UNITED NATIONS DEVELOPMENT PROGRAMME

Planning Africa's Adaptation Finance:

Estimating and reducing country level adaptation gaps

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Acronyms and abbreviations

ABCR	Adaptation BCR
ABS	Adaptation Benefit Score
AdExp	Adaptation Expenditure
AfDB	African Development Bank
AF	Adaptation Fund
AFF	Adaptation Financing Framework
AG	Adaptation Gap
AGCS	Adaptation Gap Closing Strategy
AGR	UNEP Adaptation Gap Report
AOC	Adaptation Objectives Score
AR1-7	IPCC Annual Assessment Reports
ASAL	Arid and Semi-Arid Land
AUC	African Union Commission
BA	Biennial Assessments
BCR	Benefit Cost Ratio
BTR	UNFCCC Biennial Transparency Report
BUR	UNFCCC Biennial Update Report
CAR	Central African Republic
CBT	Climate Budget Tagging
CC	Climate Change
CCFF	Climate Change Financing Framework
CCIA	Climate Change Impact Appraisal
CFU	Climate Funds Update
CFL	Climate Finance Landscape
CGE	Computable General Equilibrium
COP	UNFCCC Conference of the Parties
CPEIR	Climate Public Expenditure and Institutional Review
CPI	Climate Policy Initiative
CRA	Climate Risk Assessment
CSO	Civil Society Organization
CSVM	Climate Change Security Vulnerability Model
DAC	Development Assistance Committee
DBCR	Development BCR
DCPEIR	Disaster and Climate Public Expenditure and Institutional Review
DRC	Democratic Republic of the Congo
DRM	Disaster Reduction and Management
EICC	Economic Impact of Climate Change
ETF	Enhanced Transparency Framework
FNC	First National Communication
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Green Environment Facility
GoK	Government of Kenya
IAM	Integrated Assessment Model
ICOR	Incremental Capital Output Ratio
IPCC	Intergovernmental Panel on Climate Change
IRR	Internal Rate of Return
L&D	Loss and Damage
LDC	Least Developed Country
LTS	Long-term Strategy
MDB	Multilateral Development Bank
NAP	National Adaptation Plan
NCQG	New Collective Quantified Goals
NDC	Nationally Determined Contribution
NPV	Net Present Value
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PAAF	Planning Africa's Adaptation Finance (report acronym)
PB	Program Budgeting
PEFA	Public Expenditure and Financial Accountability
PFM	Public Financial Management
PVCCI	Physical Vulnerability to Climate Change Index
SCF	UNFCCC Standing Committee on Finance
SNC	Second National Communication
SOE	State-Owned Enterprises
SRE	Standard Reference Estimate
TNC	Third National Communication
UNDP	United Nations Development Programme
UNECA	UN Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	UN Framework Convention on Climate Change
WB	World Bank

Short summary

Many African countries are working to refine their Nationally Determined Contributions (NDCs) to the Paris Agreement and to estimate the costs of implementing NDC actions. This review of Planning Africa's Adaptation Finance (PAAF) **assesses whether existing and planned adaptation expenditure is sufficient to avoid the economic impact from climate change (EICC)**. The analysis is done at country level. A wide variety of evidence is used and care is required to integrate this evidence into a single analytical framework, especially as adaptation expenditure is defined in different ways. The PAAF framework aims to capture the essence of more complex modelling using a spreadsheet in order to be transparent and accessible to governments. Some of the evidence is limited and some assumptions can be considered 'placeholders' whilst data improves. This applies particularly to the evidence on the effectiveness of adaptation expenditure in reducing EICC and to the scale of private sector adaptation.

For Africa as a whole, the PAAF analysis suggests that GDP will be 9.3 percent lower in 2050 as a result of climate change and the Net Present Value of GDP from 2020 to 2050 will be 3.8 percent lower. Only part of this EICC is avoidable by cost-effective adaptation actions. **The annual adaptation expenditure needed to avoid all avoidable EICC is 10.4 percent of GDP but the majority of this expenditure makes a strong contribution to development, in addition to adaptation. Existing adaptation expenditure is 3.3 percent of GDP and full implementation of NDC actions would cost a further 2.4 percent of GDP.** Full funding of current NDC costings could be achieved within 10 years through a mix of domestic revenue, international assistance and the private sector, provided past growth is maintained. This would address 55 percent of needs. The remaining 45 percent will need to be included in NDC costings as new actions are added (e.g. relating to health and labour productivity) and the scale of actions is refined. In fast growing African countries, the full needs could be fundable mainly from national public and private sources within about 25 years. In the short- and mid-term, most African countries are close to debt ceilings and therefore are very dependent on international grants. The analysis has implications for the scale of New Collectively Quantified Goals for adaptation funding and of the Loss and Damage Fund agreed at COP27.

At country level, the PAAF analysis shows that there are wide variations in the gap between the needs and existing supply of adaptation funding. The countries with the highest gaps tend to combine both high needs and low existing adaptation expenditure and include: Benin, Burkina Faso, Cameroon, Central African Republic, Democratic Republic of the Congo, Liberia, Niger and Somalia. **The PAAF analysis also estimates sectoral adaptation gaps for each country, which may help to guide the focus of NDC costing work towards sectors that are most underfunded, relative to needs.** Work on refining NDCs could include a strategy for closing the adaptation gap, covering all potential sources of finance.

Executive summary

Introduction

Climate change is expected to substantially reduce the development gains that Africa is projected to make over the coming decades. However, we know that through adaptation action there are a multitude of solutions that can support countries to lessen or avoid these socio-economic impacts. To do so requires finance and yet current funding levels towards adaptation remain well below what is required. At global and country levels, the estimation of the adequacy of adaptation expenditure has generally been guided by three main strands of work:

A. Cost estimates for delivering Nationally Determined Contributions (NDCs) and associated strategies at country level;

B. Mainstreaming adaptation at country level into planning and budgeting, through climate expenditure reviews, budget tagging and other initiatives; and

C. The use of economic models to show the optimum levels of adaptation spending, mostly at a global or regional level.

Although these three strands of work are typically undertaken largely in isolation from each other, UNEP's Adaptation Gap Reports (AGRs) do compare the results from each of the strands. Additionally, as countries continue to mainstream climate across sectors through NDC and National Adaptation Plan (NAP) processes, we are seeing improved coherence. Nonetheless, there is some continuing isolation of this work, which is partly because of the different objectives and scope of the strands and partly due to technical challenges, including the need to adopt common definitions of adaptation expenditure.

Objectives. The overall objective of this report on Planning Africa's Adaptation Finance (PAAF) is to contribute to the ongoing improvement in the quality and influence of adaptation planning in Africa at a country level. The report seeks to achieve this through the following detailed objectives:

- To develop and apply a practical **methodology** for estimating country adaptation gaps;
- To strengthen evidence on the **economic impact of climate change** (EICC) at country level by producing estimates using a transparent method that facilitates comparability across countries and triangulation with different studies in one country;
- To promote the ongoing growth of evidence on **effectiveness** and show how this can be used to improve prioritisation and estimate the adaptation **funding needed** to avoid EICC;
- To support ongoing international work to build coherence in defining and reporting on **adaptation expenditure**, applying consistent methods to publicly available data in the national budget, from international sources and in the private sector;

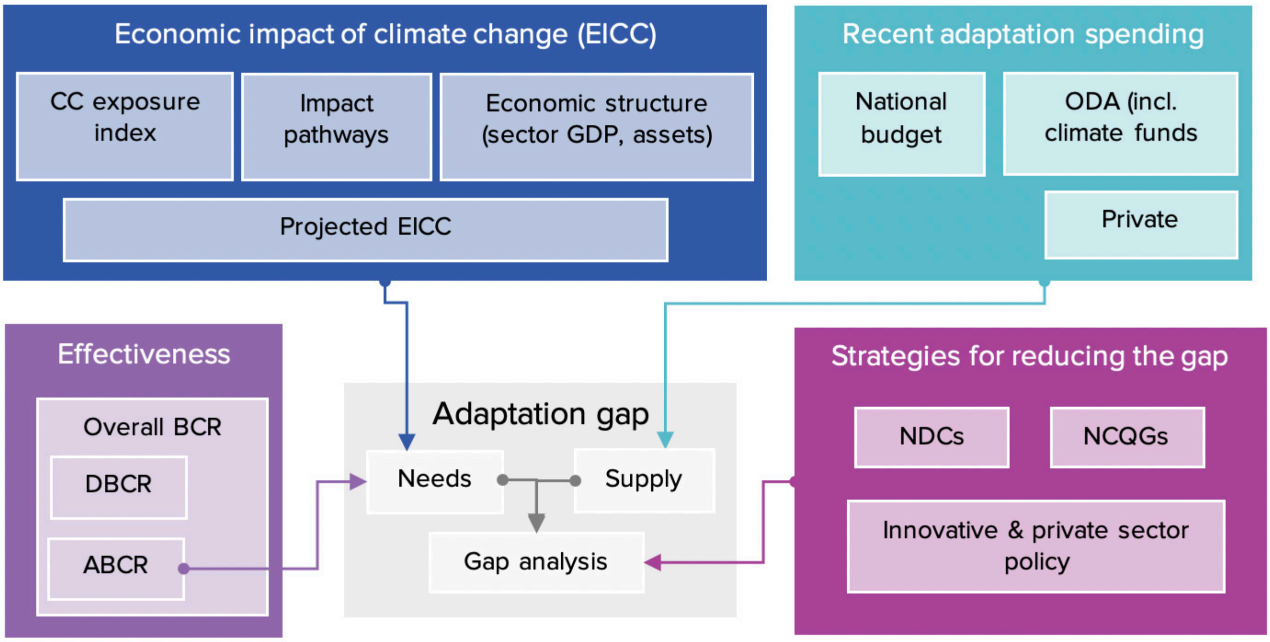
- To provide an initial overview of the adequacy of adaptation finance for Africa, and of the potential contribution of the main sources for closing the gap, thus contributing to the ongoing debate about the scale and focus of the Loss and Damage Fund agreed at COP27 in Egypt; and
- To illustrate, though country case studies, how the Standard Reference Estimate produced by PAAF can be replaced by improved national estimates, when additional resources are available to explore country specific evidence.

Methodology – Using country adaptation gaps to strengthen adaptation planning

The analysis estimates the adaptation gap as the difference between the total needs for adaptation expenditure and current levels of expenditure (see Figure S1). This methodology is applicable in any region and allows for comparison with related approaches to estimating the adaptation gap. To facilitate direct comparison between needs and supply, figures for needs and supply are presented as a percent of Gross Domestic Product (GDP). For Africa as a whole, GDP in 2019 was US$2.502 billion, so 1 percent of GDP is $25 billion. There are challenges in defining adaptation expenditure and weights are sometimes used to recognise the fact that most adaptation expenditure also contributes to development. The PAAF analysis presents unweighted adaptation expenditure alongside weighted expenditure to facilitate comparison with NDC costing work.

- EICC is estimated from 5 climate risks through 13 impact pathways. Country exposure to climate risks is based on 16 different international indices. Sectoral GDP is reduced both directly and through a growth effect resulting from reduced investment. The economic impact from existing climate risks is not included in EICC. The adaptation expenditure needed to avoid this EICC, is estimated by dividing the EICC by the effectiveness of expenditure in delivering reduced EICC.
- Current public adaptation expenditure is derived from national budgets, using the most recent budget data available before Covid-19. Line items are tagged using 20 standard climate subsector codes, each of which has a standard Climate Public Expenditure and Institutional Review (CPEIR)-style weight. This produces results that are roughly comparable with the standard OECD DAC approach to weighting. An initial illustrative estimate of private adaptation is made from national accounts data on total private investment and pan-African evidence of the sectoral composition of private investment.

Figure S1: PAAF methodology

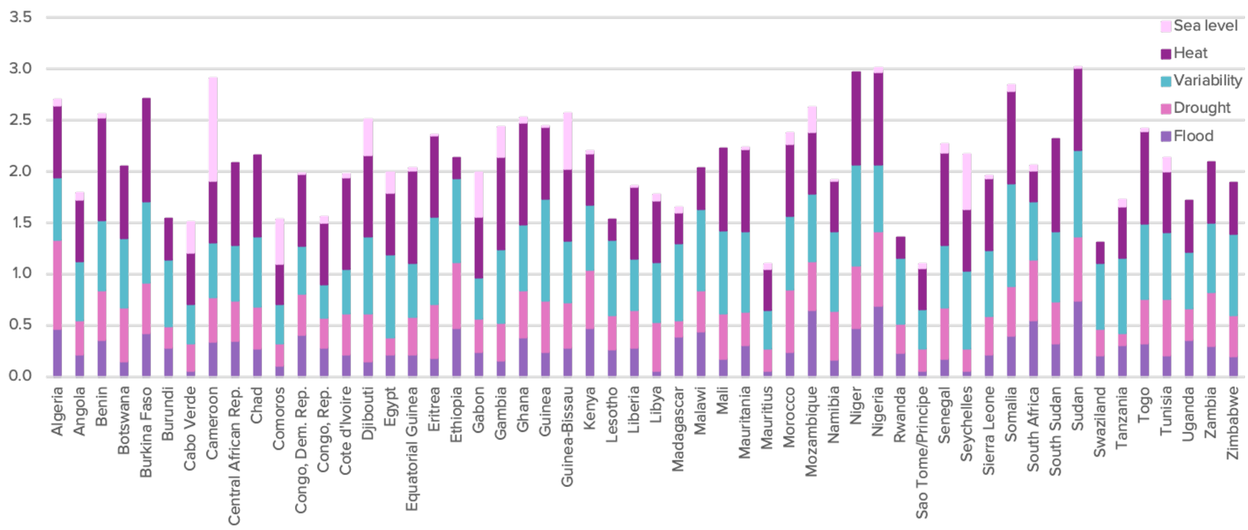


ODA = Official Development Assistance; BCR = Benefit Cost Ratio, DBCR = Development BCR, ABCR = Adaptation BCR (i.e. reduced EICC / costs), NDC = Nationally Determined Contributions, NCQG = New Collective Quantified Goals

Economic impact of climate change – Synthesising evidence into consistent estimates

Exposure. Figure S2 describes the results of the analysis of exposure to climate risks. Whilst most countries are exposed to significant climate risks from heat, drought and rainfall variability, exposure to flood risks and sea level rise is more varied.

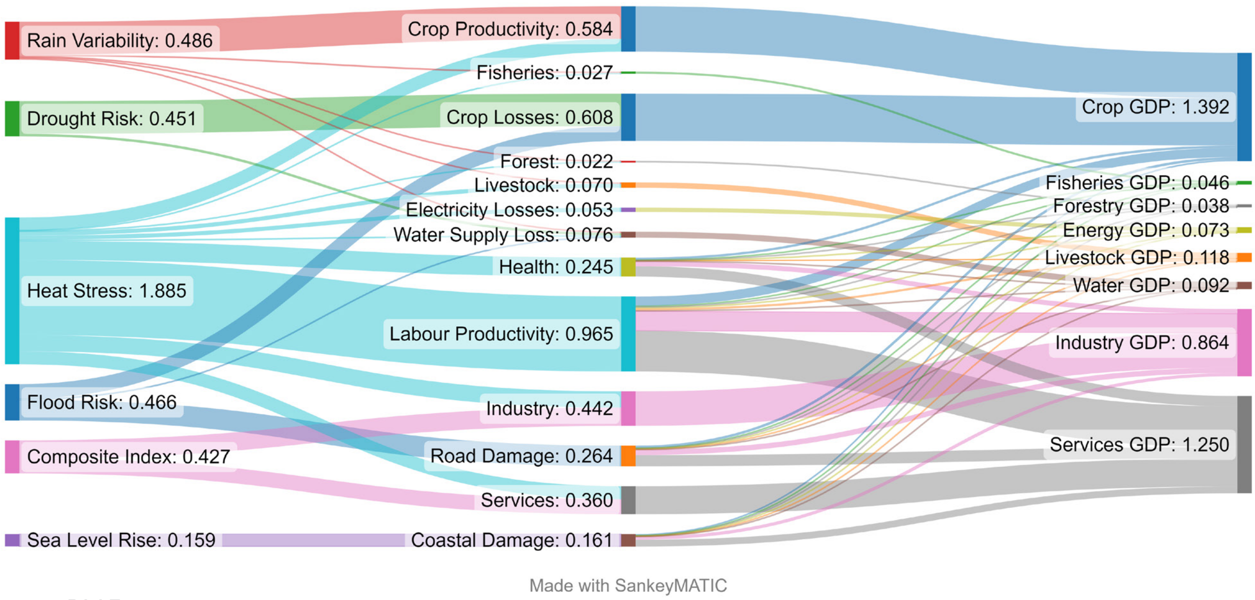
Figure S2: Exposure to five climate risks (index of 0-1 for each risk)



Source: PAAF analysis of 16 global indices.

Economic impact. Figure S3 presents a Sankey diagram of the way in which the 5 climate risks affect the 13 impact pathways which then contributes to impact on GDP sectors. The figures are for Africa as a whole, adding the separate impacts for each of the 51 countries covered. **The total EICC for Africa is 3.8 percent, when expressed as the Net Present Value (NPV) over the period to 2050, and 9.3 percent when expressed as the reduction of GDP in the year 2050.**

Figure S3: Climate risks, pathways and GDP impact (NPV of GDP loss to 2050)



Source: PAAF estimates.

Effectiveness – Understanding how adaptation actions reduce EICC

PAAF defines the effectiveness of adaptation expenditure as the Benefit Cost Ratio or BCR of related expenditure (i.e. the total benefits from related expenditure divided by the expenditure). The total effectiveness is divided into development effectiveness (i.e. the contribution to economic, social and environmental development) and adaptation effectiveness (i.e. the contribution to reducing the EICC). The evidence for effectiveness is taken from three global reviews (by African Development Bank and Global Center on Adaptation) and grey literature on Climate Change Impact Appraisal (CCIA) case studies. BCRs are estimated for each sector and the analysis suggests that, **for Africa as a whole and across all sectors, 13 percent of the benefits from adaptation expenditure come from reducing EICC and 87 percent come from development, including protection from existing climate risks**. There is no evidence of the effectiveness of private investment in each sector in delivering adaptation benefits and, as a working 'placeholder' assumption, it is assumed that this is half the effectiveness achieved by public expenditure in the sector.

Adaptation needs – Using EICC and effectiveness to estimate total needs

The total adaptation expenditure needs are estimated by dividing the EICC by the adaptation effectiveness of expenditure, as expressed in an Adaptation Benefit Cost Ratio (ABCR), although adjustment factors are required to ensure that the time periods for EICC and benefits are consistent. **The analysis suggests that Africa as a whole would need to devote 10.4 percent of GDP annually to unweighted adaptation (both public and private) to avoid all the EICC that can be avoided by cost-effective adaptation options.** This is 27 percent of total public and private investment, which seems large. However, most adaptation is development expenditure that generates additional benefits as existing climate risks becomes more severe. The adaptation benefits may occur either without change in design or with some changes (e.g. proofing or targeting).

Adaptation expenditure – Consistent definitions and sources

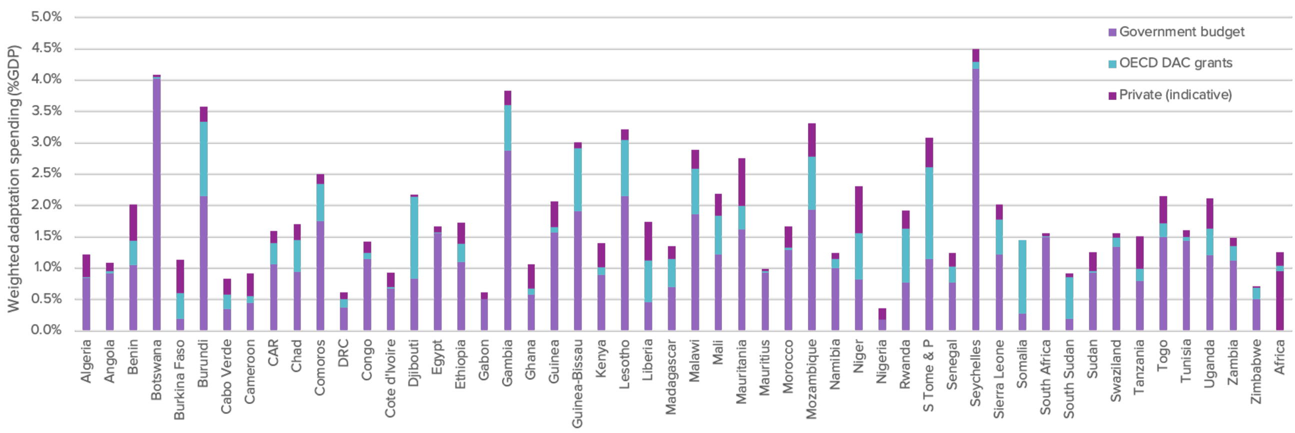
National budget. The analysis of current public spending on adaptation uses the budget documents that are publicly available on the websites of finance ministries and from the World Bank's **BOOST open budget portal**. The analysis uses the latest budget available that was approved before the start of Covid-19 (i.e. usually for 2019). In most countries, the level of detail goes one level below that of ministry (e.g. to directorate or program). The analysis does not pick up: subnational expenditure (except for South Africa and Seychelles); or agencies and public enterprises (except for Seychelles, South Africa and Egypt). These are often important sources of adaptation finance and the way they are financed varies greatly from country to country, so further work on this is an important priority for improving evidence on the adaptation gap. Expenditure is classified according to a standard system of subsectors, with associated weights that are consistent with normal practice in CPEIRs.

International. The OECD DAC figures of Official Development Assistance (ODA) include 'Rio markers' that identify whether development assistance has adaptation objectives (either primary or secondary objectives). This includes funding from multilateral development banks and bilateral partners. International climate funds are also included but account for less than 2 percent of public adaptation for Africa as a whole, although they contribute more than 10 percent for a few countries. ODA loans will normally be included in budget figures and the analysis assumes that ODA grants are all off-budget. In practice, some grants will be on-budget but there is no easy way to identify which.

Private adaptation. PAAF considers the potential for the private sector to contribute to adaptation, in order to assess the adequacy of public adaptation. Data on this is limited. The Climate Policy Initiative (CPI) Climate Finance Landscape studies for Kenya and South Africa pick up very little private adaptation. However, there is good anecdotal evidence that enterprises and households are highly motivated to improve resilience, especially in the agricultural and water sectors. National accounts contain estimates of total private investment and financial sector surveys provide evidence of the sectoral breakdown of private investment. No evidence is available on the 'adaptation share' of private investment (i.e. the share of private investment that contributes to adaptation). To obtain a first working estimate of private adaptation, PAAF made the conservative assumption that the private adaptation share was half the public adaptation share.

Figure S4 presents the results of the analysis of budgets, ODA grants and private adaptation. The analysis covers only preventive adaptation and does not cover reactive adaptation (e.g. humanitarian aid, social protection or insurance), which would ideally focus on EICC for which there is no cost-effective preventive adaptation. Figures S4 shows that **total weighted adaptation expenditure is about 1.26 percent of GDP for Africa as a whole, comprised of 0.95 percent in the government budget, 0.09 percent from ODA grants and 0.22 percent from private adaptation. In most countries, weighted adaptation is between 0.5 percent and 1.5 percent of GDP**. Countries with low levels of adaptation spending, even taking into account grants include: Cabo Verde, Democaratic Republic of the Congo and South Sudan. Nigeria may be a special case because the analysis does not include subnational expenditure, which is likely to be large. Countries with high adaptation expenditure include higher-income countries (e.g. Botswana and Seychelles) and low-income countries for which adaptation in the budget is probably funded mainly from ODA loans (e.g. Burundi, The Gambia, Guinea, Guinea-Bissau, Lesotho, Malawi, Mauritania, Mozambique and Togo). Converting from weighted to unweighted expenditure is not straightforward, however as first estimate, **total existing adaptation expenditure is 3.3 percent of GDP while estimated adaptation needs are 10.4 percent. The latest estimates from ongoing NDC costing work suggest that full NDC implementation would increase adaptation spending by 2.4 percent of GDP (i.e. from 3.3 percent to 5.7 percent), thus meeting over half of adaptation needs**.

