin case study	Uses a partial IFF analysis and adaptation signatures approach to assessing water resource adaptation in the river basin case study	Fairly in-depth top-down and bottom-up study of adaptation for Kenya, but its water sector focus is limited – looking only at this particular river basin and focusing mainly on the economics of broad WRM adaptation.	Illustrative Sector-level
SEI, 2009b *Economics of climate change in Rwanda*	Explores three methods of assessing the adaptation intervention costs for the Rwandan water sector	Rwanda	Has a section on water supply, but it only really addresses water demand.	Uses a partial IFF analysis and adaptation signatures approach to assessing flood risk	Fairly in-depth top-down and bottom-up study of adaptation for Rwanda's water sector, but its outputs are limited to the Rwandan context and do not include any actual adaptation intervention cost estimates.	Illustrative Sector-level

Study	Overview of the study	Area of African focus	WASH focus	WRM focus	Strengths and critiques	Classification[7]
Callaway et al., 2009 *Benefits and costs of measures for coping with water and climate change: Berg River Basin, South Africa*	Benefits and costs of measures for coping with water and climate change for the Berg River Basin, building on Callaway et al. (2008)	South Africa	(None)	Based on a water-climate-economy policy-planning model, it analyses a set of scenarios, resulting in alternative uses of the Berg River Dam. It finds that adding dam storage capacity is better for coping with climate change impacts than using water markets.	Presents an in-depth and highly contextualised model, the results of which are cited positively by several other authors. That said, it acknowledges a need to give more attention to other, less quantifiable management approaches, like basin planning, ecosystem resilience and cross-sectoral linkages (Watkiss et al., 2010).	Practical Project-level
GRI-CCE, 2009 *Possibilities for Africa in global action on climate change*	A multi-sector, region-wide review of climate change issues for Africa, including adaptation economics. Gives separate figures for the water sector.	Africa	Provides cost estimates for African countries to "climate-proof" their water infrastructure and re-shape demand patterns to respond to climate change.	Considers factoring climate change into the design and planning of water productivity and efficiency in farms, factories and cities	As highlighted in AfDB (2011), this study explicitly includes social adaptation and attempts to address the adaptation deficit, though still overlooks ecosystem adaptation.	Illustrative Sector-level
Ward et al., 2010 *Partial costs of global climate change adaptation for the supply of raw industrial and municipal water: a methodology and application*	Method for estimating partial global / regional adaptation costs for raw water supply, defined as the costs for providing enough raw water to meet future industrial and municipal water demand in 2050.	Includes African estimates	Focuses solely on the supply of raw industrial and municipal water, estimating costs for a baseline scenario excluding climate change, and then additional adaptation costs. It assumes increased demand will be met mostly via increased reservoir yield, with the highest costs of this in sub-Saharan Africa.	This raw water supply focus somewhat straddles the WASH/WRM boundary – e.g., it projects urban water demand (a WASH topic), but assumes that demand was met through reservoir yield (a WRM topic) – so it can be considered a focus on both here.	Undertakes the analysis with three scenarios: a 'socioeconomic baseline', a 'baseline plus climate change' and a 'climate change only' scenario, which allows it to separate out the adaptation deficit in its cost estimates. However, it does not explore other 'soft' interventions beyond that of increasing reservoir yields, such as costing efforts to instead decrease demand. The method is suitable only at the global or regional scale, not at the local or basin scale.	Illustrative Sector-level

Study	Overview of the study	Area of African focus	WASH focus	WRM focus	Strengths and critiques	Classification[7]
Jeuland, 2010 *Social discounting of large dams with climate change uncertainty*	Reviews the implications of the controversy over discounting for the appraisal of a hydropower project in Ethiopia	Ethiopia	(None)	Uses an integrated hydro-economic model that accounts for how the dam's transboundary impacts vary with climate change, running it with various different discount rates	An in-depth assessment of the challenges to social discounting under climate change. For this case study on dams though, it acknowledges a lack of data on decommissioning costs at the end of a dam's lifespan – a potentially large future cost like this (and others, like rising environmental costs) could significantly affect the net present value (NPV) calculations obtained via the discounting process.	Practical Project-level
UNFCCC, 2010 *National environmental, economic and development study (NEEDS) for climate change in Nigeria*	UNFCCC-supported studies for interested countries to assess adaptation costs, with some including the water sector in their assessments.	Nigeria case study considers the water sector.	(None)	Estimates cost of new small dams based on cost of a single, larger, previous dam.	Little detail on water provided, and the costing methodology relies heavily on extrapolation from a single case.	Illustrative Project-level
IIED, 2013 *Stakeholder-focused cost-benefit analysis in the water sector*	A comprehensive guidance document for stakeholder-focused CBA in the water sector (including adaptation intervention costs), based on experience piloting the approach in five case studies.	Malawi case study considers a lake and its upstream basin	(None)	Provides NPV trends for separate and combined adaptation strategies in water resources, mainly focusing on soil/water conservation and fisheries.	Strengths and weaknesses essentially relate to the method itself, as discussed in Table 1 above.	Practical Project-level

4.2 Further discussion of these studies

These 13 studies all consider some aspect of adaptation economics for the water sector in Africa, yet they vary significantly. In an attempt to draw out some of their similarities and differences, we classify them in two different ways: 1) their usefulness as a learning tool ('practical' / 'illustrative') and 2) their general focus ('sector-level' / 'project-level'). We assess 'usefulness' based on whether methods and assumptions are fully laid out and easily replicable, scoring 'practical' in this case or merely 'illustrative' if not. We assess general focus based on whether the study tackles broad water economics questions or focuses on the economics of discrete interventions, scoring 'sector-level' in the former case and 'project-level' in the latter case. As visible from the table, one of the studies is classed as 'practical and sector-level', four are classed as 'practical and project-level', seven are classed as 'illustrative and sector-level', and one is classed as 'illustrative and project-level'.