Figure S4: Weighted adaptation expenditure (%GDP)

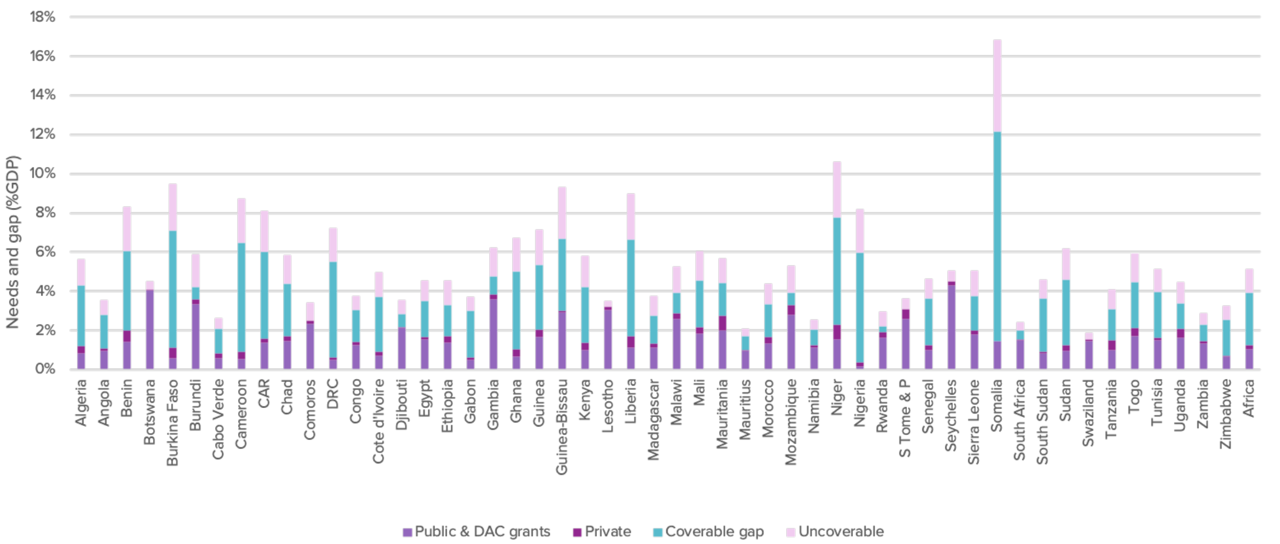


Note: Seychelles and Botswana outliers are caused primary by large expenditure on water supply some of which includes adaptation.
Source: PAAF estimates.

The adaptation gap – Using evidence about the gap to guide adaptation planning

The adaptation gap is the adaptation needs less the current spending on adaptation, both public and private, with both expressed as percent GDP and in weighted expenditure. Projections of both EICC and of the reduction in EICC from adaptation expenditure follow sharply increasing trends which are not fully aligned but which are approximately comparable. The trends are compared using the NPV of both projections. A part of total needs is 'uncoverable' and cannot be met by any cost-effective adaptation. This is estimated using global modelling results, with sectoral details informed by the AfDB 2019 report on climate change impacts in Africa. The blue bars in Figure S5 show the coverable gap (i.e. needs which are not currently met, but which could be met cost-effectively). **The figures suggest that, for Africa as a whole, weighted adaptation expenditure needs to increase from the current level of 1.26 percent to 4.1 percent of GDP.** For comparability with NDCs, the unweighted expenditure equivalent involves an increase from 3.3 percent to 10.4 percent and the coverable gap is 7.1 percent of GDP (i.e. $178 billion in 2019). **For most countries, the coverable gap is between 4 percent and 10 percent of GDP.** This a large requirement, but most of the adaptation expenditure is delivering development benefits (i.e. GDP growth) as well as adaptation benefits (i.e. reduced climate EICC).

Figure S5: Existing adaptation expenditure and coverable and uncoverable gaps (%GDP, weighted)



Source: PAAF analysis.

The UNEP 2023 Adaptation Gap Report (AGR) found that the latest estimates of adaptation financing needs for all developing countries are higher than the previous AGR estimate and are now 0.6 to 1.0 percent of GDP. This is lower than the PAAF estimates for Africa, probably because the AGR includes middle-income countries. Financing needs are 10 to 18 times international public adaptation flows, leaving a large and growing adaptation gap.

Matching sectoral spending with needs. The analytical framework makes it possible to explore the adaptation gap for key sectors in each country. **For Africa as a whole, the sectoral shares of adaptation expenditure are reasonably well aligned with sectoral shares of needs.** To summarise the detailed country results, a country alignment index assesses the alignment of expenditure with needs. This suggests that the following countries have best aligned their existing adaptation spending with needs: Algeria, Chad, Democratic Republic of the Congo, Egypt, The Gambia, Lesotho, Morocco, Namibia, Niger, Senegal, South Africa, Swaziland and Zimbabwe. However, this analysis should be considered provisional and indicative and is useful mainly for illustrating methods that could be used to ensure that NDC sectoral allocations are aligned with needs. The analysis raises some key questions including: challenges in analysing the water sector, partly related to the fact that water sector GDP estimates may be based on costs and not the value of water; low funding for livestock; and issues relating to potential EICC in the wider economy (including manufacturing and services) as a result of health and labour productivity effects.

Closing the gap. Figure S6 presents an illustrative example of a strategy for closing the adaptation gap over 25 years for a hypothetical country, based loosely on average figures for Africa.

Figure S6: Strategy for closing the adaptation gap over 10 and 25 Years

Sources	2019	Y10	Y25	Comments and assumptions
GDP growth		34%	109%	Assuming 3% annual growth
Public adaptation funding				
Own revenue	2.18%	2.68%	3.43%	Increases by 0.05% GDP/year
Budget effectiveness growth		0.27%	0.86%	BCRs improve by 1% per year
ODA grants	0.23%	0.76%	0.30%	Achieving COP15 $100bn target
ODA loans	0.26%	0.30%	0.50%	DRR/CCA receive higher share of ODA loans
NCQG contribution		0.33%	0.33%	Assuming extra $20bn adaptation
Innovative instruments		0.10%	1.00%	Fiscal space created by bonds, swaps …
Total	**2.67%**	**4.43%**	**6.42%**	
Private adaptation funding				
Existing and natural growth	0.56%	0.80%	1.50%	Increasing focus on adaptation
Accelerated growth		0.50%	1.60%	Policy dependent acceleration
Total	**0.56%**	**1.30%**	**3.10%**	
Coverable adaptation gap				
Coverable needs	10.40%	10.12%	9.51%	Declines with economic growth
Public and private funding	3.23%	5.73%	9.52%	Y10 growth of 2.36% GDP typical NDC costing
Gap (unweighted)	7.17%	4.39%	0.00%	For comparison with unweighted NDC costing
Gap (weighted)	2.80%	1.71%	0.00%	Comparable with CPEIR-weighted analysis

Note: the implications of economic growth for the adaptation gap are explored in section 6.4.

Source: Section 6.4 of the PAAF report.

Most African countries are close to debt ceilings and cannot incur new borrowing. As a result, increasing adaptation spending from own revenue would require a reduction in other spending, which is likely to be politically and economically undesirable. There will be some increase in absolute spending with GDP but the gap analysis defines both needs and spending as a percent of GDP and both therefore increase in line with GDP. Opportunities for closing the gap include the following:

1. GDP growth is strongest in sectors with lower EICC (e.g. industry and services) and total coverable needs thus decline by 0.28 percent GDP in Year 10 and 0.89 percent in Year 25.

2. In most countries, the revenue share of GDP rises with development and this could provide an additional 0.50 percent of GDP in 10 years.

3. An increase in climate sensitisation of existing expenditure (i.e. improved effectiveness of public spending in reducing EICC) could reduce the gap by 0.27 percent of GDP in 10 years.

4. If the $100 billion target for climate finance is met, and if half is devoted to adaptation and Africa receives 34 percent of the global total, this could deliver an additional 0.57 percent of GDP, mostly through grants, given limits to borrowing. The scope of New Collective

Quantitative Goals has not yet been agreed, but if they result in provision of an additional global total of $20 billion for adaptation, this could meet a further 0.33 percent of GDP.

5. New financing instruments, like green or blue bonds and debt swaps, could make an important contribution although the new fiscal space created by such bonds is limited for most African countries, because they are close to debt ceilings.

6. The private sector is increasingly interested in adaptation. The current levels of private investment are likely to increase substantially (e.g. by 0.4 percent of GDP) and supportive public policy could double that natural rate of increase.

The combined effect of all the above sources would be to increase public and private funding by 2.5 percent of GDP in 10 years, which is similar to the costs involved in full implementation of NDCs, based on the latest evidence from costing work. Much of this growth in adaptation spending is mildly exponential, in line with GDP growth accelerated by supportive policy, which suggests that it could be possible to fund all adaptation needs from domestic public and private sources after about 25 years. In the short– to mid-term, most African countries are very dependent on the New Collective Quantified Goals delivering a substantial increase in international funding for adaptation.

Conclusions and recommendations

Many African governments are working to improve the quality and influence of their NDCs. This work could include the identification of adaptation gaps and a strategy for closing the gap by considering the potential contribution of all the main sources of finance, including both public and private expenditure. This strategy will create the analytical framework that justifies the level and nature of funding for adaptation, which should motivate governments, enterprises and international partners.

The framework will influence government adaptation by: providing demand for improved country evidence on the economic impact of climate change (EICC); requiring existing methods of assessing expenditure effectiveness to be adjusted to accommodate the adaptation benefits from reducing EICC; and guiding the way in which adaptation expenditure flows are monitored (through climate budget tagging) and evaluated (in CPEIRs). The framework will also encourage international institutions to integrate adaptation funding within national systems and strategies, within the budget as much as possible. Finally, the framework could help build collaboration on adaptation with the private sector and orient legislatures and civil society in their role of raising awareness about the role and importance of adaptation. The report concludes with technical recommendations for analysts in building consistency in country work on adaptation financing.

1 Introduction

This chapter reviews the background and objectives of the report. It also presents an overview of the methodology and how the various strands of evidence are used to estimate the adaptation gap. Further details of the methods and sources of evidence are also presented in the chapters on each element of the analysis.

1.1 Background

Climate change is expected to reduce substantially the development gains that Africa is projected to make over the coming decades[1] (AfDB, 2019b). However, we know that through adaptation action there are a multitude of solutions that can support countries to lesson or avoid these environmental and socio-economic impacts. To do so requires finance, and yet, current funding levels towards adaptation remain well below requirements[2].

At global and country levels, the estimation and adequacy of adaptation expenditure has generally been guided by three main strands of work:

A. Cost estimates of delivering Nationally Determined Contributions (NDCs) and associated strategies at country level;

B. Mainstreaming adaptation at country level into planning and budgeting, through National Adaptation Plans (NAPs), climate expenditure reviews, budget tagging and other initiatives; and

C. The use of economic models to show the optimum levels of adaptation spending, mostly at a global or regional level.

These three strands of work have typically been undertaken largely in isolation from each other, although the United Nations Environment Program's (UNEP) Adaptation Gap Reports (AGRs) compare the results from all strands and support to climate mainstreaming work, through programmes such as the United Nation Development Programme's (UNDP) Climate Promise, is building improved coherence by strengthening governance, policy and planning of climate action through a whole-of-economy and whole-of-society approach. Nonetheless, there is some continuing isolation of this work, which is partly because of the different objectives and scope of the strands and partly due to technical challenges, including the need to adopt common definitions of adaptation expenditure.

1 The PAAF review concentrates on the period up to 2050 because: a) it is long enough to register the cumulative impact of climate change; b) it is the longest time period typically covered by long-term government strategies; and c) thirty years is the typical period considered in the economic analysis of policies and programmes.

2 'Requirements' are defined as the expenditure needed to fund all cost-effective adaptation actions, with cost-effectiveness determined by whether adaptation expenditure delivers returns that are competitive with development expenditure.

UNFCCC and climate finance governance

The United Nations Framework Convention on Climate Change (UNFCCC) is the mechanism within which countries can structure the global response to climate change while the annual Conferences of the Parties (COPs) provide the space to negotiate this response. COP21 (Paris) defined clear targets for reducing climate change and highlighted the importance of NDCs as policy instruments facilitating countries to define their national climate pledges and priorities. COP26 (Glasgow) further elaborated commitments to mitigation, including the growing role of Long-Term Strategies (LTSs) to achieve net-zero targets. Importantly, at COP26 it was registered that the pledge made by developed countries at COP15 (Copenhagen), to provide US$100 billionn annually of climate finance by 2020, was unlikely to be met. Figures from 2019 suggest flows of only $79.6 billion (UNFCCC, 2022b). COP27 took a critical step forward by establishing the Loss and Damage (L&D) Fund to provide finance to vulnerable countries to address the consequences that arise from the unavoidable risks of climate change.

The Paris Agreement included a commitment by all parties to report on progress with mitigation and adaptation every five years, starting in 2023. The UNFCCC subsidiary bodies have been developing methods for standardising reporting and at COP26, Parties agreed to an Enhanced Transparency Framework (ETF) that requires countries to produce Biennial Transparency Reports (BTRs) with the first BTR due at the end of 2024.

The UNFCCC Standing Committee on Finance (SCF) provides Biennial Assessments (BAs) of climate flows, including domestic financing and covering both developed and developing countries. The **latest BA** was produced in 2022 and reports on major improvements in the coverage and granularity of reporting climate finance flows by Parties to the Paris Agreement (SCF, 2022a). It found that finance for adaptation accounts for less than 10 percent of total climate finance reported in the 2022, although it is growing at a faster rate than mitigation finance. The BA includes data on climate finance flows from developed to developing countries and of this, 14 percent is for adaptation. Africa received 27 percent of climate finance flows in 2022.

The SCF also reported to COP27 that there has been progress to improve the consistency of definitions and practices through a program of extensive consultation, which included African stakeholders (SCF, 2022b). The consultation suggests that there is widespread demand for clearer definitions of adaptation finance, with a degree of international consistency, whilst also allowing for country variation. Many countries reported using the definitions used by the OECD Development Assistance Committee (DAC) for **Rio markers**. There is some consensus on the challenges faced in agreeing to a definition of adaptation finance but no clear conclusions. Improved SCF reporting tables are due to be introduced in 2024. The SCF reports that progress is especially marked for private sector climate finance, although this is focused mainly on mitigation and little work has yet been done on adaptation.

UNEP Adaptation Gap Reports (AGR)

UNEP has produced six editions of the AGR, the latest, **AGR7**, was published in 2022. In 2016, **AGR2** focused on adaptation finance. The 2023 AGR provides an update to the 2016 assessment, reviewing the latest evidence from global models and country estimates and found that the adaptation financing needs for all developing countries are higher than the previous AGR estimated. The AGRs are the authoritative source on the adequacy of the global adaptation effort. They have not yet, however, reported comprehensively at a country level. This PAAF analysis complements the AGRs by adding the following context:

- PAAF produces country-specific Standardised Reference Estimates (SREs) of the adaptation gap, using a standard approach that aims to be sufficiently simple to be applied in the context of NDC refinement, whilst capturing the most significant features of more complex analysis;
- The country SREs provide estimates that can be used for cross-country comparison and as a starting point for more detailed country work that builds on country-specific evidence across any elements of the analysis. This work may take place in the context of evaluation, applied research and the revision of plans and strategies, including NDCs (see Box 8); and
- Both the AGR and PAAF analysis require estimates of the effectiveness of adaptation expenditure. The AGR refers to work using a range of different measures of effectiveness. The PAAF analysis uses Benefit Cost Ratios (BCRs), which can be then used as yardsticks for appraising adaptation programs.

Mainstreaming initiatives

There are a range of tools and practices for integrating climate change into planning and budgeting which are being applied in both developed and developing countries (UNDP, 2022). **Climate public expenditure reviews** (including CPEIRs) provide occasional evaluations of expenditure patterns and institutional roles and can be influential in the evolution of climate plans and strategies. **Climate budget tagging** (CBT) provides the ability to report on climate expenditure in the budget on a routine annual basis and provides evidence to influence annual budget formulation and negotiation. **Climate Change Impact Assessment** (CCIA) offers line ministries the ability to assess the effectiveness of programs in reducing the Economic Impact of Climate Change (EICC). Although these practices allow for country variations in methods, there is some emerging consensus. The approach used by the OECD DAC for **Rio markers** provides a clear foundation, but more detailed methods are emerging and OECD DAC is participating in this improvement (OECD DAC, 2021).

1.2 Objectives

This report attempts to bridge the three strands of work on the adaptation gap by reviewing public and private expenditure on adaptation and providing a rapid assessment of the adaptation financing gap in 51 of 54 African countries[3]. In doing so, it aims to help governments understand their adaptation financing gaps so they can better strategize how to close that gap, including through NDCs and policies that mobilise international and private sector funding.

3 Equatorial Guinea, Eritrea and Libya were excluded because no data was found on public expenditure.

The detailed objectives associated with the stands of this work include:

- Illustrate a practical method for providing country specific SREs for each African country, covering: the EICC, effectiveness and levels of existing expenditure, adaptation financing needs and adaptation gaps[4] and comparing this with related evidence from other sources to encourage consistency and comparability.
- Highlight the importance of evidence on adaptation effectiveness and show how it can be used for estimation and prioritisation, thus strengthening demand for this evidence within NDCs.
- Contribute to the refinement of methods for measurement, reporting and verification (MRV) of adaptation expenditure, to support improved coherence and comparability, in line with recent interest at OECD DAC and from some Multilateral Development Banks (MDBs) (OECD DAC, 2021; Pizarro, Delgado, Eguino, & Pereira, 2021).
- Contribute to the debate over the adequacy of adaptation finance for Africa, including the range of situations in countries across the continent[5], and the debate over the potential contribution from the main sources of adaptation finance, including innovative sources and the ongoing work to define which adaptation needs are covered by the L&D Fund, established at COP27.
- Illustrate, through country case studies, how the country SREs can be improved with more detailed country work, including country-specific analysis of the adaptation gap, and how this can assist countries in refining NDC costing estimates (see Box 8).

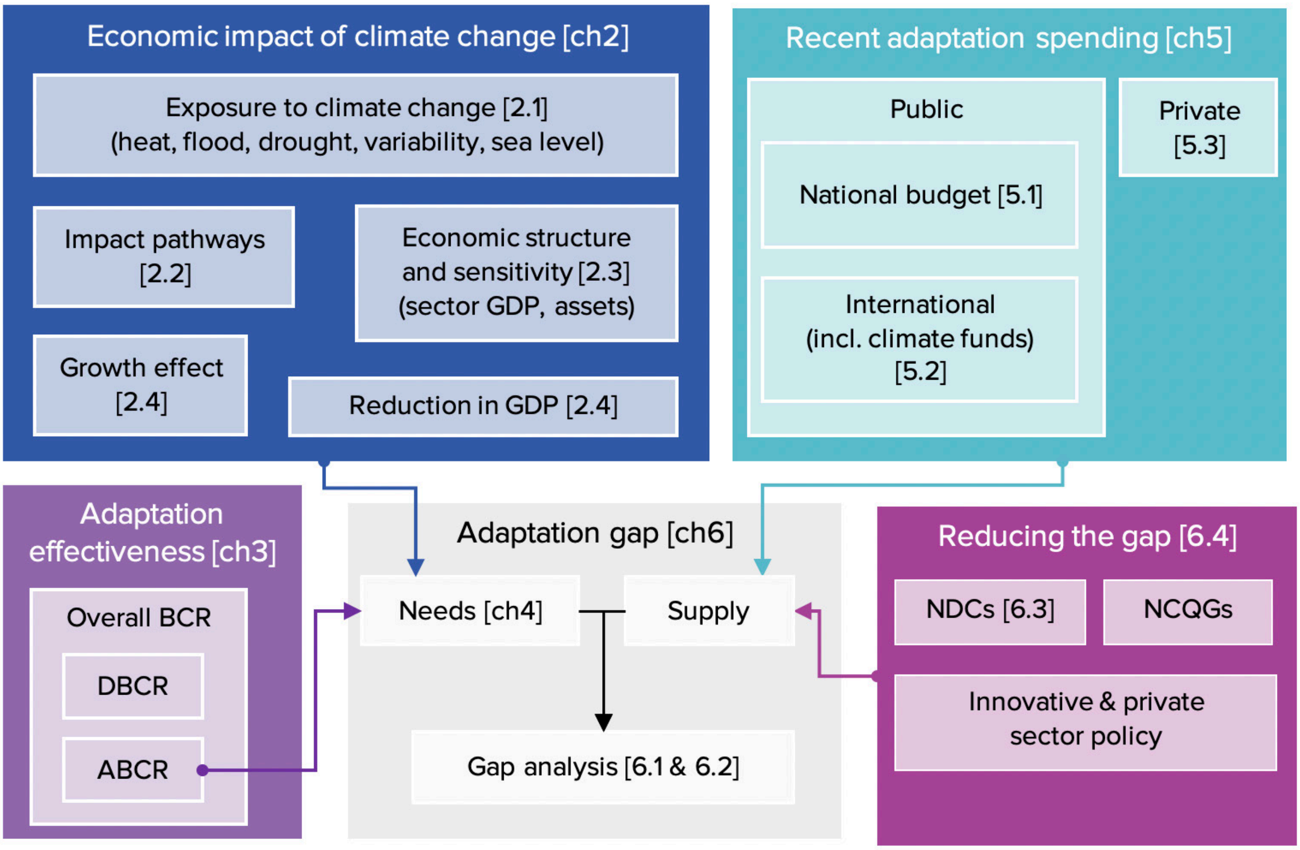
1.3 Methodology and definitions

This section addresses key questions about definitions and provides an overview of the logic of the analysis. More details about the definitions and data sources for each element of the analysis are presented in chapters 2 to 6. The analysis compares the needs for adaptation finance with the planned supply, based on current national budgets and private investment. Figure 1 summarises the key elements of the analysis and cross-references which chapters and sections in the report describe the methods used in more detail. The evidence from each element of the analysis is typically reported in different units and care is required to convert the units in a consistent manner (see Box 12). All supply and expenditure needs are presented as percent of GDP. The analysis is done by applying the standard analytical framework at a country level. Results for Africa as a whole are the sum of the country analysis. The analysis uses a spreadsheet that is intended to be transparent and publicly available as a starting point for more detailed country analysis.

4 The practical nature of the PAAF approach is illustrated by the fact that the pan-African analysis and reporting was undertaken with 90 days of expert input and with three of the four main experts involved being African.

5 A final draft of the report was presented at COP27 and at 2022 Africa Climate Week.

Figure 1: PAAF methodology



ODA = Official Development Assistance; BCR = Benefit Cost Ratio, DBCR = Development BCR, ABCR = Adaptation BCR (i.e. reduced EICC / costs), NDC = Nationally Determined Contribution, NCQG = New Collective Quantified Goals

Note: Figures in square brackets refer to chapters and sections in this report.

Economic impact of climate change (EICC)

The EICC is calculated by estimating the EICC from 5 climate risks through 13 impact pathways (see Figure 5). The global maximum potential EICC for each pathway, without adaptation, is based on expert opinion derived from country analysis and international literature (section 2.2). More detailed work is required to refine and reference the estimates of maximum global EICC. The country level EICC is based on the global maximum EICC and a country index (from 0 and 1) of exposure to the climate risk behind each pathway. The exposure indices are derived from an average of 16 different international indices, across all risks, weighted according to their perceived status. Data and sources are summarised in Table 2 in Section 2.1.

A ‘first round' estimate of the economic impact in a country is provided by applying the country level EICCs for each pathway to the GDP of the sector affected by the pathway. Sectoral GDP is taken from national accounts (section 2.3). The analysis then adds a second round ‘growth effect', reflecting: a) the reduction in investment caused by a first-round reduction in GDP; and b) the reduction in investment for growth caused by needing to divert capital to replace lost or damaged assets.

Box 1: Economic impact and L&D

The potential EICC is the projected reduction in GDP, often presented as a timeline showing the increasing impact over time and summarised as the Net Present Value (NPV) of the reduction in GDP, expressed as a percent of the NPV of GDP without climate change. There is, as yet, no definitive consensus on the definition of L&D. The Warsaw Mechanism was agreed at COP19 in 2013. The UNFCCC description of the Warsaw Mechanism adopts a broad definition of L&D, including both extreme events and slow onset impact, which is similar to the definition of EICC. At COP27, one of the main achievements was an agreement on funding for L&D. A 'Transitional Committee' (TC) has been established and will consider the definition of L&D. One possibility is that L&D funding should focus on all climate change impacts that cannot be addressed cost-effectively by adaptation (Panwar & Wilkinson, 2022; UNEP, 2022b). To avoid confusion with this ongoing debate about the definition of L&D, PAAF uses the term EICC, rather than L&D.

Recent adaptation spending

Recent national public adaptation expenditure is derived from national budgets, using the most recent budget data available before the Covid-19 pandemic (section 5.1). Although this data is now several years old, it was considered more representative of likely funding patterns in the mid- to long-term, given the major disruption caused by the pandemic response in the short-term. In more detailed country studies, it could be useful to consider several years of data, but this was not possible in the limited time available for this analysis. Line items are tagged according to a standard climate subsector code and each subsector was assigned an estimated ABCR, based on the analysis of effectiveness (Box 5). A comparison with the climate expenditure in the OECD DAC database provides evidence of the consistency with budget analysis and an estimate of off-budget international grants (section 5.2). Evidence for private sector adaptation is limited, but is based on the total private investment in national accounts and the sectoral breakdown of this investment derived from banking survey data (section 5.3).

Adaptation effectiveness

The effectiveness of adaptation expenditure is defined as the benefits of the expenditure divided by the costs (Chapter 3). The analysis uses the BCR as the measure of effectiveness. Most adaptation expenditure provides both development benefits (i.e. economic growth[6]) and adaptation benefits (i.e. reduced EICC). The BCR can be divided into development BCR (DBCR) and an adaptation BCR (ABCR). The reduction in EICC caused by adaptation expenditure is the expenditure multiplied by the ABCR. The data on BCRs and ABCRs is still patchy, but there is a growing library of evidence, much of which shows strong positive returns.

6 The development benefits may also include social and environmental benefits, which may be valued in terms of their impact on GDP, through techniques of economic valuation.