An example of each category is discussed here. We deem Dyszynski et al. (2009) as the only 'practical, sector-level' study. It gives good detail on its methodologies and assumptions for assessing the adaptation intervention costs for the Kenyan water sector as a whole. One of the 'practical, project-level' studies is IIED (2013). It presents itself as a user-friendly guidebook on using the stakeholder-focused CBA method, including a project-level case study of its use for WRM in Malawi. SEI (2009a) is one of the 'illustrative, sector-level' studies. It assesses adaptation costs and benefits for WRM and water supply activities in the Tana River Basin of Kenya, but does not provide enough detail on its methods and assumptions for the exercise to be replicable by readers. Finally, we deem UNFCCC (2010) to be the only 'illustrative, project-level' study. It assesses the adaptation costs for a dam in Nigeria, but provides little detail on its methodology.

The variety within these four categories is still significant though, as the studies can also be compared on their assessment of WASH/WRM topic(s), their use of methods and their countries/regions of focus within Africa. Four of the 13 studies have no explicit focus on WASH topics at all, while all 13 have at least some focus on WRM. The majority of studies that include both topics arguably have greater focus on WRM as well. The methods used are more nuanced. The two main methods used from Table 1 are the two forms of CBA and IFF, but several studies rely instead on context-specific modelling methods. As for country/regional focus, nine of the 13 take an individual African country for their analysis, though this consists of only seven unique countries (Kenya, Rwanda, Tanzania, South Africa, Nigeria, Malawi and Ethiopia). The remaining four focus more broadly across the continent, particularly on sub-Saharan Africa.

4.3 Research gaps and ways forward

The most notable observations from this collection of studies are how thin the list is and how little development there has been since 2010. Only one study is more recent than 2010. While there are likely some studies that we overlooked in this literature review, we conclude that research into the economics of water sector adaptation in Africa is still in its infancy. For example, only a few of the studies attempt to assess detailed water sector-level costs and benefits of adaptation for individual African countries (e.g., SEI (2009a and 2009b), AEA (2008) and Dyszynski et al. (2009)). In addition, these focus mainly on Kenya or Rwanda, and generally extrapolate their costs based on estimates for individual interventions / river basin case studies. This illustrates a need for more country-level water sector adaptation cost *and benefit* assessments. This is particularly the case for West and North Africa.[8]

[8] We acknowledge that our literature review did not include French search terms or French-language material. That said, none of the English-language literature we reviewed gives any indication that a rich variety of French-language studies exists on this topic for this region.

Likewise, only a couple of studies attempt to assess the broad costs and benefits of individual types of water sector interventions in the African context, such as dams and rainwater harvesting (e.g., AEA (2008), Jeuland (2010), UNFCCC (2010)). Their methodologies for doing so are not particularly useful for other contexts either (especially UNFCCC (2010), which provides very little detail for its estimates). This illustrates a need for more intervention-level economic assessments in the African context. This is particularly the case for WASH interventions, as WRM topics are the focus of the majority of these studies.

In addition, existing studies adopt a small number of conventional appraisal techniques - CBA, stakeholder-focused CBA and IFF – along with several custom-built and context-specific models. Although Table 1 highlights studies that apply these in the water sector, the majority are not African.

Finally, although five of the 13 studies are classed as 'practical', only the IIED (2013) study is really written as a handbook or 'tool' for new users. The other four provide detail on methods, but are not written in a 'step-by-step' manner that could provide simple and useful guidance. Arguably, ECA (2009) contains a practical annex that details a general climate risk and economics methodology in a user-friendly manner. Nonetheless, we judge it as 'illustrative', as it does not go into great depth on its water sector case study methods and assumptions. Similarly, the UNDP (2009) guidebook to IFF (from Table 1) includes guidance for the water sector, but is not specific to Africa.

There is thus a need for more guidebooks or tools that detail the application of specific economic methodologies for African water sector contexts. These could be general or country-specific and would be useful to stimulate the advance of in-country appraisals and staff capacity. Demand for this may not yet exist, but as finance for adaptation increases, such activities will become necessary in order to secure finance. Resources and researchers should thus be ready to lend their support.

5 Conclusions

As this review illustrates, it is still early days for economic appraisal of adaptation interventions for the water sector in Africa, yet work seems to have more or less stalled since 2010.

Many economic assessments to date have focused on aggregate, cross-sectoral costings for the entire African continent, with the magnitude and range of their estimates increasing as newer methods are applied to estimate ‘soft’ adaptation costs.

These newer studies are addressing some of the pitfalls of the older work, such as moving beyond cost estimates for physical infrastructure into more challenging realms such as ecosystem adaptation and social adaptation. However, three key challenges remain: fully incorporating ‘soft’ costs, costs associated with the ‘adaptation deficit’, and residual damage.

Water sector-specific studies on adaptation costs and benefits for African countries are still relatively rare and, to date, mainly rely on a few traditional methods. They have focused more on WRM than WASH and cover only a few countries, limiting the conclusions that can be drawn and highlighting the need for more work on the topic.

Across these studies, a key appraisal challenge is the fact that local water sector adaptation interventions lie at the end of a cascade of uncertainties and assumptions. This makes it difficult to project both the costs of non-intervention – baseline conditions – and the benefits that could be attributed to interventions. New assessment methods like robust decision making show promise in their ability to tackle this challenge, but remain to be tested in the African water sector context.

The forthcoming 2014 Fifth Assessment Report of the Intergovernmental Panel on Climate Change will include a chapter on the economics of adaptation. This may draw new insights from existing work, but will likely highlight the need for further research in this evolving field.

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