Adaptation gap

The ABCR is the adaptation benefits (reduction in EICC) divided by the costs (expenditure). Therefore, the adaptation expenditure needed to avoid the full EICC is the EICC divided by the ABCR. This analysis is not complex, but it does require some care, to ensure that the units used for estimating adaptation needs are consistent with the units used in recording actual adaptation expenditure. In particular, the estimate of adaptation expenditure needs to be presented in a weighted format that is consistent with that used in the analysis of expenditure supply. The analysis uses the concept of weighted expenditure that has become common in CPEIRs (Box 2). The unweighted estimate is also included, which is comparable with NDC costing.

Box 2: Definitions of adaptation expenditure

Budgets and plans (including NDCs) usually present adaptation expenditure as unweighted total expenditure. To recognise that most adaptation expenditure is partly adaptation and partly development, climate expenditure reviews and budget tags typically apply weights (usually using either the DAC or the CPEIR system) and present tables of the trends and patterns in weighted climate expenditure. Analysis of international climate finance flows, as tagged by OECD DAC Rio markers, also applies weights to recognise the fact that programs with secondary climate objectives are primarily development programs. In most models, adaptation expenditure is a theoretical measure given a monetary value by dividing the reduction in EICC caused by adaptation by a measure of the effectiveness of adaptation, using a mathematical 'effectiveness function' (Roson & Sartori, 2016). This analysis illustrates the use of conversion factors to enable the different interpretations of adaptation to be compared, including in the estimation of an adaptation gap between the needs estimated in models and the supply estimated in budgets and plans. Table 1 summarises these various definitions.

Table 1: Definitions of adaptation expenditure

Definition	Use	% of UNWT[a]	Interpretation
Unweighted (UNWT)	• Budgets • NDC costing	100%	'Raw' expenditure registered in budget documents and in most NDC costing work. The total cost of each program identified as making a contribution to adaptation.
Objectives Weighted (OBJWT)	• CBT • CPEIR • OECD DAC	41%[a]	Raw expenditure multiplied by weights that reflect the fact that many programs have dual objectives (i.e. adaptation and development). Weights, or Objectives Based Scores (OBSs), reflect the relative importance of adaptation in objectives.
Benefits Weighted (BENWT)	• Models	11%[a]	Raw expenditure multiplied by weights that reflect the fact that programs contribute both the adaptation benefits (i.e. reduced EICC) and development benefits (i.e. growth). Weights, or Adaptation Benefits Scores (ABSs – see **Box 5**), reflect the relative importance of adaptation benefits in total benefits.

a Relative sizes will depend on the composition of adaptation expenditure in each country. These estimates are derived as a pan-African weighted average (based on expenditure composition) of the weights used for the standard adaptation subsectors. The BENWT value is obtained from the PAAF analysis of budgets and is the average ABS for all expenditure for all of Africa.

The gap between needs and supply is estimated by comparing recent expenditure with the adaptation expenditure needed to avoid the EICC. Care is required to ensure that time periods used for projections of EICC, needs and supply are converted into a common metric (Box 12). To raise awareness about the importance of clarity on metrics, the results are presented both in terms of the net present value of flows to 2020 and the absolute values in 2050.

The analysis must recognise that some of the EICC is 'uncoverable' and cannot be avoided by any cost-effective adaptation actions (see Box 3).

Box 3: Uncoverable EICC and residual L&D

Economic models estimate the optimum balance between adaptation and development expenditure, based on maximising utility over time. The optimum levels are sensitive to assumptions on time-preference and the effectiveness curves which determine the rate at which the benefits from development and adaptation decline as expenditure increases. The term 'residual L&D' is sometimes used to refer to the EICC that cannot be met by cost-effective adaptation, although it is also sometimes used to refer to the EICC left after planned adaptation is undertaken. As a result, there are wide variations in estimates of residual EICC (Agrawala et al., 2011; Bruin, Dellink, & Agrawala, 2009; Estrada, Tol, Botzen, & Wouter, 2019; Markandya & González-Eguino, 2019; Stern, 2006).

To avoid this confusion, **this analysis uses the term 'uncoverable EICC'**. More work is required on this subject, including specifically in Africa. Pending further evidence, this analysis adopts placeholder assumptions for uncoverable EICC in each sector at three percent levels, based on expert opinion about the challenges facing adaptation in each sector. The three percent levels include:

- Uncoverable EICC at 30 percent applies to: crops, which have good adaptation options for rainfall variability, but more limited options for flood/drought; and fisheries, where there may be major ecosystem disruption meaning adaptation will take more time.
- Uncoverable EICC at 20 percent applies to: livestock and forestry, which are similar to crops but have more adaptation options; energy supply vulnerability, for which adaptation may include technical design and diversification; heat and labour productivity, for which there are good adaptation options involving adjusted working practices.
- Uncoverable EICC at 10 percent applies to infrastructure (e.g. water, buildings, roads, etc.) where new design standards can eliminate most of the risk.

These estimates are lower than estimates from economic models (see Annex 2 for description of related economic models), which is justified by the recent positive evidence on adaptation effectiveness (see Chapter 3) and evidence from this report's analysis on the scale of EICC relative to growth (see Box 9). The relative level of EICC for different sectors is informed by AfDB estimates of residual EICC for key sectors and regions of Africa (AfDB, 2019b) and by estimates quoted in the Asian Development Bank report on economic analysis for climate proofing (ADB, 2015). Applying these assumptions to each country, taking into account the sectoral composition of GDP in each country suggests that **23 percent of EICC is uncoverable**.

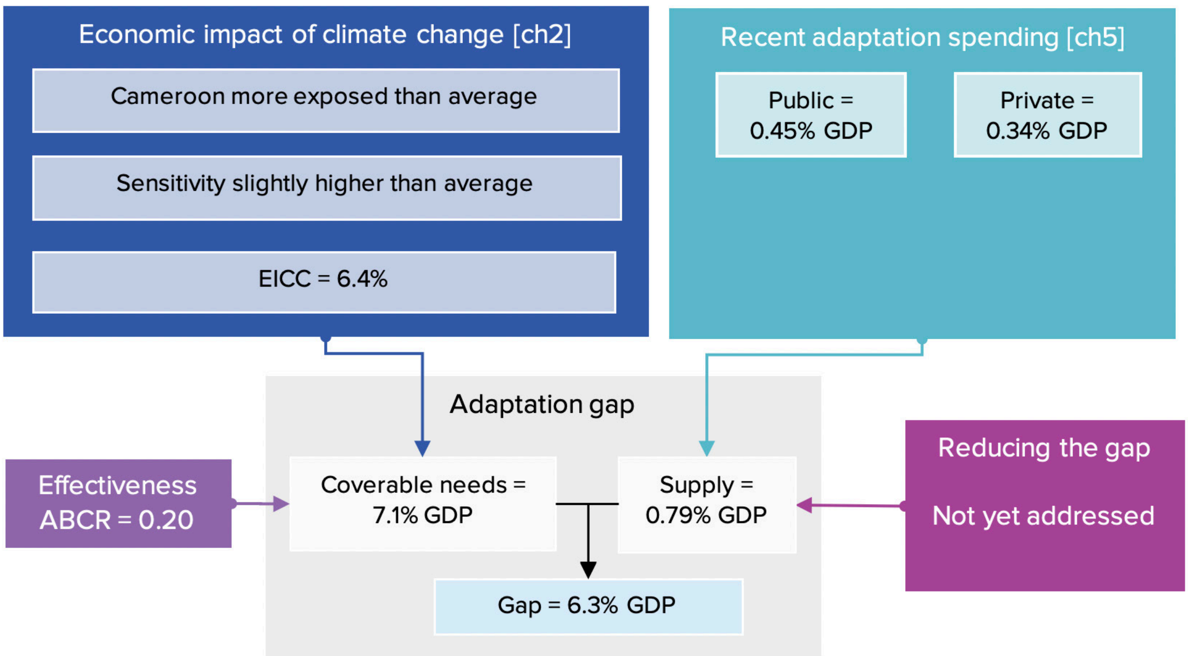
Reducing the gap

The options for closing the gap are explored using evidence about the likely scale of funding from each potential source (section 6.4). This takes into account evidence of how GDP growth affects public expenditure as a percent of GDP and EICC as a percent of GDP. The prospects for sources of international finance are informed by the latest international commitments. Growth in private sector adaptation is based on recent trends. This options analysis should be treated as illustrative and will require more detailed country-based analysis.

Box 4: Illustration of the methodology for Cameroon

The analysis of climate risk indices suggests Cameroon is more exposed than the average African country to all climate risks except rainfall variability (section 2.1). The sensitivity to climate risks is mixed, with a slightly higher than average share of agriculture in GDP but relatively low at-risk road and power assets (section 2.2). The net effect of exposure and sensitivity is for the potential EICC to be significantly higher (6.4 percent) than the African average (3.8 percent), expressed as the NPV of EICC to 2050 (section 2.4). The EICC is divided by a measure of effectiveness (Chapter 3) to give an estimate of needs (Chapter 4). This is done first by dividing by the adaptation BCR (0.20 for Cameroon, given the expenditure mix) and then multiplying by the average CPEIR weight (26 percent) so that the needs are presented in CPEIR weighted expenditure that is directly comparable with the analysis of existing expenditure. For Cameroon, total needs are 9.5 percent of GDP, weighted, of which about a quarter is uncoverable by any cost-effective adaptation options (Box 3), leaving coverable needs of 7.1 percent of GDP weighted (Chapter 4). This is significantly higher than the African average of 5.9 percent and reflects Cameroon's relative vulnerability. The analysis of CPEIR-weighted current adaptation expenditure suggests that public expenditure on adaptation is 0.45 percent of GDP (section 5.1) and private expenditure on adaptation is 0.34 percent of GDP (section 5.3), leaving an adaptation gap of nearly 6.3 percent of GDP, which is nearly 90 percent of coverable needs and reflects the urgency with which Cameroon needs to increase access to adaptation finance through all channels, including international assistance.

Cameroon steps in estimating adaptation gap (following Figure 1 format)



1.4 Structure of the report

Chapter 1 of the report describes the context and objectives and provides an overview of the methodology. Chapters 2 to 5 explain in more detail the key steps in the analysis to estimate needs and supply of adaptation finance, including the sources of evidence used in each step. Chapter 6 brings together the results of these steps to estimate the adaptation gap for each country, the breakdown of this gap by sector, the extent to which existing NDC costings close the gap and options for closing the remaining gap. Chapter 7 presents case studies from Kenya, Niger and Burkina Faso to illustrate how country-specific analysis can improve on the Standard Reference Estimates (SREs) provided by PAAF. Chapter 8 presents recommendations for key stakeholders. Further detail on evidence and methods is provided in the Annexes.

2 Economic impact of climate change

This chapter presents the evidence and analysis used to estimate the economic impact of climate change (EICC) for each African country. Vulnerability can be divided into three aspects: exposure to climate risks; sensitivity of people and ecosystems that experience climate risks; and the adaptative capacity of those people and ecosystems to reduce the impact of risks (IPCC, 2007). The chapter reviews first the evidence on exposure to five climate risks, developing country indices of exposure to each risk. Impact pathways are then defined to specify how key sectors and assets are affected by each risk. The relative sensitivity of the country to risks is determined by the sectoral composition of GDP and by the size of climate sensitive assets. The final section of the chapter includes a comparison of the results of the analysis with other related analysis of EICC which aims to help build confidence in EICC estimates by explaining differences in approach and, hence, promoting comparability.

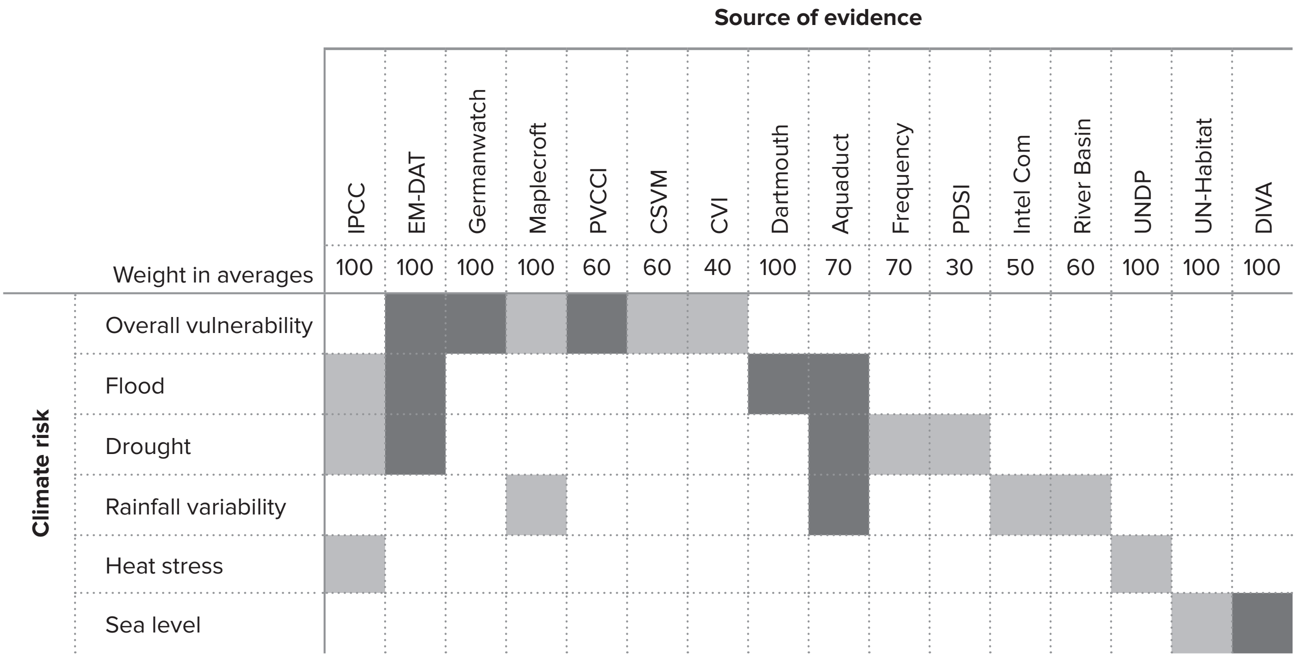
2.1 Exposure to climate change

Exposure to climate change refers to the extent to which people and ecosystems are exposed to climate-related risks. The evidence for changing exposure is based on climate modelling and evidence from recent climate-related events. This analysis uses 16 international sources of evidence on exposure to climate risks (see Table 2) to generate country exposure indices for five climate change risks. It was considered useful to include all 16 sources of evidence on exposure because they have differing approaches and strengths which result in quite a wide range of results. Five climate risks were selected to capture the majority of the economic impact, based on a review of the literature on climate change damage (Roson & Sartori, 2016)[7]. The five country exposure indices are averages for the evidence from each of the 16 sources of evidence, with each source given a weight that reflects an expert judgement of the reliability of the source (e.g. how up to date and easily quantifiable it is and the level of resources devoted to establishing and maintaining the source). For example, the country index for exposure to drought is derived from five related indices, two of which provide quantitative figures for

7 The country level of each index is calculated first by estimating a weighted average for the risk of all sources and by dividing this weighted average by the maximum value of the weighted average for all countries. This results in a range of scores between 0 and 1 for each index.

country risk (EM-DAT and Aquaduct) and three of which present results in map form (IPCC, the Dai frequency analysis and the PDSI). A weighted average of these sources is estimated, with IPCC and EM-DAT having a weighting of 100 percent, the Aquaduct and Dai sources of 70 percent, and PDSI of 30 percent. See Annex 1 for the evidence in more detail.

Table 2: International indices used for weighted average exposure indices



Note: Dark shaded cells give raw data and light shaded cells are from maps using a 1-5 score. Acronyms and sources are described below.

Key sources

Key global data on exposure to climate change risks includes the following sources. Further sources are discussed in the discussion of each climate risk later in the section.

- **IPCC** AR6 provides maps at a global level but give a broad indication of the differences across Africa in respect to changes in temperature, precipitation and soil moisture (IPCC, 2022b). Temperature in Africa will rise roughly in line with global averages in all parts except Central Africa, which will see lower rises. All areas except Southern Africa and the Mediterranean coast will become wetter. Soil moisture will decline in Northern and Southern Africa but improve in West, Central and East Africa. Sea level rise around the continent is likely to be 0.5m to 0.8m.
- **EM-DAT** is a database of extreme events that is maintained by the Centre for Research on the Epidemiology of Disasters at Leuven University. The database suggests that the East and South Coasts, plus the Sahara have been exposed to the most climate related disasters, although some other countries have also experienced large numbers of climate related disasters.
- **Maplecroft** produce a composite Climate Change Vulnerability Indicator that is made up of 26 indicators covering exposure, sensitivity and adaptive capacity. The data is available only by subscription and the latest published evidence is from 2014 (Maplecroft, 2014). The Maplecroft Index suggests that Africa is less at risk than parts of Asia, with most African countries in the mid-risk category. The index picks out Madagascar and Mozambique as especially high-risk.

- **Germanwatch** produce a Global Climate Risk Index based on extreme weather events since 1992 and is based on data from the Munich Re NatCatSERVICE (Kreft & Eckstein, 2014). The latest version of the index is based on data from 2000 to 2019. There is little regional pattern to the results and results vary greatly over time.
- **PVCCI** *The Fondation pour les Etudes et Recherche dur le Developpement International* prepares an index of physical vulnerability to climate change (PVCCI), based on five components (sea level rise, aridity, rainfall, temperature and storms) with data from a range of studies.
- **CVSM** The Climate Change and African Political Stability program at the Strauss Centre in Texas, USA has developed a Climate Change Security Vulnerability Model (CSVM) which presents an index of vulnerability covering a range of exposure, sensitivity and adaptive capacity factors (Busby, Smith, & Kirshnan, 2015).
- **CCRI** UNICEF have produced a Children's Climate Risk Index that is a composite index of exposure to nine climate and environmental shocks (UNICEF, 2021). The original sources of data include many of those identified within this chapter.
- **Aquaduct** The World Resource Institute's Aquaduct analysis provides a range of indices around rainfall, flooding, drought and variability, including variability between seasons and between years, as well as an overall water risk, all of which are presented in the Water Risk Atlas (WRI, 2015).

The five climate change risks, and key sources utilised to analyse them, are as follows:

Flooding. Key sources for flood risks are listed below. The sources roughly support the 'doubling rule of thumb' from the Special Report on Extreme Events, which suggested that the frequency of flooding will roughly double by 2050 in Africa for all severities of flood (IPCC, 2012b). Thus, the concentration of flood risk is in those areas that are currently most vulnerable to flooding (i.e. Central and Eastern Africa, coastal parts of West Africa and Southeastern Africa).

- Most of the international work on flood risks is based on the **Dartmouth Flood Observatory** data which has a database going back to 1988, including the estimated cost of flood events (Dartmouth Flood Observatory, 2008).
- A **study on large flood events** from 2001 to 2016 (Brakenridge, 2017).
- A **review of flood risk distribution** (Dilley, Chen, Deichmann, Lerner-Lam, & Arnold, 2005)
- The IPCC Working Group 1 **Interactive Atlas** includes a map of the change in maximum five-day rainfall for different scenarios.

Drought. There are a wide variety of sources looking at the current severity of drought (Dilley et al., 2005; UNICEF, 2021). Two sources look at change in drought severity and rainfall over the last 50 years and suggest significant drying has occurred across most of Africa, particularly in West and Central Africa (Dai, 2011; IPCC, 2014b). The results also suggest some wetting in the far Southwest of Africa. Future projections are broadly consistent and show an increase in drought risks in Northern and Southern Africa and coastal areas of West Africa, but some reduction in parts of Central and Eastern Africa (IPCC, 2023; IPCC, 2021; WMO, 2019; Sheffield & Weed, 2007).

Rainfall variability. Direct indices of exposure to worsening variability of rainfall are difficult to find. However, there is a clear consensus that variability will increase markedly (IPCC, 2022b).

Indices of water insecurity provide a reasonable proxy for exposure to the widespread risks of worsening rainfall variability. **Aquaduct** provides a range of indices of current variability, including variability between seasons and between years, as well as an overall water risk. The various sources provide a mixed picture. Variability between years is closely related to rainfall and is higher in dry zones. In contrast, variations in seasonality are concentrated in two belts across the continent, one from the Sahel to the Red Sea and the other from Angola across to Tanzania and Mozambique. Two further sources provide some confirmation of this pattern, although they also pick up further hotspots in variability, including in Egypt, Morocco, Somalia and Botswana (Intelligence Community, 2011; Stefano et al., 2010).

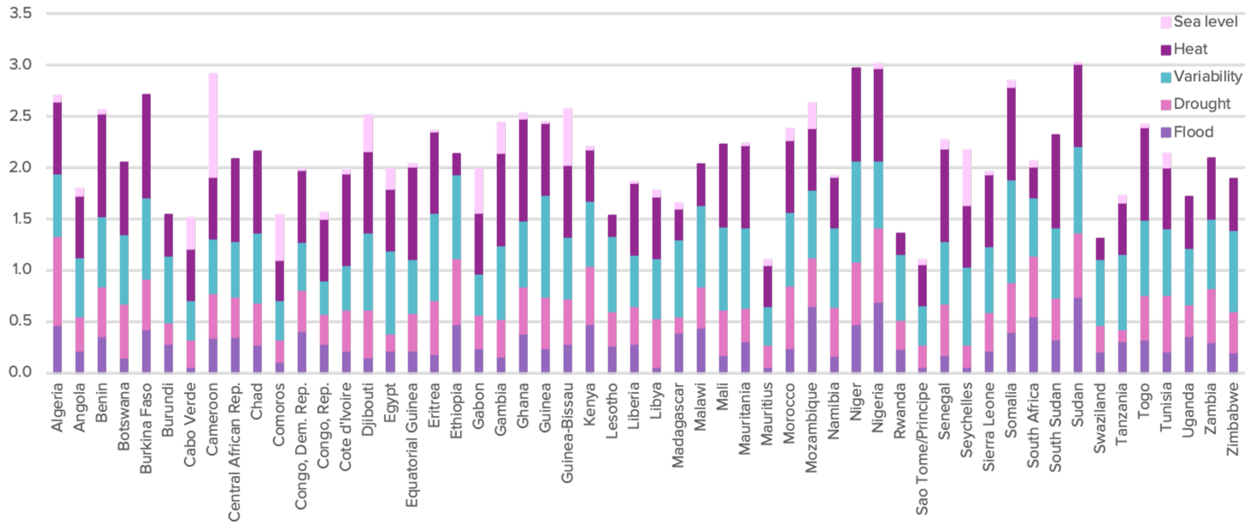
Sea level rise. Two sources of evidence on sea level risk are used, one using the **DIVA model** which takes account of urban population, socio-economic characteristics and sea level rise (Brown, Kebede, & Nicholls, 2011) and the other from **UN-Habitat** based on city size and the proportion in low-lying zones (UN-Habitat, 2010). The relative exposure of each country is largely dominated by the proportion of population in coastal cities, with most of the major cities along Africa's coast being vulnerable.

Heat stress. Recent studies have suggested that the impact of heat stress on health and labour productivity could be amongst the most serious effects arising from climate change in tropical countries. **UNDP** and **UNICEF** have both reviewed current heatwave frequency and the evidence on potential impact, including maps of current heat stress (UNDP, 2016; UNICEF, 2021). **IPCC**, **WMO** and **HEIT** review the likely increase in heatwaves (HEIT, 2016; IPCC, 2021; WMO, 2019). The metrics used are slightly different but there is a common pattern, with the highest increase being across the Sahara and in inland Southern Africa. IPCC also suggest that West Africa and Somalia could see some of the most serious increases.

Composite risk index. The PAAF analysis includes the compilation of a composite risk index as one of the sources of evidence for the impact on wider industry and services. This is compiled as a weighted average of maps from six sources. The maps that focus on exposure to climate change risks (i.e. EM-DAT, PVCCI and CSVM) suggest that East Africa and the Horn of Africa will be exposed to relatively high risks. Two out of three maps suggests that Mozambique and the southeast coast of South Africa will also have high risks while two maps also suggest that the Sahel will have high risks. There is, however, little agreement on other regions of Africa.

Figure 2 presents the five main exposure indices. Risks associated with heat, drought and rainfall variability are experienced in most countries. Flood and sea level risks are more variable. Most countries that have high total exposure combine exposure to all of the four dimensions (e.g. Niger, Somalia and Sudan). A few are highly sensitive to most dimensions, but not to all (e.g. Ethiopia, which is less exposed to heat risks, and Niger, which is less exposed to flood risks). The chart is a stacked bar-chart, showing the individual exposure indices for each country as different colours, as well as the total of the five indices.

Figure 2: Combined exposure indices by country



Note: Each of the 5 exposure indices varies between 0 and 1. The graph is a stacked bar chart, so the maximum total of all indices is 5. But no country scores 1 in all indices and the highest total score is 3.5 (Sudan).

Source: PAAF synthesis from 16 international indices described in section 2.1.

2.2 Impact pathways and damage functions

Impact pathways. The potential EICC is the economic impact that would occur with no adaptation. EICC is estimated using 13 impact pathways, as illustrated in Figure 5, that were selected to capture the majority of the economic impact of the five climate risks (Figure 2). These impact pathways are based on a **review of the literature on climate change damage** (Roson & Sartori, 2016). Damage functions define the maximum EICC in each sector that would be experienced in the countries with the highest exposure to each climate risk and the EICC for each country is then proportional to the exposure indices for the country.

Damage functions. At the heart of any analysis of the economic impact of climate change are damage functions that specify how economies can be expected to respond to changes in climate. The rise in temperature usually provides a common metric for the severity of climate change, but the damage functions consider the full range of impact pathways that are associated with a rise in temperature.

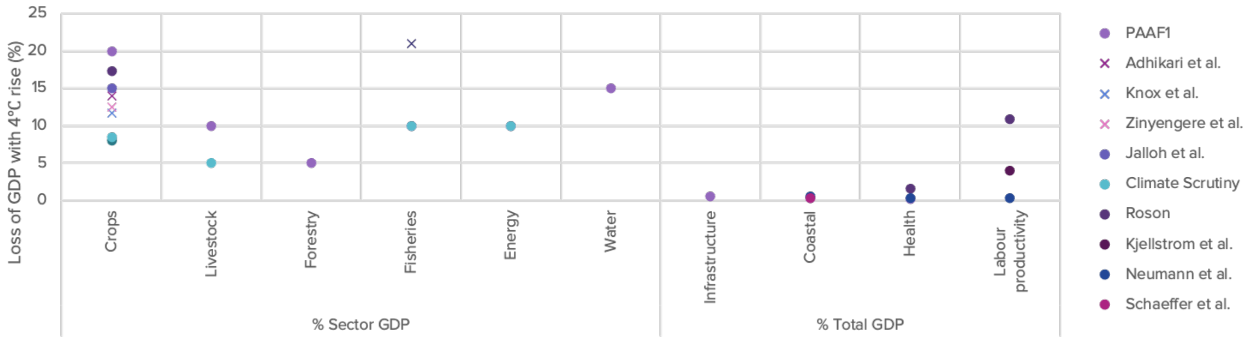
In most models, damage functions are presented as curves that show how the loss of GDP increases with temperature rise. In most cases, the impact pathway is very complicated and the loss of GDP is caused by many interrelated factors[8]. A single damage function that relates crop GDP to temperature is a very simplistic way of capturing the net effect of all these factors. There are models that take many of these factors into account in great detail, but these are normally appropriate for analysis of crop response in a particular location and are not practical to apply to many locations in a country and aggregate the results so as to provide national level results.

8 For example, the response to crops is affected by a range of interrelated factors including: soil type and slope; choice of crops and markets for switching crops and/or varieties; vulnerability to pests; ability to adjust crop husbandry practices and effects of labour and land tenure; level of household risk aversion; and the interplay between crops and other sources of land use and income.

In addition to the complexity of the relationship between temperature and losses, analysis often suffers from very patchy data, built up from case studies based on site-specific observations. One approach is to rely on statistical analysis of data for crop yields and temperature, which requires a reasonable volume of data over time and/or space[9]. In practice, damage functions are usually the result of synthesising the results from case studies, but even this is challenging because studies often report results using different parameters.

Figure 3 presents a synthesis of the evidence on potential damage for different impact pathways, based on evidence from 11 studies, of which 7 are themselves reviews of evidence and 4 are individual case studies.

Figure 3: Maximum potential economic impact with 4°C rise



To note: Single case studies are marked with crosses and synthesis results from review papers are marked with solid dots; Many of the studies do not report results explicitly for a rise of 2°C. Where other scenarios are used, these are converted to 2°C assuming that the damage function is linear.

Source: compiled from the sources listed in the figure (Adhikari, Nejadhashemi, & Woznicki, 2015; Climate Scrutiny, 2021; Jalloh, Nelson, Thomas, Zougmoré, & Roy-Macauley, 2013; Kjellstrom, 2015; Knox, Hess, Daccache, & Wheeler, 2012; Neumann et al., 2020; Roson & Sartori, 2016; Schaeffer et al., 2014; Zinyengere, Crespo, & Hachigonta, 2013):

The key assumption on EICC for each pathway are based on the evidence reviewed in Figure 3 and are summarised in the bullets below. All losses refer to a comparison of current climate with an increase of 2°C rise and exclude the growth effects of the gradual rise in temperature to 2050.

- **Direct impact on GDP:** Loss of production is taken from the sources in Figure 3. Maximum losses are: 25 percent of crop GDP; 10 percent of fisheries GDP and livestock GDP; 5 percent of forestry GDP; 10 percent of energy GDP; and 10 percent of GDP from water and sanitation.
- **Road damage:** Maximum loss of 5 percent of road asset value, reflecting the potential doubling of road rehabilitation and maintenance with increased flooding.
- **Health:** Maximum loss of 0.6 percent of all GDP as a result of increased health burden from climate sensitive diseases, assumed to be proportion to exposure to heat risks. This is based on the data in the WHO Global Health Observatory[10]. It does not include the health impact of increased malnutrition and reduced water quality, which are assumed to be covered in the valuation of agricultural and water sector EICC.

9 But, to have confidence in these relationships, it is then necessary to control for all the main factors that might be affecting crop yields, so that the impact of climate can be isolated. It is challenging to find enough suitable data in developed countries and very challenging in developing countries.

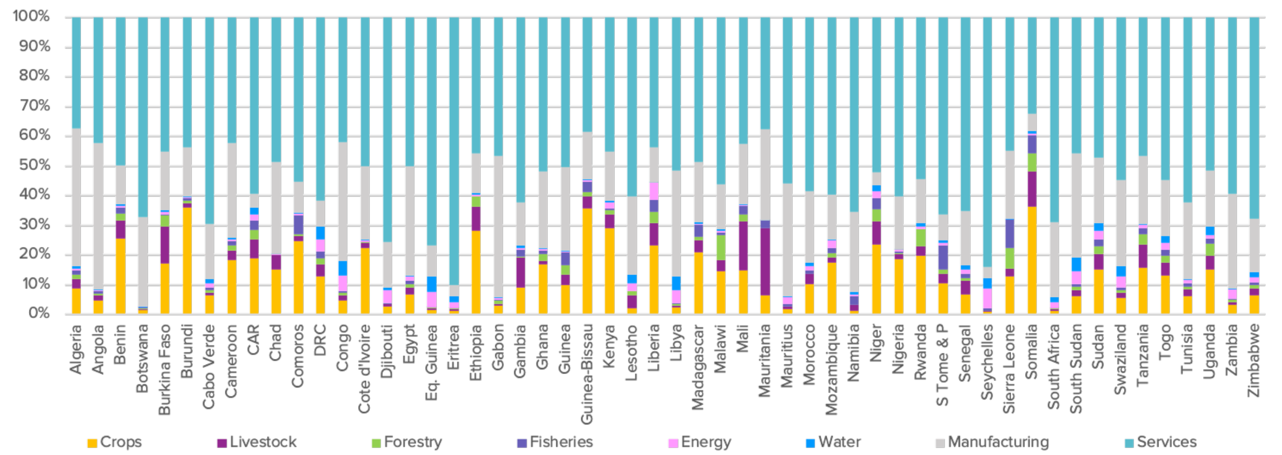
10 The Global Health Observatory suggests that about 300 Disability Adjusted Life Years (DALYs) per 100,000 people were lost per year in 2004 as a result of climate change to the point, and assuming that DALYs are valued at per capita GDP and the projected increase in heat stress by 2050 is double the historical increase to 2004 (WHO, accessed August 2022).

- **Labour productivity:** Maximum loss of 10 percent of GDP for heavy manual work (crops, livestock, fisheries, forestry and construction), 5 percent for light manual work (industry) and 1 percent for services (Kjellstrom, 2015).
- **Coastal damage:** Maximum potential damage of 4.8 percent of total GDP, based on the worst-case scenarios in the global indices of risks to sea level rise.

2.3 Economic structure: sensitivity to climate change

For most risks, sensitivity depends largely on the sectoral breakdown of GDP and this study attempts to use the most recent data on GDP composition (Figure 4). Risks that have an impact on assets (sea level rise and floods) require evidence on the value of assets, which is compiled from yearbook data. Multiplying sectoral GDP and asset values by exposure indices and EICC factors for each sector/asset provides an estimate of the total EICC for the whole country. This is a relatively simple and transparent methodology that could be available for all African countries in the context of work to update NDCs, until more detailed country analysis is available (see Box 8).

Figure 4: Structure of GDP

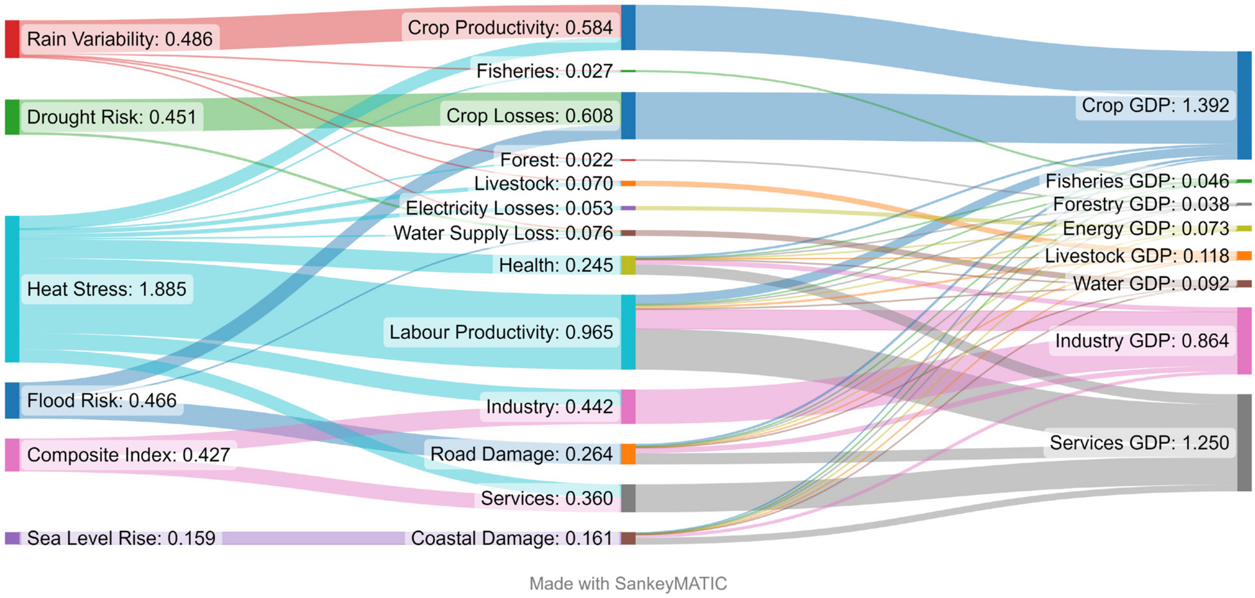


Source: AfDB African Information Highway, 2022.

2.4 Economic impact

Figure 5 presents a Sankey diagram of the way in which the five climate risks affect the 13 impact pathways and how this then contributes to GDP impact. In doing so, it presents the results of the PAAF analysis for Africa as a whole, obtained by summing the results for each of the 51 countries covered. The PAAF analysis allows for separate Sankey diagrams to be presented for each country, as illustrated in Chapter 7. The total EICC for Africa is 3.8 percent, when expressed as the NPV of the loss over the period to 2050, and 9.3 percent when expressed as the reduction of GDP in the year 2050.

Figure 5: Climate risks, pathways and GDP impact (NPV of GDP loss to 2050)



Note: All figures are presented as percent of GDP taking the NPC of impact over the period 2023 to 2050 (e.g. heat stress reduces the NPV of GDP to 2050 by 1.885 perccent, through the various pathways and sectors affected).

Source: PAAF analysis.

Table 3 compares our analysis of EICC with estimates from other sources. The sources present results using different metrics and some conversion has been done to present all the results in the same metric of change in the NPV of GDP to 2050. The table shows a remarkable degree of agreeme nt that most estimates expect the NPV of GDP to 2050 to be between about 3 percent and 6 percent lower as a result of climate change, if there is no adaptation and temperatures increase by about 2°C. More details of the sources are provided in Annex 2.

Table 3: Economic impact: PAAF and other sources (%GDP, NPV to 2050)

Sources	EICC	Comments
PAAF (2023)	3.8%	Africa as a whole
AfDB/UNEP/UNECA, 2019b	< 6.1%	Africa, AD-Africa[a], country/regional variations
Nordhaus & Moffat, 2017	< 3.0%	Global, mostly IAMs, mostly before 2010
Khan et al., 2019*	1.1%	Global, stochastic macro model, Africa higher
SwissRe Institute, 2021*	5.7%	Africa, Moody Analytics model
Roson & Sartori, 2016*	< 4.9%	26 African countries, own model of damage functions
Kompas et al., 2018*	< 2.5%	25 African countries, GTAP[b] model
Pretis et al., 2018*	< 6.5%	African countries, econometric analysis of past trends
Andrijevic & Ware, 2021*	5.3%	Developing countries, econometric analysis

* Starred reports do not present loss of GDP in NPV to 2050. Conversion to NPV of GDP is achieved by dividing reduction in absolute GDP in 2050 by 2.45 and multiplying reduction in growth rate in 2050 by 3.25 percent. If different climate change scenarios are used, these are converted to the PAAF scenario (2°C by 2050) by assuming impact is proportional to temperature rise.

a AD-Africa is an integrated assessment model used for assessing the economic impact of climate change.

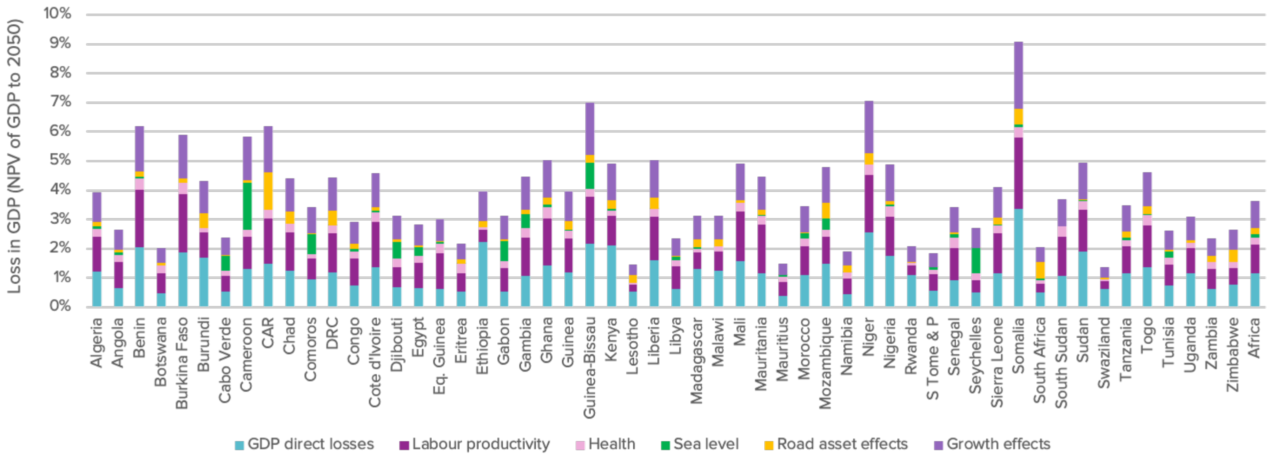
b GTAP is a computable general equilibrium model that includes trade responses to climate change.

Sources: Links to all sources are provided in the table and more detailed descriptions provided in Annex 2.

Figure 6 shows the variation in EICC amongst African countries. The worst affected countries (Benin, Burkina Faso, Cameroon, Central African Republic (CAR), Guinea-Bissau, Niger and Somalia) are hit two to four times harder than the least affected countries (Eswatini, Lesotho and Rwanda). The reasons for this are unique for each country and depend on a combination of differences in exposure to climate related risks and differences in the sensitivity of the country, as described in the economic structure and value of assets at risk. The results for some island states (especially Mauritius and Sao Tome and Principe) could be much higher, as there is limited data on the Dynamic Interactive Vulnerability Assessment (DIVA) and UN-Habitat sources on the potential impact on sea level rise (DINAS-COAST, Undated) (UN-Habitat, 2010).

The figure breaks down the impact into six broad categories, which are a combination of the 13 impact pathways (Figure 5) to simplify the presentation. The direct GDP losses refer to the impact of floods, droughts and rainfall variability on each sector of the economy. Labour productivity effects arise from the impact of heat on labour productivity. Health effects refer to the increased health burden from climate sensitive diseases. Sea level impacts are self explanatory. The impact of floods on road assets occurs through the diversion of investment into replacing damaged assets. Growth effects are the second-round effects of reductions in investment generated by the loss of GDP through the other categories. The breakdown of economic impact into the six components shows that countries with high total impact generally experience high impact across most impact pathways.

Figure 6: Economic impact of climate change without adaptation (NPV of GDP to 2050)



Source: PAAF analysis.

3 Effectiveness of adaptation expenditure

This chapter reviews the evidence on effectiveness and presents the assumptions used in the PAAF analysis. In order to estimate the expenditure needed to reduce EICC, it is necessary to have an estimate of the effectiveness of adaptation expenditure in reducing EICC. In complex models this is typically contained in assumptions about 'effectiveness curves'. The PAAF analysis relies on simpler assumptions about Benefit Cost Ratios (BCRs), familiar to government planners. Most adaptation expenditure delivers both development benefits (i.e. socio-economic growth and improvements in environment) and adaptation benefits (i.e. reduction in EICC, or reduced costs of inaction). BCRs for adaptation need to be not only greater than 1 (i.e. benefits greater than costs) but also competitive with BCRs for development expenditure, which are typically required to be greater than 2.0. Including adaptation benefits in BCR estimates should lead to an improvement in overall BCR which will help improve the prioritisation of expenditure that contributes to adaptation.

The IPCC 2022 Working Group II report describes the multiple dimensions of adaptation effectiveness, including economic, technological, institutional, social, environmental and geo-physical (IPCC, 2022a). In theory, economic analysis provides methods for integrating all these dimensions into a single measure of benefits, expressed in monetary terms which then provides an estimate of the impact of the adaptation expenditure on GDP. In practice, the evidence of the potential impact on social and environmental benefits for GDP is often controversial and the analysis of effectiveness tends to rely primarily on those economic benefits that can be more easily quantified, including the costs of addressing technological, institutional and geophysical factors.

Despite the complexity of developing evidence of adaptation effectiveness, strategic planning of adaptation requires measures of adaptation effectiveness[11] that relate to the overall challenge of responding to the potential EICC. The quantitative evidence on effectiveness is still very patchy and, whilst the evidence base is growing, it is necessary to use a 'placeholder' estimate to assess adaptation needs. A BCR of 2.0 seems appropriate for this[12]. Several international

11 For example, Benefit Cost Ratio (BCR), Internal Rate of Return (IRR), Incremental Capital Output Ratio (ICOR).

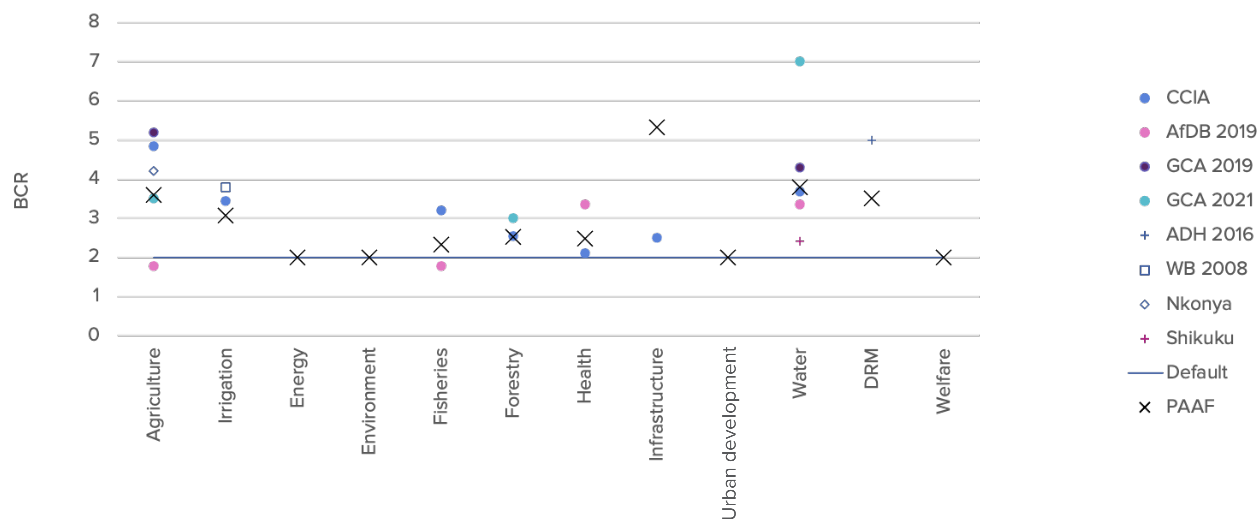
12 Although not ideal, there are several reasons why this is not unreasonable: a) it is impossible to estimate the adaptation gap without an assumption; b) the planning system should ensure a threshold of about 2.0 is reached, even if this is more through qualitative checks and balances than formal appraisal; c) an early review of Integrated Assessment Models (IAMs) found that they used assumptions that delivered an average BCR for adaptation of between 1.80 and 2.03 (Agrawala et al., 2011).

reports have provided reviews of the effectiveness of adaptation expenditure. These include the **GCA 2021 State and Trends** report, the **GCA 2019 Adapt Now** report and the **AfDB/UNEP/UNECA 2019 Climate Change Impact of Africa's Economic Growth** report. There is also a growing body of grey literature on Climate Change Impact Appraisal (CCIA) as part of country's climate mainstreaming initiatives (e.g. in climate change financing frameworks). Some of these reports include conservative estimates for social and environmental benefits and the way these are affected by climate change. In addition, there are increasingly more case studies for individual subsectors and locations, which mostly report BCRs of between two and five.

There is also a body of work on the effectiveness of disaster risk reduction (DRR) expenditure (Hallegatte, Rozenberg, Rentschler, Nicolas, & Fox, 2019; Hugenbusch & Neuman, 2021; Mechler, 2016; Shreve & Kelman, 2014; Vorhies, 2012). This is largely separate from work on climate adaptation effectiveness, which is surprising given the fact that much of the analysis relates to flood and drought risks. Shreve and Kelman reviewed 22 studies on the cost effectiveness of DRR expenditure and found widely varying results (Shreve & Kelman, 2014). Half of the studies reviewed reported BCRs of between two and five, roughly in line with the emerging norms for adaptation effectiveness. But the review also covered some studies with much higher BCRs and identified a number of key areas for improvement, including clearer context and sensitivity analysis, which would help in clarifying the wider relevance of very high effectiveness scores. Shreve and Kelman reported that few of the studies took into account the implications of climate change. If the adaptation benefits (i.e. the additional value of reducing risks, when disasters become more frequent) had been taken into account the BCRs would have been significantly higher.

Annex 3 reviews these sources and reproduces the key diagrams that summarise the results while Figure 7 summarises the results. The sources all show quite wide ranges of BCRs, reflecting differences in country situations, evidence available and the scope of the analysis, especially of benefits. In Figure 7, the data points in the graph are the mid-point estimates and for each source the 'X's show the assumptions used in the PAAF analysis which are an average of the various sources. The placeholder value of 2.0 is included in this average, which helps to ensure that the PAAF estimate is a conservative estimate.

Figure 7: Mid-range estimates of effectiveness by sector

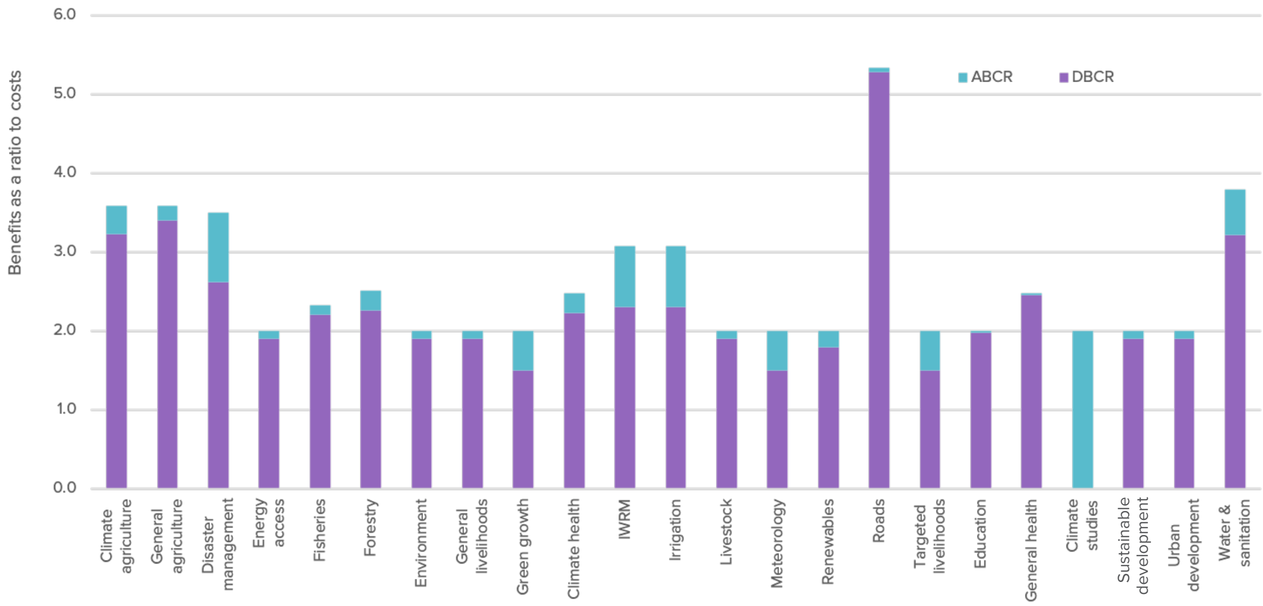


Note: datapoints are mid-range, often with variation of at least +/- 50 percent.

Sources: Own estimates based on data from (AfDB, 2019b; Aktion Deutshland Hilft, 2016; Global Center on Adaptation, 2019, 2021; Nkonya et al., 2016; Shikuku et al, 2021; World Bank, 2008). For a more detailed overview please see **Annex 3**.

Figure 7 presents the total BCR, including adaptation and other benefits. For most adaptation expenditure, part of the benefits comes from development (i.e. GDP growth) and part from adaptation (i.e. reduced EICC). Box 5 describes the evidence for estimating the division of benefits into adaptation (i.e. ABCR) and development (i.e. DBCR). This is summarised in Figure 8.

Figure 8: Overall BCR and adaptation and development BCRs



Source: PAAF assumptions based on sources reported in Figure 7.

The use of quantitative assumptions about adaptation effectiveness is essential for an estimate of the adaptation gap. It is also important for adaptation expenditure to be able to compete for scarce public funds in the planning system, especially for the larger spending programs that are exposed to economic analysis. Adaptation expenditure is sometimes still perceived as an environmental concern and needs to be understood as a solid economic investment in Ministries of Finance, with BCRs that are competitive with public resources devoted to economic growth. If substantial additional finance becomes available (e.g. from international assistance) it is not obvious that the best policy for a country is to devote this to adaptation spending unless returns to adaptation are not only positive but better than to development. **In practice, many programs that deliver adaptation benefits also deliver development benefits and the recognition of the additional adaptation benefits helps to increase the priority given to the program**. As adaptation spending increases, and the most effective options are covered, it is important to assess effectiveness to ensure that more marginal adaptation programs are not included, if the climate risks involved would be better addressed by general development and/or forms of reactive adaptation, such as social protection.

Box 5: The adaptation share of total benefits

Most adaptation expenditure delivers both adaptation benefits (i.e. reduced economic loss) and development benefits (i.e. economic growth) and a BCR can be split into two parts (i.e. ABCR and DBCR) reflecting the two benefits[13]. The share of adaptation benefits in total benefits is captured by the Adaptation Benefits Score (ABS). The evidence on ABSs is still limited and assumption are based on CCIA in four countries. The table below summarises the climate subsectors and gives a brief indication of the basis for the default ABS scores used. In some cases, adaptation benefits happen without the need to adapt program design (i.e. without the need for proofing). In other cases, program design needs to be proofed. The ABS scores assume that programs are proofed, if this is needed.

Sector	Subsector	ABS	Adaptation benefits (proofed or incidental)[a]	Development benefits
Agriculture	Climate agriculture	10%	Targets reduction in 20% EICC by 2050[b]	Growth in agricultural GDP
	General agriculture	5%	Incidental reduction in EICC	
	Irrigation	25%	Water stress protection twice as valuable by 2050	
	Livestock	5%	Incidental reduction in EICC	
	Fisheries	5%	Uncertain whether incidental protection occurs	
	Forestry	10%	Reduced risks (e.g. species choice, fire management)	
Water and natural resources	Water & sanitation	15%	Adaptation reduces increased costs	Water sector GDP (valued at cost)
	IWRM	25%	Water management twice as valuable by 2050	Growth in each water using sector
	Disaster reduction (CC)	25%	Disaster reduction twice as valuable by 2050	Protects investment
	Environment	5%	Reduces growing threat to diversity from climate change	Biodiversity benefits all sectors
Energy	Renewables	10%	Renewables improve reliability of supply	Growth in energy sector GDP
	Energy access	5%	General improvement in reliability of supply	
Social	Education	1%	Devotion of 1% of curriculum to CC related subjects	Education GDP (valued at cost)
	Climate health	10%	EICC from CC sensitive diseases 20% higher in 2050	Health EICC affects all GDP
	General health	1%	1 in 10 patients are for CC sensitive diseases	
Assets	Roads	1%	Road proofing reduces future L&D	Lower costs used for investment
	Urban development	5%	Proofing costs 5% of total with same returns	
Income generation	CC resilient livelihoods	25%	Value of resilient incomes doubles by 2050	Growth across all sectors, in different proportions
	General livelihoods	5%	1 in 5 beneficiaries are climate vulnerable	
Technical	Meteorology	25%	Value of weather service doubles by 2050	All GDP (especially rain/flood sensitive)
	Climate studies	100%	No value unless CC occurs	Proportional to sector EICC

a Adaptation benefits may require some change in design (i.e. proofing) or may occur incidentally, without requiring proofing.
b EICC increase refers to absolute levels in 2050. Average levels are half this, assuming climate change is linear.

13 The PAAF estimates of EICC include growth effects to show the full potential impact of climate change. However, most BCR evidence excludes growth (or multiplier) effects and the calculation of needs is therefore based on EICC excluding growth effects, divided by BCRs.

Box 5: The adaptation share of total benefits (cont.)

The 2012 IPCC Special Report on Extreme Events (SREX) suggested that, across Africa, the frequency of unusual climate events was likely to increase by 20 percent to 100 percent by 2050 and the maps in the IPCC AR5 suggest that this was an underestimate (IPCC, 2012a, 2014b). This applies both to smaller frequent events and to larger infrequent events and to most of the events that cause climate risks (floods, droughts, rainfall seasonality and heatwaves). It seems reasonable to apply a 'doubling rule of thumb' and assume that all unusual climate events will double by 2050. This is clearly a simplification, that should be refined with country evidence, but it is a powerful planning tool that is broadly consistent with the evidence. The SREX doubling rule of thumb means the maximum level of the ABS for such actions is 25 percent[14].

The BCRs and ABSs for each adaptation subsector are assumed to apply to all African countries. In practice, both BCRs and ABSs will be vary between countries, because of differing climate risks and expenditure composition.

14 Assuming the doubling is linear, the adaptation benefits added over the whole period are 33 percent of the total benefits (adaptation and development). For example, if the benefit is 1 unit in 2020, then without climate change there would be 30 units of development benefit in the period to 2050. With climate change, the benefits grow linearly to 2 in 2050 which adds 15 units over the period. If benefits are discounted, the ratio falls from 33 percent to about 25 percent.

4 Needs for adaptation expenditure

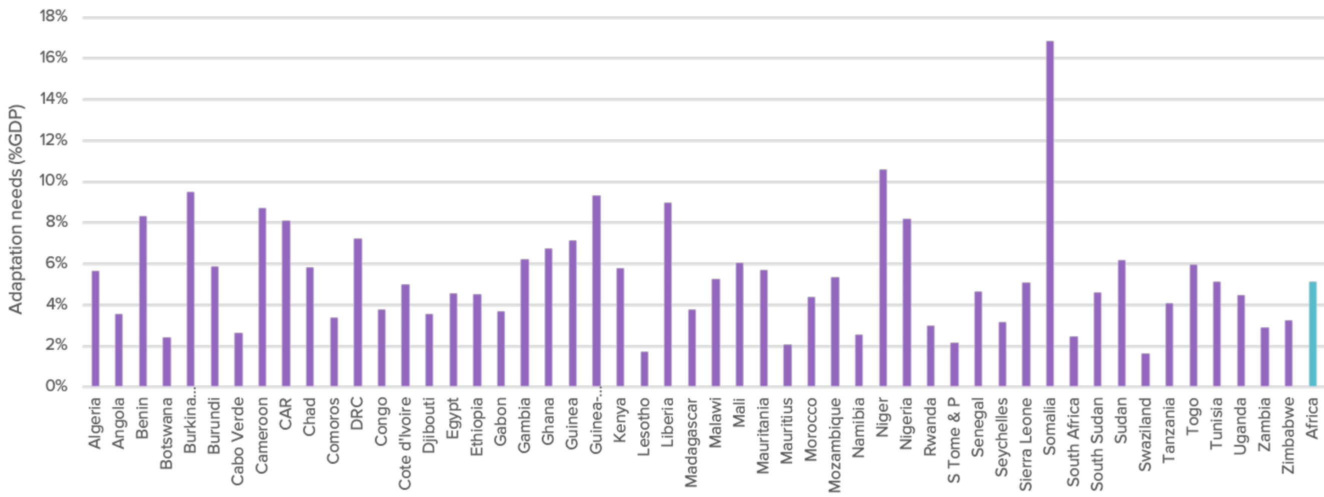
This chapter explores total adaptation expenditure needs, which are estimated by dividing the EICC by the adaptation effectiveness of expenditure, as expressed in the Adaptation Benefit Cost Ratio (ABCR). Needs can be expressed in weighted expenditure, to be comparable with the analysis of existing expenditure, and unweighted expenditure, to be comparable with NDC costing work.

The adaptation benefits from adaptation expenditure are the reduction in EICC and the expenditure needed to reduce all EICC is therefore obtained by dividing the EICC by the ABCR. Adjustment factors are required to ensure that the time periods for EICC and benefits are consistent[15]. Figure 9 presents the adaptation expenditure that would be required to avoid all EICC, assuming that the expenditure achieved average BCRs. **The total annual adaptation needs (both coverable and uncoverable) for Africa are 5.3 percent of GDP in weighted expenditure and 13.7 percent unweighted. Of these total needs, coverable needs are 4.1 percent of GDP, weighted, and 10.4 percent unweighted, or about $255 billion in 2019.** Some country specific conclusions can be drawn from Figure 9.

- About a quarter of African countries have needs that are above 6 percent of GDP. These countries are all ones for which needs are expected to be high.
- About half the countries can be considered average, with needs of between 3 percent and 6 percent of GDP.
- The lower needs of the other countries can be explained as follows: Eswatini, Lesotho, Rwanda and Zimbabwe have relatively diverse economies and may be less exposed to risks associated with heat stress; Botswana, Mauritius, Namibia, and South Africa have relatively developed and diverse economies; Cabo Verde and Sao Tome & Principe are special cases that are probably not sufficiently represented in the exposure indices.

15 EICC grows in a roughly linear trend to 2050. Adaptation benefits growth exponentially. The benefits from an individual adaptation investment grow in line with EICC and there is a cumulative impact as more years of adaptation are added. On the other hand, many of the benefits of adaptation expenditure before 2050 are experienced after 2050. Adjustment factors are used to account for these issues.

Figure 9: Adaptation needs (weighted expenditure)



Source: PAAF estimates.

5 Current levels of adaptation expenditure

This chapter assess current levels of adaptation expenditure. There is a wealth of international experience in defining and tracking adaptation expenditure and many African countries have undertaken CPEIRs and are planning to introduce CBT. The PAAF analysis makes a rapid and rough estimate of climate expenditure, based on publicly available data for the most recent budget approved before Covid-19. The data is presented as weighted expenditure using weights that are typical used in CBT and CPEIR work, to facilitate comparison. Estimates of off-budget adaptation grants are based on OECD DAC data. Estimates of private adaptation are based on total private investment in the national accounts and the sectoral breakdown of investment from banking surveys.

5.1 Adaptation in the national budget

Coverage and data sources

This study includes domestic and international climate finance as captured by the national budget. In total, 51 African countries are included in the analysis, which is mainly limited to the central government's recurrent and development budget. Supplementary data was included for subnational governments in South Africa and Egypt. Subnational expenditure is about 12 percent of general government expenditure in Africa as a whole (OECD & UCLG-CGLU, 2022) and is much higher in decentralised systems. Subnational governments can therefore be responsible for significant proportions of adaptation spending (UNDP, 2022) and further work is required at country level to incorporate this spending into the analysis. The analysis also does not cover adaptation spending by state-owned enterprises (SOEs), unless this is included in the budget (e.g. as a transfer to an SOE or project finance managed by an SOE). For adaptation, this may be particularly important in countries where water supplies are managed by SOEs.

We make use of the approved budget as detailed in the national budget documents. The Covid-19 pandemic saw an extraordinary change in budget allocations, as expenditure for containing and treating Covid-19 was prioritised. We therefore made use of pre-Covid-19 data from 2019. This provided a snapshot of the composition of expenditure for a single year. Future research should review a longer time period, including the post Covid-19 period as sufficient budget data becomes available, to give added confidence to the figures. The analysis of options for closing the adaptation gap (section 6.4) includes an assessment of the increase in public expenditure as a percent of GDP as a potential source of increased adaptation finance. Country level work should be able to analyse time series budget data to explore both the growth of public expenditure as a percent of GDP and whether the adaptation share of total public expenditure has been increasing.

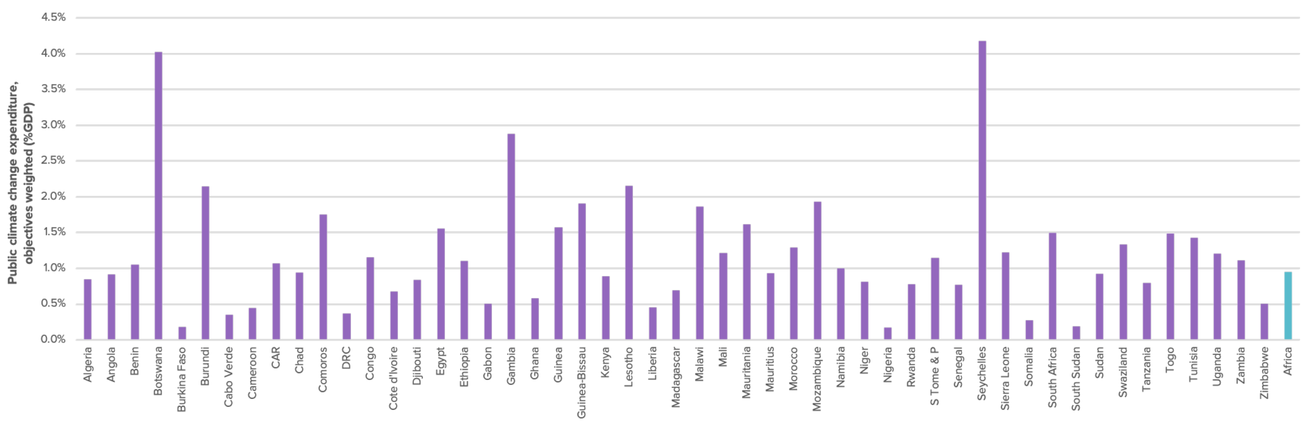
The main source for public expenditure is national budget data, obtained either from the BOOST open budget portal or from budget documents from ministry of finance websites. Annex 5 contains a full list of the countries included, the period covered and the data sources. The BOOST open budget portal provides comprehensive time series budget data for 13 African countries. For the countries where BOOST data is available, our analysis covers the period 2010 to 2019, which enables the observation of trends in the adaptation gap over time.

PAAF estimates of public adaptation expenditure

The national budget is screened to identify and tag climate relevant expenditure. Five levels of budget data are defined: national, ministry, department, unit and project. The level of granularity varies across countries, depending on data availability. Data is tagged at the project or unit level, however, if this level of data is not available, then it is tagged at the department or ministry level.

The analysis classified all expenditure items according to 21 adaptation relevant subsectors, each having an objectives-based score taken from typical CPEIR values. **Figure 10 presents the objectives-weighted climate expenditure as a percentage of GDP. Results vary from about four percent in Botswana and Seychelles to less than one percent in Burkina Faso, Cabo Verde, Cameroon, DRC, Liberia, Nigeria, Somalia and South Sudan. The average for Africa is 0.95 percent of GDP.**

Figure 10: Existing weighted climate expenditure (%GDP)



Source: PAAF analysis of budget data.

CPEIRs and CBT in Africa

The PAAF analysis in Figure 10 can be compared with other work on climate expenditure. CPEIRs have been done for at least 12 African countries as show in Table 4. These are often the starting point for climate change mainstreaming into public financial management (PFM) systems and provide qualitative and quantitative data on climate public expenditure. The PAAF study makes use of similar methods applied in CPEIRs, in the way that data from national budget is screened, classified, tagged and weighted.

At least 10 African countries have introduced or are in the process of introducing CBT. When operational, this will enable the routine identification and tracking of climate expenditure in the national budget. Eswatini and Namibia are currently designing their CBT systems, while Ethiopia, Mauritius, Nigeria, Seychelles, South Africa and Uganda are in the piloting phase. Ghana and Kenya have successfully rolled out CBT at the national and subnational level. However, countries do not regularly report on their climate expenditure.

Table 4: Climate public expenditure and institutional reviews in Africa

Africa	CPEIR	PEFA-C	CPI CFL	Other	CBT
Benin	2017				
Eswatini	2021				Design phase
Ethiopia	2014[a]	2021			Piloting phase
Ghana	2015; 2021				Rolled out
Kenya	2016		2021		Rolled out
Mauritius				PEER 2016; TPSEE 2018	Piloting phase
Morocco	2012				
Mozambique	2016[b]			PEER 2012	
Namibia					Design phase
Nigeria					Piloting phase
Rwanda	2013				
Seychelles				BPER 2019	Piloting phase
South Africa			2021		Piloting phase
Tanzania	2013				
Uganda	2013				Piloting phase

PEER is public environment expenditure review, TPSEE is tracking of public sector environment expenditure, BPER is biodiversity public expenditure review, CPI CFL is the CPI Country Finance Landscape studies.

a is partial CPEIR carried out in Ethiopia.

b the Mozambique CPEIR is pending validation by the government.

Climate Finance Landscape (CFL) reports

CPI prepare Climate Finance Landscape (CFL) reports at a global level and for specific countries. According to the 2021 global CFL, international climate public finance flows to sub-Saharan Africa were $17 billion in 2019/2020[16], accounting for 88 percent of total climate finance in Africa, making the subregion highly dependent on international public finance (CPI, 2021a). At country level, climate finance landscape assessments were completed for **Kenya** (KNTP & CPI, 2021) and **South Africa** (CPI, 2021b), which assessed the flow of public, private, international and domestic climate finance.

The time period covered for Kenya is 2018 and South Africa is 2017 and 2018. Both studies find that there is underinvestment in climate adaptation, accounting for just 7 percent of flows in South Africa and 11.7 percent in Kenya. There is some additional climate finance going towards actions with dual benefits, accounting for 13 percent and 8.5 percent in South Africa and Kenya respectively, however, the majority of climate finance went towards climate mitigation actions, which accounted for roughly 80 percent of climate flows in both countries. The majority of climate adaptation finance came from public sources, both international and national. In South Africa, 90 percent of adaptation finance was funded from public sources and the remaining 10 percent through blended finance, while no private climate finance was channelled towards adaptation activities.

Table 5 shows how the PAAF estimates compare to estimates from CPEIR and CFL studies. Caution is needed when comparing climate expenditure as there are differences in the way climate relevant expenditure is defined and weighted. In addition, for half the countries, the CPEIR was done prior to 2015 and may therefore not reflect more recent developments in climate public expenditure. However, in general, there is a good level of consistency between the PAAF results and the results obtained entirely independently from CPEIRs and CFLs. There are two main studies that are significantly different to the PAAF results. The Kenya CFL has a very low figure, which is out of line with the CPEIR and may reflect a much more restrictive approach to defining adaptation expenditure. This is unexpected, though, since the result in South Africa is more in line with normal country levels. The Uganda CPEIR also reported very low levels of climate expenditure. This may be influenced by the fact that it is now an old CPEIR and level of adaptation expenditure may have been much lower ten years ago. However, the other early CPEIRs report higher levels, which suggests that there may have been other reasons.

16 Private flows stood at $2 billion (CPI, 2021).

Table 5: Public expenditure: PAAF and comparative sources (in % GDP)

	Comparative results					PAAF
	Study	Year	Lead partner	Unweighted[a]	Weighted[a]	Weighted[a]
Ethiopia	CPEIR	2014	ODI	6.27%	1.83%	1.10%
Ghana	CPEIR	2015	ODI	4.77%	0.67%	0.58%
Ghana*	CPEIR	2021	UNDP		0.77%	
Kenya	CPEIR	2016	UNDP	5.85%	2.86%	0.89%
Kenya	CFL*	2021	CPI	0.48%		
Tanzania	PEIR	2013	ODI	7.06%	1.43%	0.79%
Uganda	CPEIR	2013	ODI	3.3%	0.2%	1.20%
Eswatini	CPEIR	2021	CS*			1.34%
South Africa	CFL	2021	CPI	6.13%		1.50%

* CFL is CPI's Climate Finance landscape studies; for Ghana the estimate is an average over six years from 2015 to 2020; Eswatini had Commonwealth Secretariat as lead partner.

a The weights used are the objectives based weighted commonly used in CPEIRs and CBT.

Source: compiled from (CPI, 2021b; Government of Eswatini, 2021; Government of Ghana, 2021; Kenya National Treasury and Planning, 2016; KNTP & CPI, 2021; ODI, 2016).

Box 6: Egypt's public expenditure and climate change

Egypt ratified the UNFCCC in 1994 and was among the first countries to respond to the threats of climate change. Egypt submitted its Intended Nationally Determined Contribution (INDC) in November 2015 to achieve the global targets set out in the Paris Agreement. After Egypt signed the Paris Agreement in April 2016 and ratified it in June 2017, the INDC was considered Egypt's first NDC. It aligned with Egypt's developmental and climate change policies, including the country's Sustainable Development Strategy: Egypt's Vision 2030, the emerging Long-Term Low Emission Development Strategy 2050 (LT-LEDS), the National Climate Change Strategy 2050 (NCCS), National Strategy for Disaster Risk Reduction 2030, and the National Strategy for Adaptation to Climate Change. In addition, the first NDC aligned to sectoral strategies, such as: Integrated Sustainable Energy Strategy 2035, National Energy Efficiency Action Plan II (2018 – 2022), National Water Resources Plan (2017- 2037), Integrated Solid Waste Management Strategy, and Sustainable Agricultural Development Strategy towards 2030 (SADS 2030).

The table below presents climate changes' public expenditure in FY 2019/20. It should be mentioned that public expenditure in Egypt is not exclusively limited to the state's national budget expenditure, but it includes many off-budget expenditure items. The major part of the off-budget public expenditure is related to urban infrastructures, roads, and housing. The table below presents climate changes' public expenditure in FY 2019/2020 classified into budget and off-budget items in EGP billions.

Box 6: Egypt's public expenditure and climate change (cont.)

Public climate change expenditure in Egypt in FY 2019/2020 (EGP billions)

Sector/ target	Budget expenditure	Off-budget expenditure
Agriculture - crops research and extension	3.2	1.7
Agriculture - general sector management	6.1	24.3
Energy access		8.2
Fisheries	2.8	1.1
Forestry (unless with specific CC focus)	8.9	
General environment and wildlife	2.4	
General livelihoods & welfare without vulnerability focus	18.5	
Irrigation and drainage	2.7	
Livestock research and extension	3.2	
Meteorology and climate science	0.3	
Renewable energy and energy efficiency	3.9	6.0
Road infrastructure and transport services	26.3	141.4
Rural primary health, general	27.7	
Studies and capacity building dedicated exclusively to CC	0.6	
Sustainable economic development, incl. tourism	1.2	2.5
Urban development, housing, local development	4.8	114.3
Water supply and sanitation	15.5	58.0

Source: Calculated from Egypt's Ministry of Finance database for FY 2019/2020.

According to the second **NDC**, prepared in 2022, the financial resources required to implement the NDC up to 2030 is estimated at minimum $246 billion, of which $196 billion is for mitigation and $50 billion for adaptation. The financial estimates are derived from the required upfront capital expenditures to implement mitigation and adaptation programs, capacity building and technology transfer, and the human resources needed to implement the actions. The actual implementation of these mitigation and adaptation measures are conditional on the provision of adequate, appropriate international finance through highly concessional finance and grants as appropriate.

GCA 2021 State and Trends Africa Report 2021

The **State and Trends Africa Report** (Global Center on Adaptation, 2021) provides a comprehensive overview of current and projected climate change risks and related implications for Africa, alongside a 'blueprint' for the design, financing and implementation of adaptation plans. It focuses on key sectors, including agriculture and food systems, trade, drylands, transport and energy, urban development, water resources management, floods, and disaster risk management, as well as the cross-cutting themes of health, gender, the sustainable development goals, conflict and migration.

Box 7: Budget and actual expenditure

The PAAF analysis uses data on budget estimates, rather than actual expenditure. In theory, it would be useful to consider both budget and actual data since the budget data shows the adaptation gap that would result if government was able to deliver on their intentions and actual expenditure shows the adaptation gap actually experienced. In practice, actual data is often available only several years later than budget data and is often presented at an aggregate level.

In Africa, the main reasons for low outturn rates (i.e. actual expenditure below budget estimates) are: unpredictable international funding; response to disasters, conflict or other unexpected events; and economic crises that reduce domestic revenue. There is no reason for climate expenditure to be more affected than other expenditure by problems with international financing. However, there may be a tendency for climate expenditure to be squeezed more than some other sectors, if revenues fall or expenditure is diverted to respond to crises.

The Public Expenditure and Financial Accountability (PEFA) assessment includes two indicators of the divergence between budget and actual expenditure, one of which refers to the aggregate divergence and the other to the divergence amongst ministries. **Countries with low scores on this PEFA category are likely to have actual adaptation gaps significantly lower than the gaps that are indicated by the budget data used in PAAF.**

To give an indication of the difference between budget and actual expenditure for climate, evidence from CPEIR work showed that for the period 2015 – 2020, the average budget execution rate for climate relevant expenditure in Eswatini was 51.9 percent and in Ghana was 38.1 percent for ministries, departments and agencies and 34.2 percent at the subnational level.

5.2 International adaptation finance

The PAAF analysis aims to cover both expenditure that is labelled and identified as 'climate finance' and expenditure that is considered as development expenditure and not presented as a climate project, but which makes a secondary or implicit contribution to adaptation. For domestic expenditure, it is possible to do this using the full budget data. The analysis also includes international finance that is classified as climate expenditure using the OECD DAC Rio markers, including both loans and grants. The analysis should also pick up international loans for development that do not have Rio markers but which make secondary or implicit contributions to adaptation because the loans should be included in the budget. However, international grants that do not have Rio markers are not included.

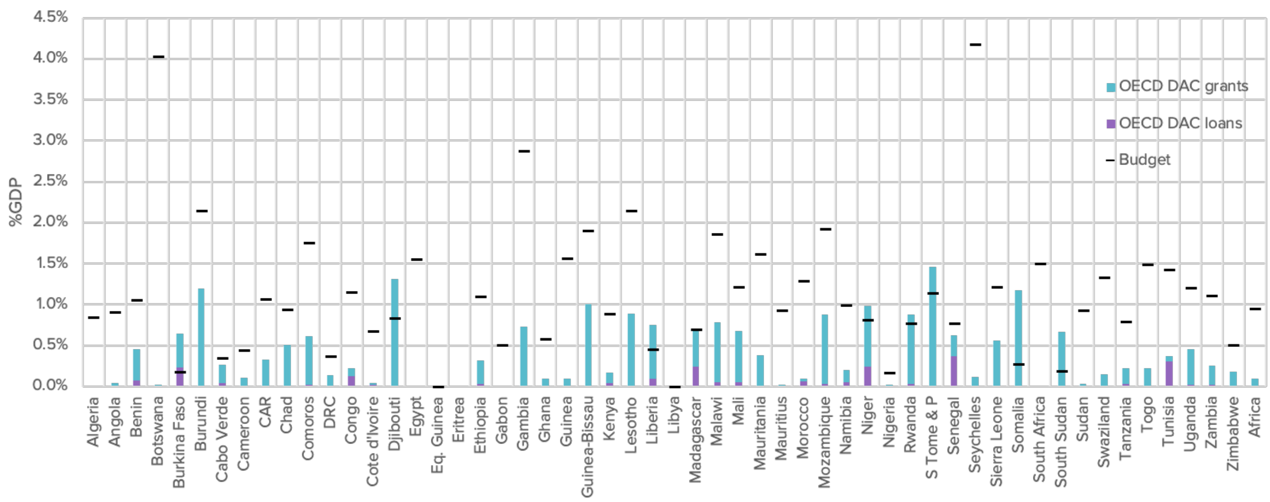
OECD Development Assistance Committee (DAC)

The **OECD DAC database**, accessed in July 2022, had data covering the period 2002 to 2020 on official development assistance (ODA) by recipient, sector and project. These are recorded by the funding body. For a substantial African country there are typically over 1,000 projects for one year. These will include many that are in the budget and many that are not.

The OECD DAC database requires funding agencies to specify whether adaptation is the principal objective of a program or a significant objective, following the standard definitions used for all Rio markers. For 2019, there were 1,006 programs in Africa for which adaptation was the principle objective and 3,507 programs for which it was a significant objective. The average annual adaptation ODA received by Africa from 2015 to 2019 was $5.6 billion, including both principle and significant adaptation spending and without applying weights. The normal convention in summing the principle and significant adaptation ODA is to apply weights of 100 percent and 40 percent for principle and significant programs. These weights are roughly equivalent to the CPEIR-style codes used in the PAAF analysis.

Figure 11 compares the OECD DAC and budget analysis data. The comparison is not straightforward because many grants will not be in the budget and the OECD DAC database records commitments on a calendar year that may not coincide with annual budgets. The figure suggests that the countries that are most dependent on ODA for adaptation funding are: Burundi, Chad, Djibouti, The Gambia, Guinea Bissau, Lesotho, Liberia, Malawi, Mali, Mauritania, Mozambique, Niger, Rwanda, Sao Tome and Principe, Somalia and South Sudan. It also suggests that there are a few countries that are major recipients of ODA that contributes to adaptation[17], but which also have significant domestic spending, including: Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Uganda, Zambia and Zimbabwe. Countries that receive little adaptation ODA but have substantial domestic funding for adaptation include: Algeria, Angola, Botswana and South Africa.

Figure 11: Climate change expenditure in budgets and in OECD DAC ($ million, weighted)



Note: DAC uses DAC weights and budget use CPEIR-style weights, but the results are roughly comparable.
Source: OECD DAC database and PAAF budget analysis (OECD, Accessed 2 August 2022).

Multilateral Development Banks (MDBs)

Since 2012, MDBs have jointly reported on their climate finance, using distinct methodologies which respectively track and report climate change adaptation and mitigation (MDBs, 2015). This includes commitments from MDB's own accounts as well as external resources channelled

17 There are ongoing discussions amongst UNFCCC Parties about how to define development and climate finance in a manner that clearly identifies the additionality of climate finance, either through new programs that are considered wholly climate change or through additional features and funding for programs that deliver both development and climate benefits.

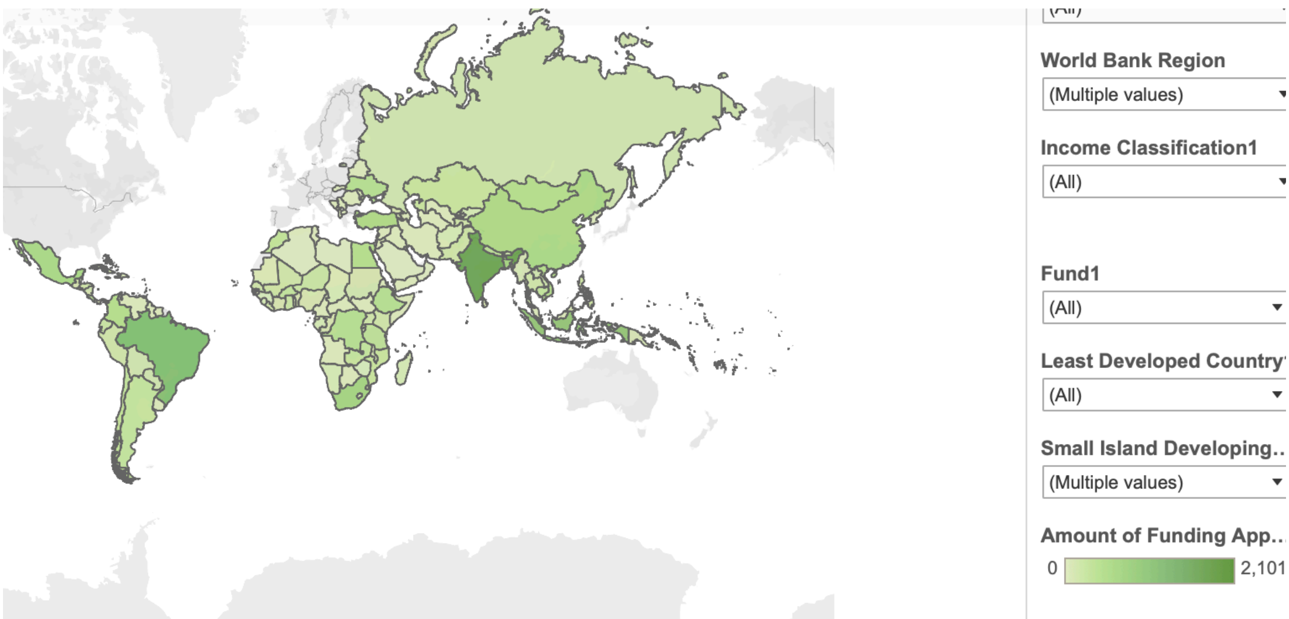
through and managed by MDBs. The methodology for tracking climate adaptation finance is based on a context and location specific approach which captures the value of activities directly linked to climate change vulnerability. It aims to capture the incremental cost of climate adaptation activities. Since 2015, MDBs have jointly reported on co-financing flows for climate change adaptation and mitigation. This captures climate finance from MDBs and contributions from private and public external sources. The most **recent report** provides climate finance data for 2020 (MDBs, 2021), which suggests that adaptation spending by MDBs in 2020 for sub-Saharan Africa and North Africa and the Middle East was $6.06 billion, up from $4.61 billion in 2019, having increased steadily from $1.05 billion in 2016.

MDBs are currently in the process of refining the classification of climate change expenditure and a new system is being piloted.

International Climate Funds

The global climate finance architecture is complex, with multiple sources of funding, some of which is channelled through climate change funds which have been growing in number and significance (Climate Funds Update, 2021). The **Climate Funds Update** tracks multilateral climate funds that assist developing countries in addressing the climate change challenge. It provides cumulative data from 2003 onwards, with data on contributors, recipients, the status of finance (i.e. pledged, deposits, approved and disbursed funds) and the type of finance (i.e. grant finance, technical assistance, concessional loans, credit finance, non-concessional loans, equity and guarantees). Included are the operating entities of the UNFCCC, such as the Global Environment Facility (GEF), the Adaptation Fund (AF) and the Green Climate Fund (GCF). Figure 12 below provides an overview of the recipients of the $28 billion that has been approved globally by climate funds.

Figure 12: Map of recipients ($ millions)



Source: Climate Funds Update, 2021.

Table 6: Climate finance to Africa, as reported by OECD DAC, MDBs and the CFU

	2016	2017	2018	2019	2020	Total
Adaptation only ($ billion)						
OECD DAC (Africa)						
Principal Adaptation Objective	2.16	2.03	1.08	1.38	2.30	10.64
Significant Adaptation Objective	4.89	4.77	5.53	5.18	6.27	30.32
Total	7.05	6.80	6.61	6.56	8.57	40.96
OECD DAC by MDB (Africa)						
AfDB	0.28	0.78	0.70	1.47	1.44	4.67
AIIB	0.00	0.00	0.00	0.00	0.00	0.00
EBRD	0.00	0.16	0.02	0.07	0.18	0.43
EIB	0.02	0.03	0.10	0.10	0.34	0.58
IsDB	0.00	0.00	0.00	0.08	0.09	0.16
WB	0.71	1.76	2.18	3.21	4.21	12.07
Total	1.01	2.74	3.00	4.92	6.25	17.92
MDB Joint Report						
Total (SSA and MENA)	1.13	2.55	4.71	4.61	6.07	19.07
Adaptation and mitigation ($ million)						
All Climate Funds Update (SSA & MENA)						
Green Climate Fund IRM (GCF IRM)	48.0	254.2	422.6	409.3	364.8	1876.4
Clean Technology Fund (CTF)	0.0	30.0	60.0	272.7	0.0	594.0
Least Developed Countries Fund (LDCF)	28.8	25.5	111.0	52.0	87.9	366.0
Adaptation Fund (AF)	9.3	18.4	38.5	42.4	79.1	224.3
Global Environment Facility (GEF7)	0.0	0.0	0.0	0.0	87.0	231.6
Global Environment Facility (GEF6)	55.2	41.8	64.4	84.1	1.8	247.2
Central African Forest Initiative (CAFI)	10.6	175.0	0.3	9.4	0.3	201.8
Global Climate Change Alliance (GCCA)	0.0	45.0	74.7	34.2	32.7	186.7
Forest Investment Program (FIP)	10.5	19.8	43.4	28.4	4.5	114.6
Other Climate Funds	198.9	79.8	85.2	51.5	30.9	497.0
Total	**361.3**	**689.5**	**900.2**	**983.8**	**688.9**	**4539.7**

Source: Compiled with data from OECD DAC, 2022; MDB, 2021; Climate Funds Update, 2022.

SCF climate financing flows assessment

The Standing Committee on Finance (SFC) **fourth Biennial Report** (BR) provides an assessment of climate finance flows and related implications for international efforts to address climate change. Covering data up to 2018, it provides an overview of climate finance flows between countries, domestic climate finance, south-south cooperation and other flows that constitute global climate finance (Standing Committee on Finance, 2020). The review is based largely on the sources reviewed earlier in this chapter but has also started to review data directly from recipient countries, including data reported in country BRs, CPEIRs and other country sources. Annexes include a list of 28 countries that have provided data, of which 6 are from Africa, as presented in Table 7.

Table 7: Climate finance committed in 2017 and 2018, as reported to the SCF ($ million)

	2017	2018	Total
Côte d'Ivoire	1.3	106.2	107.6
Guinea-Bissau	29.0	12.0	41.0
Namibia	0.4	0.0	0.4
South Africa	1.7	0.0	1.7
Tunisia	110.0	0.0	110.0
Zambia	95.6	0.0	95.6
Total	**238.0**	**118.2**	**356.2**

Note: Figures represent the total value of climate projects approved during the year.
Source: SCF, 2020.

5.3 Private sector adaptation

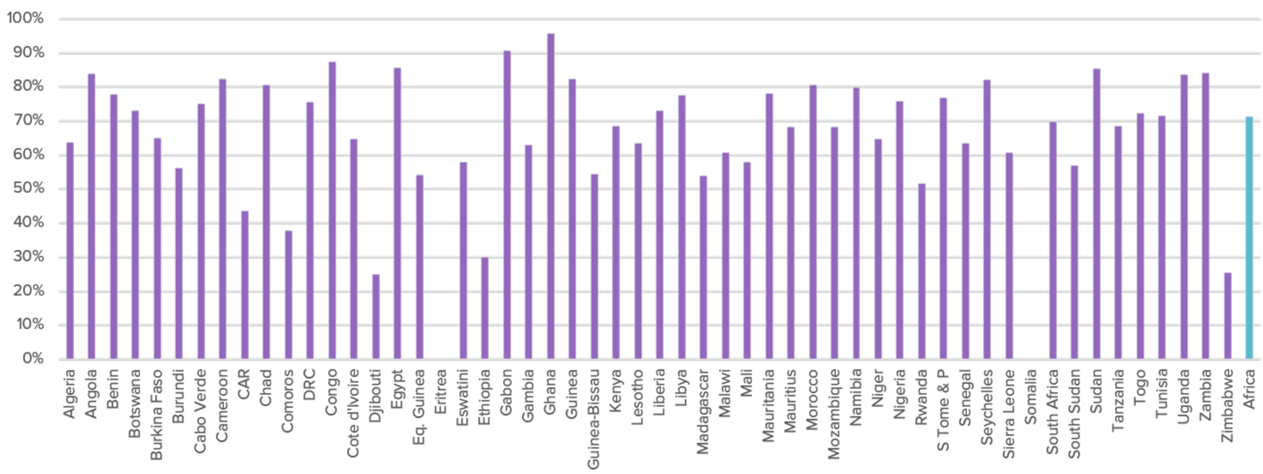
Data on private sector adaptation expenditure is very limited. There is growing interest in improving the consistency and coverage or reporting within business on sustainable financing and this is likely to produce clearer and more comprehensive data in the mid-term (TCFD, 2021). In the meantime, this section illustrates a framework for including private adaptation expenditure in the analysis of the adaptation gap. The analysis does have some evidence base, including national accounts data on private investment and evidence from reviews of the sectoral interests of private banking and equity investors. However, the figures generated should be considered as indicative, providing a very approximately reasonable placeholder for more detailed work.

The 2022 CPI **Climate Finance Landscape** reports that adaptation accounts for only two percent of total private climate finance (CPI, 2021a). Most of the private finance picked up in the CPI analysis is from formal financial sources (i.e. corporations and commercial financial institutions) but the analysis also includes 18 percent of private finance provided by households and individuals. It is not clear whether this would pick up informal smallholder and household adaptation, which is likely to be important in Africa.

There has been wide interest in the private sector in investing in adaptation, particularly from enterprises that are seeking more secure supply chains and improved productivity. Much of this interest will be reflected in adjustments to routine decisions, including those on issues such as crop choices, building standards, work scheduling, contingency planning, insurance and the integration of uncertainty into contracts and it will be difficult to distinguish adaptation spending from routine investment in the private sector, just as it is in the public sector[18]. Given the increasing awareness of climate risks, it is reasonable to expect adaptation to become an integral part of private investment and operational decisions over the next 10 years. As a first working approximation, it is therefore reasonable to assume that private investment will generate a similar reduction in climate EICC to public expenditure, for each climate sensitive sector.

Thus, a first estimate of the potential contribution to adaptation of private investment can be made by estimating the private investment in climate sensitive sectors and applying the same climate change benefit scores as are used for public expenditure in the sectors. The AfDB Socio-Economic Database includes data on the division of total Gross Fixed Capital Formation (i.e. GFCF or gross investment, not taking into account any depreciation of existing capital stock) into public and private sector. For Africa as a whole, public investment accounts for 28 percent of total investment, but this share varies greatly amongst countries (e.g. from over 70 percent in Djibouti and Zimbabwe to less than 10 percent in Gabon and Ghana). Some of this variation may be related to issues with data sources.

Figure 13: Private investment (GFCF) as a share of total investment



Source: AfDB Socio-Economic Database (accessed 5 August 2022).

There is no comprehensive data on the sectoral breakdown of private investment. The **EIB Africa banking survey** suggests that the agriculture sector (presumably including livestock, fisheries and forestry) accounts for 22 percent of bank lending and water and sanitation for 13 percent, with the remainder financing other industry and service subsectors (EIB, 2020). This is roughly supported by the **AVCA review** of private equity, which asked investors which sectors were most interesting to them (AVCA, 2021). The most popular sectors including healthcare, financial services, technology and consumer goods, which have only very limited sensitivity to climate change. However, agriculture accounted for 15 percent of the positive responses and infrastructure (probably including water and housing) accounted for 10 percent. **The PAAF analysis of likely current private sector adaptation assumes that, at a pan-African level, 15 percent of private investment is for agriculture and 5 percent is for water.** The level in each country is adjusted to reflect the ratio between the country's agricultural and water GDP and the pan-African average. For a few countries, special assumptions are required, especially

18 Much of this private adaptation may involve investment but large adaptation benefits are also possible from changing routine operating practices, with little or no investment.

in those countries with very high private investment levels that may be devoted primary to specific sectors, including mining.

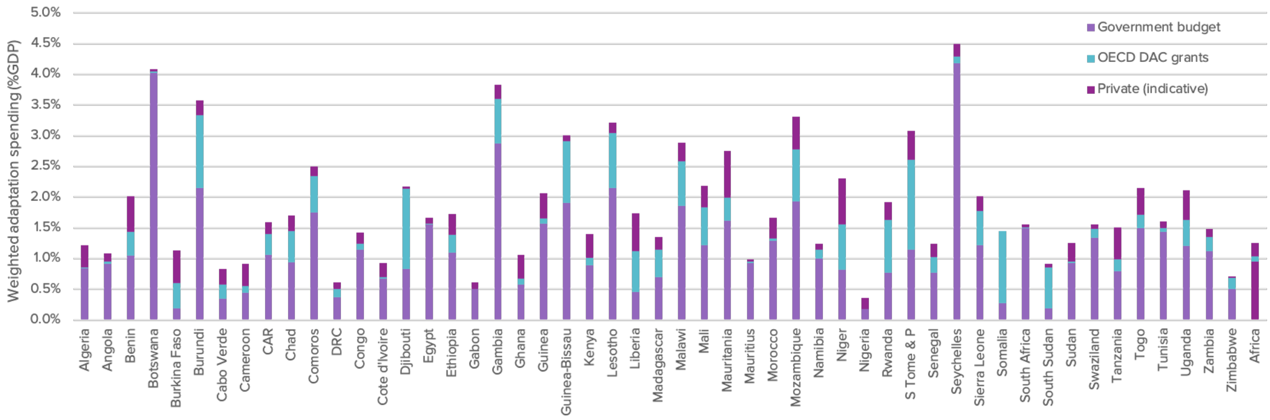
There is, as yet very little empirical evidence of the effectiveness of private investment in reducing climate EICC. However, there is some early work on the definition of adaptation benefits as a part of a potential mechanism to attract additional payments for private investors (AfDB, 2021). In the longer term, it can be expected that adaptation will be fully integrated into all private investment in climate sensitive sectors. At that point, the ABS (or ratio of the benefit from reduced EICC to costs) for private and public expenditure should be similar since, although they may perform different functions, they are generally dependent on each other and can be viewed as a package of complementary investment, with combined adaptation benefits. The PAAF analysis assumes that the private sector has made substantial progress in integrating adaptation into investment and has moved half way towards full integration, at which point the ABS will be aligned with the ABSs estimated for the public sector in Chapter 3.

5.4 Combined adaptation expenditure

Figure 14 summarises the findings of the PAAF analysis described in the first three sections of this chapter, based on the PAAF analysis of: budget data; the OECD DAC database; and the limited evidence available on private adaptation. **The PAAF analysis aims to cover all expenditure that contributes to adaptation, either explicitly or implicitly. It covers development expenditure in the budget (including that funded by international loans) that makes an implicit contribution to adaptation but it does not cover international grants for development that have no OECD DAC Rio Marker but do make an implicit contribution to adaptation.**

The figure shows wide variation in adaptation expenditure, even amongst countries that would appear to be at similar stages of development. In some countries, the high level of funding in the government budget is likely to be the result of high levels of foreign borrowing for climate sensitive sectors (e.g. in The Gambia, Malawi and Mozambique). In some cases, the reasons for this seem to be associated with the coverage and composition of the budget, including in the following ways: a) whether subnational budgets are included (e.g. the inability to cover State level funding in Nigeria); b) differences in the inclusion of state enterprises in the budget may also be important, especially where these include enterprises that are responsible for water and for rural and urban development; and c) differences in the level of detail available in budgets, especially in important climate sectors like water. Explaining these differences requires further research.

Figure 14: Total adaptation expenditure (%GDP)



Source: PAAF analysis.

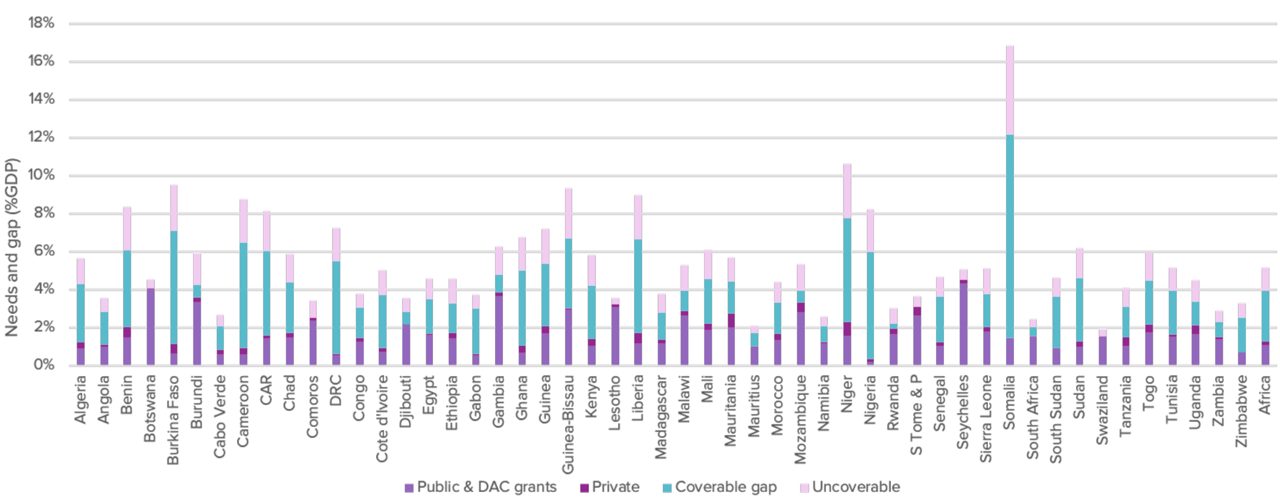
6 Adaptation gap

This chapter assesses the adaptation gap, which refers to the extent to which existing spending fails to reduce the expected EICC. In the mid- to long-term, the gap can be addressed by increased domestic funding in the government budget and from the private sector. In the short- to mid-term, African countries are dependent on increased international funding. There will be some EICC which cannot be avoided by cost-effective adaptation. This is referred to as 'uncoverable' EICC in this report (see Box 3). Some analysis uses the term 'residual loss and damage' for this concept, but the term is applied in different ways and is not used here to avoid confusion.

6.1 Country adaptation gaps

The UNEP AGR assesses the gap by comparing financing needs with supply. PAAF also adopts this approach and defines the adaptation gap as adaptation needs less current public and private spending, with both expressed as percent of GDP. Figure 15 shows the gap for 51 countries in Africa for which sufficient data is available, distinguishing between: the EICC that is already covered by public and private adaptation; the EICC that can be covered cost-effectively if funding is available; and the uncoverable EICC for which there are no cost-effective adaptation options (see Box 3). **The figure suggests that the gap is typically between about 2 percent and about 6 percent of GDP, although it is higher in some countries. For Africa as a whole, the total adaptation gap is 5.3 percent of GDP, of which about a quarter is uncoverable**. In 2019, the coverable gap was 2.5 percent of GDP for Africa as a whole ($102 million), when expressed in weighted expenditure, or 7.1 percent in unweighted expenditure.

Figure 15: Existing adaptation and the adaptation gap (%GDP, weighted)



Source: PAAF analysis.

Figure 15 suggests the following country-specific conclusions:

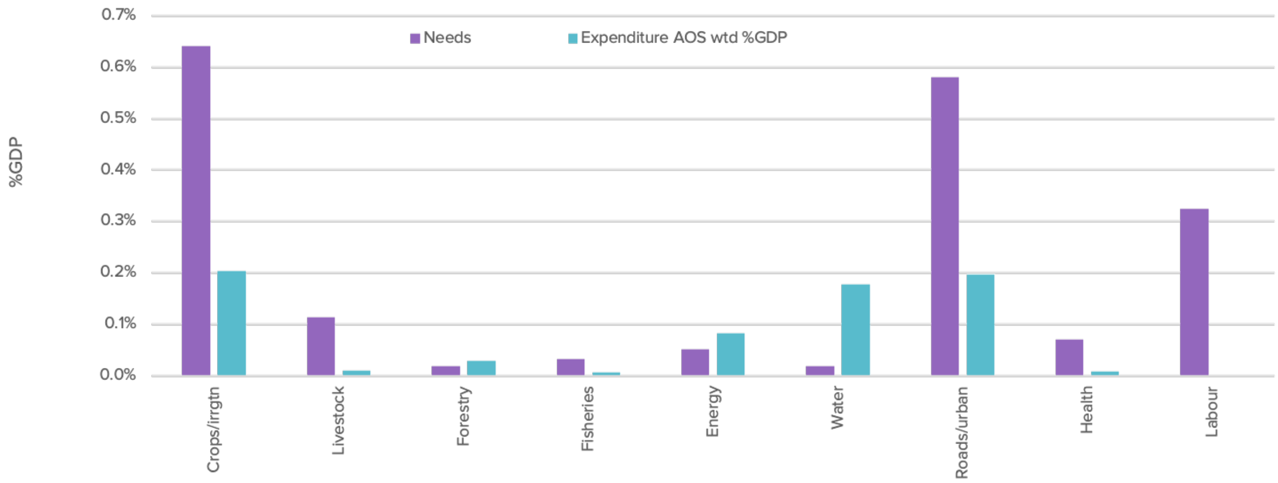
- Most countries have coverable gaps of between two percent and four percent of GDP.
- There are a few countries with gaps above four percent that are highly vulnerable and have limited fiscal capacity, including: Benin, Cameroon, CAR, DRC, Guinea, Guinea-Bissau, Liberia and Niger.
- Nigeria has a surprisingly high gap because it has relatively high needs and public expenditure appears to be focused in sectors that do not contribute to adaptation. It is possible that there is significant public adaptation spending at subnational level and in state enterprises that is not picked up in the analysis.
- Most of Africa's middle-income countries have lower gaps although North African countries mostly have significant gaps of around two percent of GDP.
- There are a few countries that are surprisingly low: Cape Verde and Sao Tome & Principe may not be well represented in the exposure evidence; Ethiopia is less exposed to heat stress than some countries; Mozambique has average needs but has a relatively high existing expenditure on adaptation; Zambia and Zimbabwe may be lower than expected because agriculture has a relatively small share of GDP.
- Somalia is an outlier, reflecting the very high EICC and low public expenditure.

The UNEP 2023 AGR found that the latest estimates of adaptation financing needs for all developing countries are higher than the previous AGR estimate and amount to 0.6 to 1.0 percent of GDP. This estimate reflects evidence from both economic modelling of EICC and from NDC cost estimates. The estimate of needs is much lower, as a percent of GDP, than the PAAF estimates for Africa, probably because the AGR estimate is for all developing countries (defined as all non-Annex 1 countries), which includes many middle-income countries. Financing needs are 10 to 18 times international public adaptation flows. The 2023 AGR reviews work on domestic adaptation financing and suggests that, whilst the evidence is still emerging and methods are not yet consistent and comparable, initial estimates are that domestic financing is much higher than international financing.

6.2 Sector adaptation gap

The PAAF data makes it possible to provide a first estimate of the extent to which public expenditure is meeting the adaptation needs of different sectors. This can be done both at a pan-African level and at country level. Figure 16 describes the adaptation needs and existing expenditure by sector.

Figure 16: Adaptation needs and expenditure by sector (weighted expenditure %GDP)



Source: PAAF analysis.

Some initial sector-specific conclusions can be drawn from Figure 16:

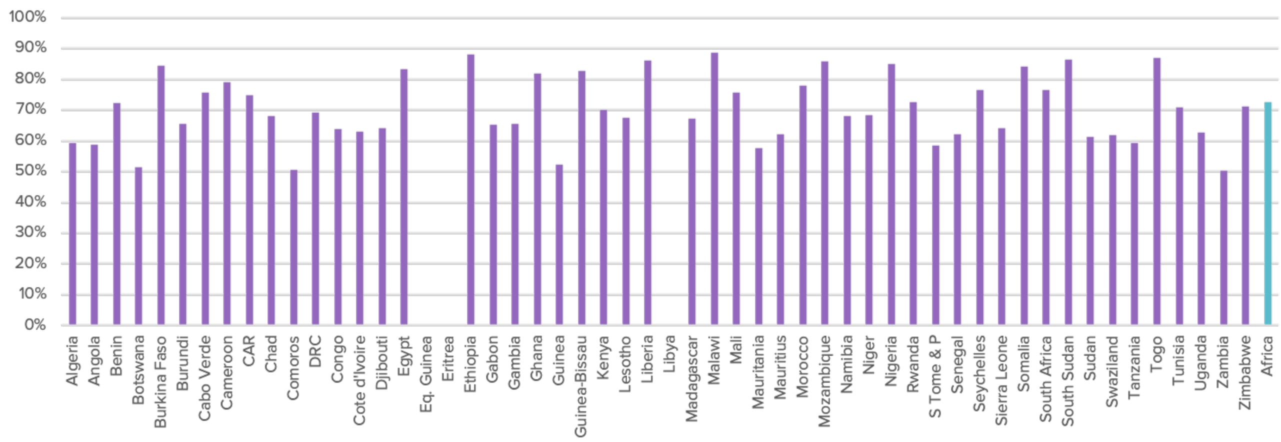
- Crops and irrigation do have significant adaptation expenditure, but they address only 10 percent of the needs.
- Livestock and fisheries have very little expenditure and appear to be neglected, compared with the needs. Forestry has slightly higher expenditure, but still has a very high gap.
- In the energy sectors, there is little evidence of the extent to which public expenditure reduces the main causes of EICC (i.e. increased cooling costs and distribution losses). Until more work is done on this, the numbers should be treated as indicative placeholders.
- The water sector has relatively high adaptation expenditure. This may reflect that water sector GDP is typically limited to the cost of providing water supply and sanitation, whilst expenditure may be on programs that service a wide range of sectors.
- The potential EICC from health and labour productivity does not yet receive significant adaptation expenditure. It is possible that private enterprise is already investing heavily in protecting labour protectivity from heat stress, but this requires more research.

Country Adaptation Alignment Index

The analytical framework makes it possible to explore the adaptation gap for key sectors. For Africa as a whole, there is reasonable alignment of needs and expenditure, although the analysis raises some key questions including: challenges in analysing the water sector, partly related to the fact that water sector GDP estimates may be based on costs and not the value of water; and low funding for livestock. Figure 17 presents an Alignment Index for each country, which varies between a theoretical maximum of 1 (when needs and spending are perfectly aligned) and 0 (when they are unrelated). The figures shows considerable variations. The reasons for this will be different in each country and require more investigation[19].

19 The index is calculated as 1 minus half the sum for all sectors of the absolute difference between the share of needs and expenditure and taking an average of these values, weighted by the sector share of GDP.

Figure 17: Adaptation Alignment Index



Source: PAAF analysis.

There are a number of reasons why the optimal sectoral distribution of expenditure might not match exactly the distribution of needs which are explored in Table 8. **The index is, therefore, only an initial indication that enables a quick overview of alignment and encourages governments to justify the reasons why they may make explicit decisions to deviate from perfect alignment.**

Table 8: Scope of the Adaptation Alignment Index

Taken into account	Not taken into account
• The thirteen climate impact pathways • Differences between countries in exposure to climate risks • Differences between economic structure and, hence, sensitivity to climate risks • Differences between sectors in the effectiveness of adaptation expenditure • Recent levels of public adaptation spending • An initial estimate of the contribution of private investment to adaptation	• Differences between countries in the effectiveness of adaptation expenditure • The fact that the effectiveness of adaptation expenditure will go down as the most attractive activities are funded and more challenging risks are addressed • Hence there is no estimate of the residual EICC which remains after cost-effective adaptation options are exhausted • The details of how the timing of expenditures and needs might alter distributional shares • Counter-productive expenditure such as fossil fuel subsidies and perverse incentives

6.3 Current status of NDC costings in covering the gap

Many countries have been working on costing their NDC actions and the UNFCCC NDC register suggests that 76 developing countries now have cost estimates (UNFCCC, accessed August 2022). This evidence is summarised in Box 8, to facilitate cross-referencing through this report. At first sight, there appears to be an emerging pattern, with average annual NDC financing needs in developing countries reporting adaptation needs between 2.0 percent and 2.5 percent of GDP and with quite a wide range of variation, from 1.0 percent to over 5.0 percent. However, this evidence is still uncertain as the AGRs report much lower figures for Africa.The UNEP 2023 AGR updated these estimates and found that the financing needs identified in NDCs and NAPs are an average of 1.5 percent of GDP. Variations reflect both differences in full needs and differences in the approach to costing, which may involve bottom-up costing of a list of programs or an estimate of total needs. **Comparing this with the PAAF estimate of an unweighted coverable gap of 7.2 percent of GDP suggests that NDC costings are still missing some adaptation programs that will be required to avoid EICC.** This may reflect the fact that many NDCs have concentrated mainly on the most vulnerable sectors and are still expanding into work in wider sectors, which could include some subsectors that have so far received limited attention (e.g. reducing the effects of heatwaves on labour productivity across all sectors). It may also reflect a concern amongst developing countries not to present needs that international partners may feel are unrealistic. **The PAAF analysis suggests that African countries can continue to expand the scope of NDCs and illustrates the analysis that can be done to support this expansion and to ensure that it is credible amongst international partners.**

Box 8: Evidence on adaptation financing needs from NDCs

One of the objectives of the PAAF analysis is to illustrate options for including in NDCs an assessment of adaptation needs, based on estimates of EICC and the effectiveness of adaptation expenditure in reducing EICC. There are a range of studies that have reviewed the financing needs already included in NDCs. These NDC financing needs have tended to increase in recent years as the coverage of NDCs expands and the work on costing NDC actions improves. However, the 2022 AGR points out that the work on NDC financing needs is "highly heterogeneous in terms of their objectives, sectoral coverage, implementation period and other aspects. They have limited transparency regarding the underlying methodology for estimation ... and should be interpreted with these limitations in mind" (UNEP, 2022a).

UNEP 2016 and **2021 Adaptation Gap Reports**. The 2016 AGR reported that the total adaptation financing specified in NDCs for developing countries was similar to World Bank estimates of adaptation needs, which were equivalent to 0.3 percent and 0.4 percent of GDP. The 2021 AGR analysed NDCs for 58 developing countries and, extrapolating those results to all developing countries, on a per-capita basis, suggested global adaptation needs by 2030 of $250 billion per year, which is equivalent to 0.7 percent of GDP and is roughly consistent with the results from the models (UNEP, 2021). These results apply to all developing countries including middle-income countries and it would be reasonable to expect needs in African NDCs to be much higher.

The **UNEP 2023 AGR** found that 85 developing countries include cost estimates in their NDCs and NAPs. This includes most African countries. For all 85 countries, the cost estimates suggest that financing needs are roughly double the estimates made in 2021, at 1.5 percent of GDP. It is not clear whether this increase is caused by the inclusion of additional countries with relatively high needs or whether countries are expanding their estimates of costs to include improved evidence of costs, adaptation to new impact pathways or concerns about the rate of climate change.

UNFCCC Adaptation Committee. In 2022, the UNFCCC Adaptation Committee produced a Synthesis Report of the costing data for 76 developing country NDCs (UNFCCC, 2022a). This suggests annual needs of between 0.7 percent and 4.2 percent of GDP, with lower-income country NDCs reporting needs of 3.5 percent of GDP and lower-middle-income countries reporting needs of 1.9 percent of GDP (UNEP, 2022a). For sub-Saharan Africa, the median NDC needs were 2.1 percent of GDP (with a range of between 0.8 percent and 6.3 percent) and for Middle East and North Africa the median needs were 0.47 percent, with a range of 0.2 to 1.3 percent.

Box 8: Evidence on adaptation financing needs from NDCs (cont.)

AfDB 2018 and 2019 report on NDC costings. The AfDB reviewed all 44 African NDCs submitted to UNFCCC at the time of the study, building on analysis by Atkins and submitted to UNFCCC (AfDB, 2018). The report found costs for adaptation in 27 of the NDCs, with total adaptation costs of $291 billion. The time period for these costs was not declared. NDCs are often costed for 10 years, which would give annual costs of 29 billionn. The GDP of the 27 countries covered was $1,212 billion, so the annual adaptation costs were 2.4 percent of GDP. However, an AfDB review in 2019 reviewed costings in 28 African NDCs and reported much lower figures of less than 0.5 percent of GDP for all 28 countries as a whole (AfDB, 2019a).

CPI 2022 Africa climate finance needs. The Climate Policy Initiative (CPI) reviewed the NDC costs in 53 African NDCs and found cost estimates in 51 countries (CPI, 2022). The analysis suggested that total NDC financing needs for $2.8 trillion from 2020 to 2030, of which 24 percent were for adaptation. This is the equivalent of 2.2 percent of GDP.

All NDC costs are presented unweighted whilst PAAF estimates of adaptation needs are presented in CPEIR-weighted expenditure (see Box 2). The comparison of NDC and PAAF needs therefore requires an estimate of the average CPEIR weight of NDC costs. There is no existing analysis of this. However, the 2021 AGR includes a breakdown of the sectoral composition of NDC costs which suggests that most of the expenditure would have a CPEIR weight of between 25 percent and 100 percent. Therefore, it is suggested that the unweighted NDC costs should be multiplied by 50 percent in order to be comparable with the CPEIR-weighted spending needs estimated by the PAAF analysis.

6.4 Closing the adaptation gap

This section reviews the options for closing the adaptation gap. It explores the potential scale of each option using a typical scenario for a hypothetical country. The figures for needs and current expenditure are based loosely on the PAAF estimates of the average for the whole of Africa. Scenarios for closing the gap present some analysis of estimates of the order of magnitude of each potential source, and the implications for the time taken to close the gap. Table 9 presents figures as percent of GDP because needs are based on EICC which is estimated as percent of GDP. Using percent of GDP also facilitates comparison across countries. In practice, country work on financing scenarios for closing the gap, including in NDC costings, is likely to be done in monetary terms (i.e. local currency or US dollars).

Table 9 presents a typical strategy for reducing the adaptation gap over 10 years and for closing the coverable gap entirely over 25 years[20]. **The table suggests that existing financing meets 30 percent of coverable needs[21], with the large majority of this coming from public adaptation. The figure identifies options that could increase this to over half of coverable needs in 10 years. This would leave a coverable gap of 4.4 percent of GDP which could be closed over 25 years. Specific dates are not provided as the impact of Covid-19 has disrupted normal growth paths and the implications of this would require more detailed analysis.**

20 The 25-year period is presented because it equates roughly to the mid-century date which is often the earliest date for EICC estimates. A period of 10 years is long enough to reflect EICC, but short enough to be relevant from medium-term budget frameworks (typically 3 years) and climate strategies (including NDCs).

21 Nearly a quarter of needs are ‘uncoverable’ by any cost-effective adaptation option (see Box 3) and need to be addressed by reactive policies (e.g. providing compensation and/or recovery funding – see Box 10).

Table 9: Typical adaptation gap reduction strategy over 10 and 25 years

Sources	2019	Y10	Y25	Comments and assumptions
GDP growth		34%	109%	Assuming 3% annual growth
Public adaptation funding				
Own revenue	2.18%	2.68%	3.43%	Increases by 0.05% GDP/year
Budget effectiveness growth		0.27%	0.86%	BCRs improve by 1% per year
ODA grants	0.23%	0.76%	0.30%	Achieving COP15 US$ 100bn target
ODA loans	0.26%	0.30%	0.50%	DRR/CCA receive higher share of ODA loans
NCQG contribution		0.33%	0.33%	Assuming extra US$ 20bn adaptation
Innovative instruments		0.10%	1.00%	Fiscal space created by bonds, swaps …
Total	**2.67%**	**4.43%**	**6.42%**	
Private adaptation funding				
Existing and natural growth	0.56%	0.80%	1.50%	Increasing focus on adaptation
Accelerated growth		0.50%	1.60%	Policy dependent acceleration
Total	**0.56%**	**1.30%**	**3.10%**	
Coverable adaptation gap				
Coverable needs	10.40%	10.12%	9.51%	Declines with economic growth
Public and private funding	3.23%	5.73%	9.52%	Y10 growth of 2.36% GDP typical NDC costing
Gap (unweighted)	7.17%	4.39%	0.00%	For comparison with unweighted NDC costing
Gap (weighted)	2.80%	1.71%	0.00%	Comparable with CPEIR-weighted analysis

Note: figures refer to unweighted expenditure, unless stated.

Source: PAAF calculations.

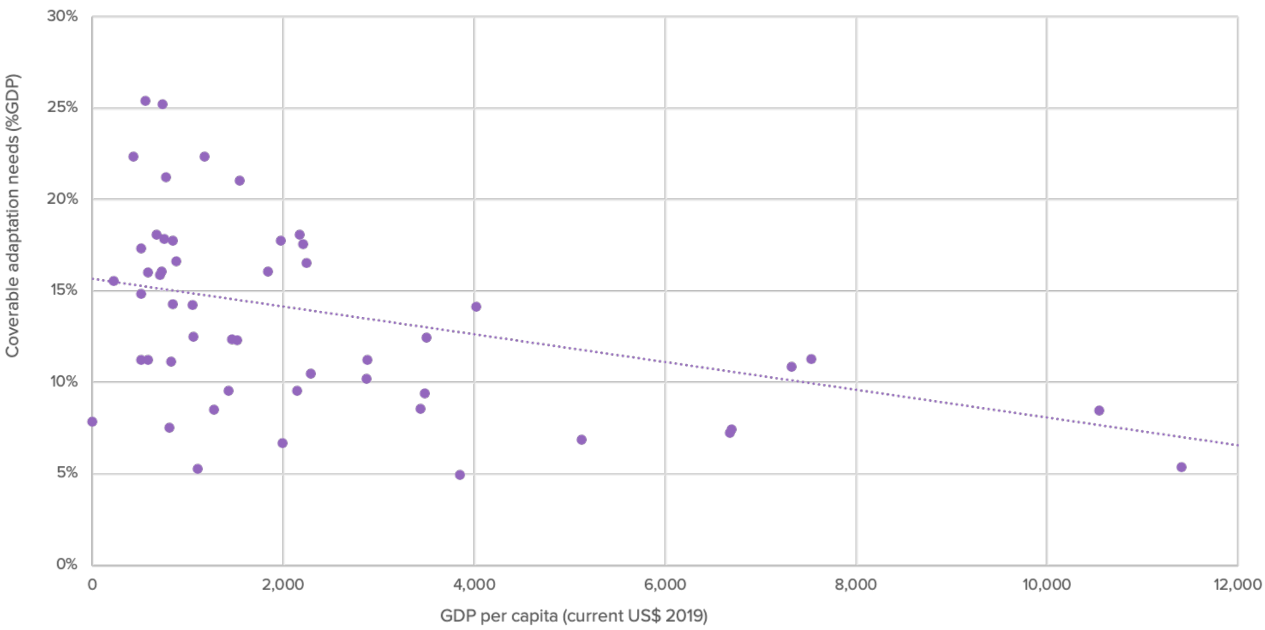
The Implications of GDP growth for closing the adaptation gap

The EICC is usually expressed as a percent of GDP and, as GDP grows so does the monetary value of EICC. However, at least for most African countries, economic growth usually involves diversification from more climate vulnerable primary sectors into industry and services. As a result, EICC usually declines with GDP growth, when expressed as a percent of GDP. As adaptation needs are closely related to EICC, they also decline with GDP growth when expressed as a percent of GDP.

Figure 18 presents the evidence for Africa, comparing the coverable needs estimated by the PAAF analysis with per capita GDP[22]. The figure includes the best fit linear regression which suggests that an increase in per capita GDP of $1,000 can be expected to lead to a drop in adaptation needs of 0.81 percent of GDP. For an African country with a current GDP per capita of $1,000 and a GDP growth rate of 3 percent, adaptation needs will be about one tenth lower in 25 years as a result of the GDP growth.

22 Figure 18 uses country variation in per capita GDP as a proxy for growth in GDP. This seems a reasonable approach to obtaining a first indicative estimate of the implications of GDP, but it raises a number of methodological questions that require more space than is available in this report. The graph also includes only a linear best fit line when the data suggest a non-linear fit would be more accurate.

Figure 18: Coverable adaptation needs and GDP per capita for African countries



Sources: PAAF estimates of needs and World Bank World Development Indicators for GDP per capita.

There has been a long-running debate in the economic literature about the relative contribution of GDP growth and adaptation expenditure in reducing EICC (Millner & Dietz, 2014). The analysis reported here is rapid and illustrative and does not resolve this debate. However, it does suggest that **economic growth will make a significant contribution but that this contribution is modest compared with the potential contribution from actions devoted to climate change adaptation**.

Improving public expenditure adaptation

Public adaptation expenditure

Table 9 assumes that there is no scope for adaptation to take a larger share of total public expenditure, given the importance of other policy priorities (including economic growth and poverty reduction). It also assumes that the growth in revenue that happens with economic growth cannot be credited as a potential source of new adaptation finance because needs are expressed as a percent of GDP and so increase with GDP. The only potential source of new funding for adaptation within the budget is the growth in revenue as a share of GDP. According to the latest OECD review of revenue statistics in Africa, the increase in revenue, as a share of GDP from 2009 to 2019 was 1.8 percent of GDP for Africa as a whole (OECD, 2021). If unweighted adaptation spending were to be allocated 25 percent of that increase, it would increase adaptation spending by about 0.5 percent of GDP by year 10.

Effectiveness

The effectiveness of adaptation expenditure can be improved by improving the quality of program design and management (e.g. with improved targeting and proofing) and by general PFM reforms (e.g. program budgeting) that build more efficiency and predictability into the planning and budget system. CBT can build incentives in the budget system to improve effectiveness and climate expenditure reviews can provide lessons to improve policy. Table 9 assumes that the combined effect of effectiveness improvements will be to increase the effectiveness by 1 percent each year, thus reducing the adaptation gap by about 0.27 percent of GDP in year 10. The contribution of improved effectiveness grows to 0.86 percent of GDP by year 25 because of the continued increase in effectiveness combined with the growth in government revenue as a percent of GDP.

Official Development Assistance (ODA)

The PAAF analysis uses 2019 data where available. In that year, **climate ODA was about $80 billion but adaptation accounted for only $8 billion of that, of which $2.9 billion was received by Africa, which is in line with Africa's 34 percent of total ODA**. The ODA for adaptation includes funding from climate funds and for development expenditure that has been tagged as climate expenditure in the OECD DAC database and weighted using the DAC weights.

The COP15 target for climate funding was $100 billion, of which half was to be allocated to adaptation. The $8 billion for adaptation in 2019 was thus much lower than the COP15 target of $50 billion. If the COP15 target was achieved, and Africa received 34 percent of that, this would deliver an additional $14 billion, or 0.57 percent of GDP (unweighted), which is 5.7 percent of total needs. This target is likely to increase substantially, when the New Collective Quantified Goals (NCQGs) are agreed for the period from 2025. If the NCQGs succeeded in increasing global adaptation by an additional $20 billion (unweighted), Africa's 34 percent share of that would deliver adaptation expenditure worth 0.57 percent of GDP. As there is limited scope to increase ODA loans, the large majority of this increase in ODA is in grants in the period to year 10. In the longer term, ODA grants are likely to decline as African countries develop and are able to fund more of their own public expenditure needs. However, ODA loans will increase substantially, assuming that borrowing limits grow in line with GDP.

Although ODA is only 10 percent of total public expenditure across the whole of Africa, it is much higher in most of the developing countries and is often between 25 percent and 50 percent of development spending and of 'discretionary' spending. Many development partners are in the process of refining the way in which their funding of climate change is defined and accounted for, which is changing the incentives for managing climate change. For example, DFID is switching from separate funding of climate change projects to an integrated approach to managing all projects, in which the climate change element is more clearly defined and enumerated. This could lead to stronger prioritisation for adaptation within development assistance and increase the contribution of ODA.

The **UN Convention on Biological Diversity** (UNCBD) is a major global initiative that seeks to follow the lead taken by UNFCCC and raise pledges of an additional $100 billion for biodiversity, in addition to the $100 billion pledged for climate. Much of this expenditure will deliver secondary adaptation benefits. A World Bank (2020) report, provides a framework where the mobilization of private finance involves the 'dual task' of developing mechanisms that increase the return on related investments and integrate biodiversity risks into investment decisions.

The potential contribution of the new Loss and Damage Fund agreed at COP27 has not been included because the focus of the fund is not yet clear. In some documents, it is suggested that the new fund should focus only on loss and damage that cannot be avoided by adaptation (i.e. uncoverable loss and damage) which will then distinguish the fund from those that focus on adaptation, which addresses the coverable loss and damage.

Innovative public instruments

There is growing interest around innovative instruments to raise public spending on adaptation, including the following:

- Taxation that incentivises the response to climate change;
- Carbon markets;
- Debt-related instruments, including various types of green or blue bonds (e.g. use-of-proceeds and KPI bonds), which provide the majority of global private mitigation finance (CPI, 2021a) but are less interesting for African countries that are at or close to their debt ceilings (World Bank, 2022a);
- Debt for climate and/or nature swaps and/or the linking of budget support to climate related key performance indicators;
- Various types of blended finance, which leverage public funds and combine elements of both public and private expenditure and related policy commitments; and
- Ethical private investment.

Most African countries are at their debt ceilings, which means they cannot increase borrowing faster than GDP without risking being downgraded in financial markets and paying higher interest rates. However, there is modest scope to increase fiscal space by reducing interest rates through 'green premiums' and there is some interest in the possibility that grants may be available to reduce capital repayments, which could have a larger impact on fiscal space and, hence, adaptation spending.

Improving private sector adaptation

Given the constraints on public expenditure and the strong growth in private sector activity in many African countries, there are good opportunities for introducing new policies and instruments that shift public expenditure away from direct expenditure and towards incentives and regulations that encourage the private sector to adapt to climate change. Areas where private sector adaptation could be particularly profitable include the following:

- Investment in climate smart agricultural methods will be a continuous practice with strong investment from enterprises seeking to establish more resilient supply chains and at the household level through conservation agriculture and particularly improved water management.
- Investment in more resilient energy, transport infrastructure and water supplies is often a public sector responsibility, but the PAAF analysis only picks this up in South Africa and Egypt. Public enterprises may have more flexible borrowing capacity than central government.
- Private enterprises across the economy will be constantly motivated to invest in changes that reduce the impact of heat stress on labour productivity. These may involve physical changes to the work environment, where this is possible, as well as changing work practices.
- Investments in housing standards will be done mainly by the private sector and can make a major contribution to reducing the health challenge associated with heat stress (especially at night) and climate sensitive diseases.

The analytical methods of CCIA have been developed largely in the context of public expenditure (Bellon & Massetti, 2022; Climate Scrutiny, 2017; UNFCCC, 2011). However, they are even more appropriate for private sector appraisal because private companies are often more focused and experienced in estimating the benefits and revenue from those benefits as part of their own financial planning. It is therefore reasonable to expect increased recognition of climate change in private investment appraisal to contribute to an increase in private adaptation. The design and appraisal of public sector policies that provide incentives and regulations for the private sector needs to be done with the same rigour, in order to ensure that policies are effective.

Optimal balance between development and adaptation

The very large adaptation needs raise the question of whether diverting such a large share of available investment resources from development to adaptation would put growth rates more at risk from reduced development than climate EICC. Box 9 describes the optimal mix between investing between development and adaptation, for the economy as a whole and more details are provided in Annex 7. The analysis assumes the BCRs for development and for adaptation are the same. Box 9 suggests that, **given current levels of investment in Africa, adaptation should receive about 3.9 percent of GDP, when expressed in CPEIR-weighted expenditure. This is roughly comparable with the PAAF estimate of 4.1 percent of GDP coverable needs for adaptation, when expressed as weighted expenditure**. However, it should be highlighted that most of this expenditure is primarily development expenditure that delivers economic growth and provides an additional (but often relatively small) contribution to adaptation. Effectively, the analysis is suggesting that due to this, **large sections of development investment need to be climate sensitive and incorporate contributions to adaptation**.

This analysis should not be treated as a recommendation for a huge expansion in adaptation spending. It provides some broader context to strategic decisions and suggests that governments and enterprises can be confident in implementing complementary plans that build adaptation into large sections of investment, without worrying that this will divert too much investment away from development. Thus, there are large areas of development finance that deliver both adaptation and development outcomes.

Addressing the uncoverable gap

The uncoverable gap refers to EICC that cannot be avoided by cost-effective preventive adaptation (see Box 3). There are, however, a range of policies available for reducing the impact of this EICC, including the following:

- The new Loss and Damage Fund agreed at COP27;
- Existing arrangements for providing humanitarian aid;
- An international mechanism that provides predictability in the provision of international resources for humanitarian aid and/or reconstruction;
- Contingency planning within country budgets;
- Social protection programs that are designed to operate efficiently even during major climate crises (see Box 10); and
- Insurance.

Box 9: The optimal mix of development and adaptation expenditure

Governments need evidence on the optimum balance between resources devoted to development and to adaptation. Economic models do this by maximising utility, taking into account the relative effectiveness of development expenditure (i.e. promoting growth) and adaptation expenditure (i.e. reducing the extent to which climate change reduces growth). This is a complex calculation, but a rough guide can be obtained by assuming that the ratio of adaptation to development spending should be similar to the ratio between EICC and GDP growth. If Africa continues growing at 3.1 percent (the average of the last 10 years), then the NPV of GDP to 2050 will be 1.40 times higher than if there was no growth. The PAAF analysis suggests the EICC will reduce GDP in 2050 by 9.3 percent. Assuming that EICC grows linearly over the period, the NPV of EICC over the period is therefore about six percent of the NPV of growth. **This would suggest that a first rough indication of investment in adaptation should also be roughly six percent of investment in development.** Total investment (public and private) for the whole of Africa was about 26.4 percent of GDP over the last 10 years, according to the AfDB Africa Information Highway. If this was split between adaptation and development using a ratio of 6:100 (i.e. reflecting the ratio of EICC to economic growth), adaptation would receive about 1.6 percent of GDP. However, this is the weighted adaptation expenditure and converting this figure using CPEIR weights gives an optimal level for unweighted adaptation expenditure of 3.9 percent of GDP. This is very similar to the PAAF estimate that coverable adaptation needs are 4.1 percent of GDP, which suggests that, although closing the gap appears to be ambitious it may be close to the optimal balance between development and adaptation.

Source: PAAF assessment.

Box 10: Social protection as a policy for addressing the uncoverable gap

A **UNDP (2017) study** showed that the average spending on social protection in sub-Saharan Africa was 5.3 percent, with a wide range from less than 3 percent in six countries to more than 7 percent in eight countries. This is substantially higher than the uncoverable gap, which averages about 0.75 percent of GDP, or about a quarter of total needs of nearly 3 percent. But the primary role of social assistance programs is to reduce inequality and poverty and not to protect against uncoverable EICC. A recent study of the causes of household vulnerability identified 20 causes of vulnerability (Mba, Nwosu, & Orji, 2021). Most of these are only weakly related to climate change. Applying the PAAF standard categories and ABS scores suggests that 5.9 percent of the benefits from social protection would be associated with protection from the increase in household risk related to climate change, as reflected in the uncoverable gap. **This analysis requires more work but gives an illustrative finding that current social protection in Africa is providing 0.3 percent of GDP (5.3 percent x 5.9 percent) of adaptation benefits and thus offsetting nearly half the uncoverable EICC (0.75 percent of GDP).**

7 Country case studies

This PAAF report makes a rapid pan-African assessment of country adaptation gaps using publicly available evidence on the needs and supply of adaptation finance. PAAF's analytical framework can provide country-specific Standard Reference Estimates (SREs) for the 51 countries that have sufficient data. Country case studies allow for more detailed analysis, comparing country specific evidence with the country SREs provided by the PAAF work. This illustrates both the value and limitations of the PAAF analysis. This should help allow for conclusions about how national mainstreaming initiatives can be improved.

This section summarises the findings from the country case studies, using sub-headings that follow the order of the main report. Each case study includes a table that summarises the findings, comparing PAAF country-specific SREs with country evidence. A summary of key information about each country is presented in Table 10. The three countries analysed all have large agricultural sectors, which are typically the most vulnerable to climate change. Niger has a particularly large agricultural sector. They all have submitted updated NDCs, including estimates of implementation costs.

Table 10: Summary of key information for Kenya, Niger and Burkina Faso

	Kenya	Niger	Burkina Faso	Africa
GDP ($ billion 2019)[a]	100.4	9.7	17.9	2502.4
Sector shares				
Agriculture	22.3%	39.2%	20.3%	15.8%
Industry	18.1%	21.8%	30.0%	30.0%
Services	59.7%	39.0%	49.6%	53.9%
Strategies and plans				
Climate strategy/plan	2018			
Latest NDC	2020	2021	2021	
NDC costing	Yes	Yes	Yes	
CPEIR/CPEBR	2016	No	Forthcoming	
LTS	Forthcoming			
Standard PAFF reference estimates				
EICC (NPV of GDP to 2050)	5.7%	8.3%	7.2%	3.8%
Benefit Cost Ratios	4.1	4.4	3.0	3.9
Needs (%GDP - ABS weighted)	6.0%	10.8%	9.6%	5.3%
Public adaptation spending (%GDP)	0.89%	0.81%	0.18%	0.95%
Alignment Index	70.3%	68.2%	84.6%	72.9%
Adaptation gap (% needs)	75.4%	85.0%	93.0%	78.0%

a *Source:* GDP data from AfDB African Information Highway, 2022 and PAFF estimates.

7.1 Kenya

Introduction

Agriculture is the backbone of the country's economy supporting 70 percent of the population and dominated by smallholder farmers practicing rainfed crop and livestock production (MEF, 2018). It enables an added 27 percent of GDP through linkages to other sectors such as manufacturing, distribution, and services (Government of Kenya, 2018).

Rising temperatures, erratic rainfall, and increased frequency and intensity of droughts and floods are some of the climate hazards impacting Kenya with the agriculture sector being one of the hardest hit. As a result, Kenya's population in need of food aid has continued to rise from about 650,000 people in 2007 to 3.8 million in late 2009 and 2010 (Amwata, 2020) to 7.9 million people in 2021 (WFP, 2021). Kenya has engaged in a broad range of work on climate change policy and research, and it is expected that more detailed evidence will be found for most of the key steps in the analysis of the adaptation gap. Useful sources include government strategies and other studies.

The Governmnet of Kenya (GoK), working with development partners, has continued to strengthen financial management systems for climate change financing in Kenya. In 2016 a **Climate Public Expenditure and Budget Review** (CPEBR) was conducted to strengthen efficiency and effectiveness of climate finance in PFM systems, with three specific aims: i) maximise budgetary allocation of public sector resources to climate change adaptation and mitigation efforts; ii) enable the tracking of public sector expenditure and its effectiveness against policies and plans; and, iil) contribute to strengthened monitoring and reporting of climate change adaptation and mitigation efforts. The study established a climate budget coding and tracking methodology designed to record and analyse climate spending in the national, sectoral and subnational level. The codes are being implemented in budgets and expenditure plans through the **Integrated Financial Management Information System** (IFMIS) Standard Chart of Accounts (SCOA) to report effectively on transactions made against funds designated as climate relevant to manage the costs of mainstreaming climate change in the GoK PFM practices.

Findings

Table 11 compares country sources of evidence with the Kenya SREs from the PAAF analysis.

Table 11: Kenya comparison of country sources with the PAAF SRE for Kenya

	Kenya	
	PAAF SRE for Kenya[a]	Comparable country sources
EICC (NPV of GDP to 2050)	5.7%	3% to 5% annually (NDC 2021) 3% to 5% plus 4% (LTS)
Benefit Cost Ratios	4.1	2.3 (LTS modelling) 1.25 urban, 5.2-5.3 agri (LTS 'bottom up')"
Adaptation needs (%GDP - ABS weighted)	6.0%	3.98% (NDC 2020)
Public adaptation spending (%GDP)	0.89%	0.32% (PBB 2022, ABS weights) 0.08% (CPEBR 2016, 3 sectors external only) 0.11% (CPI 2021, converted to ABS weights)"
Alignment Index	70.3%	50% (LTS/CPEBR, 3 sectors) 49% (CPI 2021)"
Adaptation gap (% needs)	75.4%	53.7% (LTS modelling) 90.0% (NDC, without private sector)"

a SRE = standard reference estimate produced using PAAF pan-African analytical approach

Sources: Compiled from: Government of Kenya, 2022; Kenya Ministry of Environment and Forestry, 2020; Kenya National Treasury and Planning, 2016; Kenya National Treasury and Planning & Climate Policy Initiative, 2021.

Exposure to climate risks

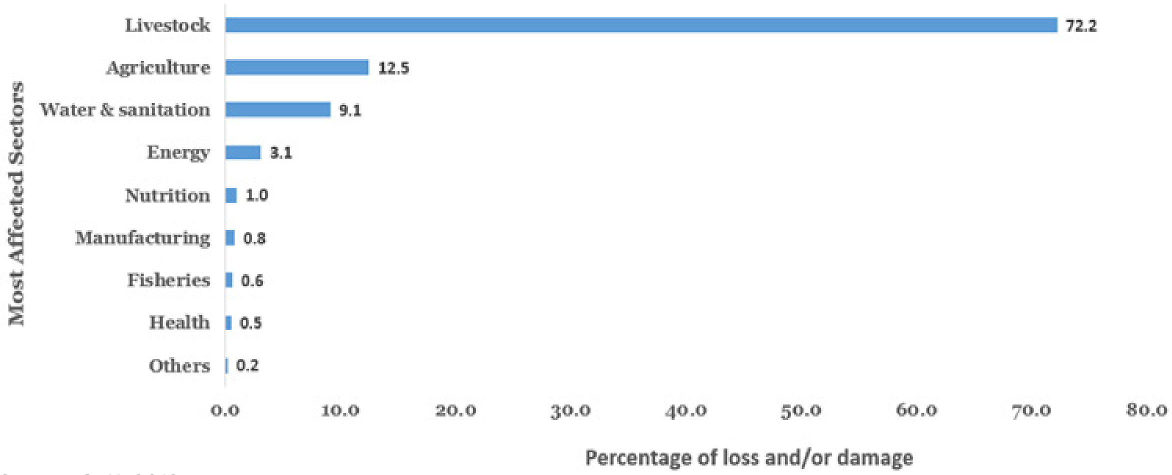
According to the Kenya NDC Technical Update report 2020, the mean scenarios for temperature from ten Coordinated Regional Climate Downscaling Experiment (CORDEX) Regional Climate Models (RCMs) for African data show a mean surface temperature increase range of 1-1.5°C by 2030, 1.5-2.0°C by 2060s and 1.5-5.0°C by 2090s (MEF, 2020). All seasons in Kenya are expected to have an increase in temperature and this increase in temperature will be observed particularly in the arid and semi-arid land (ASAL) regions (IPCC, 2021). The surface temperature trends in some Kenyan counties also show warming of more than 2.5°C by 2030 under all the scenarios, or Representative Concentration Pathways (RCPs), which surpasses the Paris Agreement goal to limit the rise in global temperature to well below 2°C above pre-industrial levels.

Potential EICC

According to the NDC technical report, on average, droughts in Kenya affect about 4.8 million people. The 2014-2018 drought which was declared a national emergency in 2017 had affected 23 out of Kenya's 47 counties, with counties in ASALs being the most affected. In 2008-2011 climate induced drought resulted in an economic impact estimated to be worth KSh 968.6 billion: KSh 64.4 billion for the destruction of physical assets and KSh 904.1 billion for losses in the flows to the economy (GoK, 2012). At least 3.4 million Kenyans were severely food insecure, and an estimated 500,000 people did not have access to water. An estimated 482,882 children, mainly from 23 ASAL counties, required treatment for acute malnutrition and school attendance dropped in counties that were impacted by the drought. Droughts also caused changes in the migratory patterns of animals, and increased conflicts between people and large mammals like elephants. Furthermore, this drought contributed to the reduction in the growth rate of Kenya's GDP from an average of 6.5 percent between 2006 and 2007, to an average of 3.8 percent between 2008 and 2012 (GoK, 2012).

The **Kenya National Climate Change Action Plan** (NCCAP) 2018-2022 reports that over the past decade, losses in livestock populations due to drought-related causes amounted to $1.08 billion (MEF, 2018). It also estimated that, between 2008 and 2011, drought-caused losses in livestock and agriculture amounted to KSh 699.3 billion for livestock (72.2 percent of total losses) and KSh 121.1 billion for crops (12.5 percent of total), respectively. Figure 19 below demonstrates this.

Figure 19: Sectoral losses and/or damages in Kenya attributed to the 2008 – 2011 drought



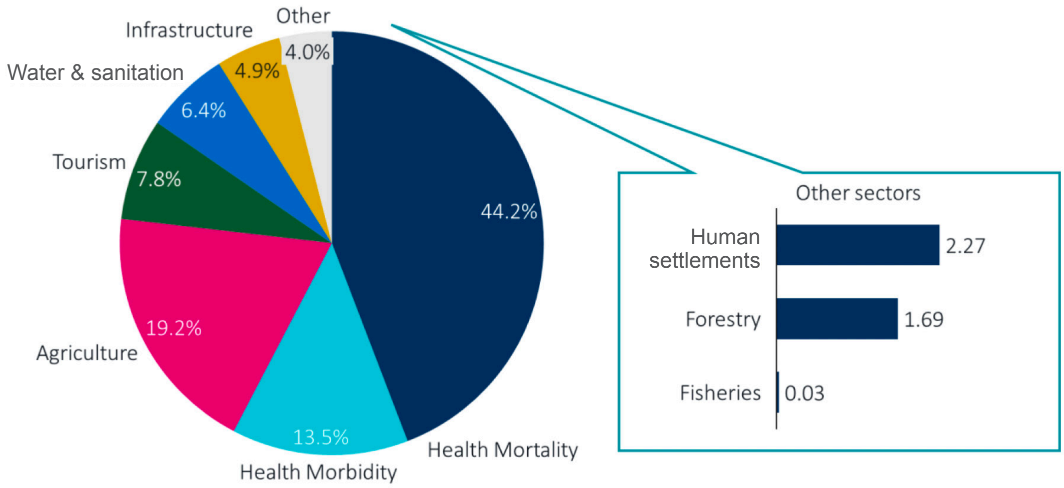
Source: GoK, 2012.

Kenya's flooding risk is particularly prevalent in the lowlands as large rivers approach the water bodies into which they empty. While usually more localized, floods have led to the greatest loss of human lives in Kenya (OCHA, 2012). The coastal areas of Kenya are experiencing coastal erosion and saltwater intrusion, and coastal flooding from sea level rise and storm surges is expected to increase. This is expected to lead to erosion of shorelines and increased salinity of coastal aquifers.

The coastal zones in Kenya have increasingly experienced rainfall induced flooding and droughts (GoK, 2010). Coastal flooding from sea level rise is projected to affect 10,000–86,000 people a year as well as lead to coastal erosion and wetland loss at an annual cost of $7–58 million by 2030, rising to $31–313 million by 2050 (SEI, 2009). Coastal erosion and saltwater intrusion already require substantial management interventions (Comte et al., 2016; Mwakumanya et al., 2009). Further there is increased submergence of mangrove forests in low-lying coastal areas.

The Kenya 2020 Long-Term Strategy (LTS) suggests that Kenya could lose an additional 3.5 percent GDP per annum, between 2021-2050 amounting to an annual average loss of approximately $11 billion per annum, at 2020 prices. Some of the greatest costs of climate change will be felt in the health sector, through increased morbidity and mortality. Increased mortality is a consequence of multiple factors, including heat stress, flooding, and vector-borne disease. Other high-risk sectors include agriculture and tourism, which are particularly vulnerable to the effects of drought and irregular weather patterns (MEF, 2021). Figure 20 illustrates sectoral losses for Kenya.

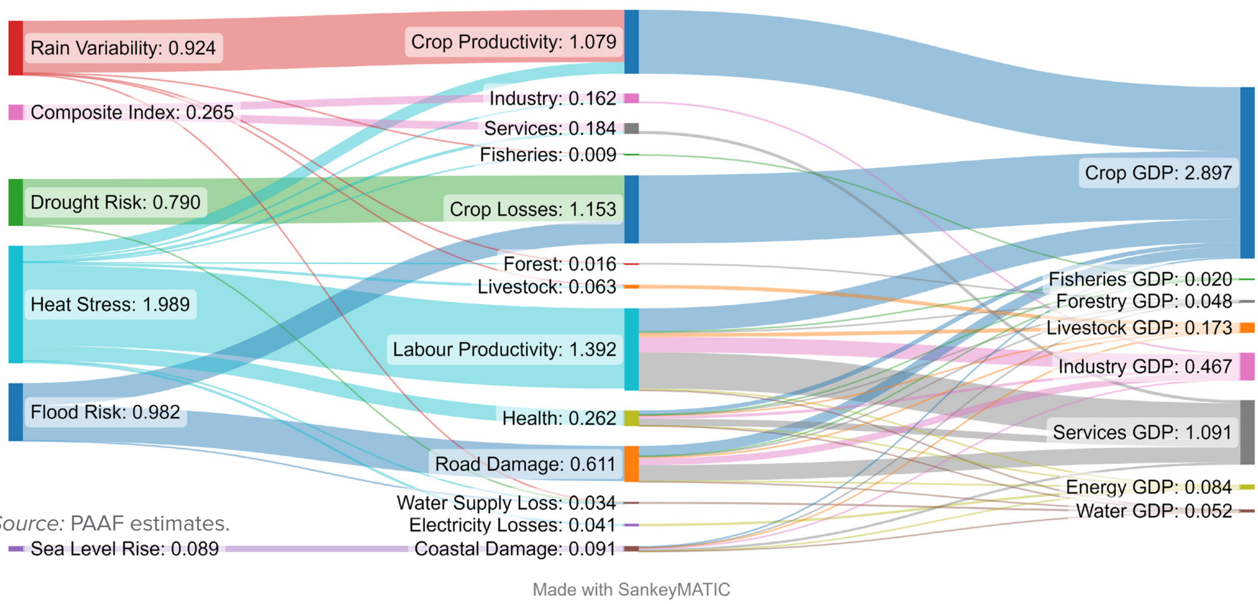
Figure 20: Sectoral composition of EICC in Kenya



Source: Government of Kenya, LTS 2021, modelling based on AfDB (2019) and UNISDR (2018).

Figure 21 shows the EICC Health Morbidity associated with key climate risks, impact pathways and sectors, expressed as a percent of GDP. In theory, the EICC reported in Figure 20 and Figure 21 should be comparable. Both figures show strong impact on agriculture and important but lesser impact on water and sanitation and on infrastructure. The main difference between the two figures relates to health-related EICC. The reasons for this difference is not obvious from the reports and requires further investigation. One possible explanation is that the LTS appears to include increased health burdens arising from EICC in other sectors (e.g. agriculture's impact on malnutrition and threats to water quality) whilst the PAAF analysis assumes that the valuation of EICC in those sectors considers the health effects.

Figure 21: PAAF estimates of EICC for Kenya (% NPV of GDP to 2050)



Source: PAAF estimates.

Effectiveness

No review of evidence on effectiveness of public expenditure was found. Some evidence is available from project appraisal reports, typical undertaken by MDBs. For example, the **2015 Project Appraisal Report** for the AfDB Small Scale Irrigation and Value Addition Project in Kenya estimated the Economic Internal Rate of Return (EIRR) at 28 percent, which is roughly equivalent to a BCR of 4.5. The **2017 Project Appraisal Report** for the World Bank Climate Smart Agriculture Project in Kenya was 16.8 percent, roughly equivalent to a BCR of 2.7. These are in line with the standard BCRs used for the agriculture sector in the PAAF analysis.

Needs

The **NCCAP 2018–2022** identifies adaptation actions on six broad issues (MEF, 2018):

- Climate induced natural disasters – drought, floods, consequent infrastructure damage, landslides, pests and diseases;
- Food insecurity – crops, livestock, fisheries;
- Water insecurity – urban and rural;
- Energy infrastructure vulnerability– resilient energy mix, robustness – biomass, solar, wind, hydrodynamic, geothermal, etc.;
- Land degradation – terrestrial (forests, wetlands, rangelands, agricultural land); and
- Marine and coastal ecosystem degradation – e.g. mangrove forests, coral reefs, sea grass beds, beaches, deltas, sea water intrusion, coastal erosion.

Kenya's updated NDC (2020), on the other hand, is more comprehensive, and identifies almost all sectors of the economy, including: energy; science, technology and innovations; public sector reforms; infrastructure; land; education and training; health; environment; water and sanitation; population, urbanisation and housing; gender, vulnerable groups and youth; tourism; agriculture, livestock and fisheries; private sector and trade; oil and mineral resources; and devolution.

Adaptation spending

The GoK 2016 CPEBR analysed climate expenditure in three broad sectors, as shown in Table 12. The CPEBR analysis showed that adaptation expenditure accounts for 20 percent of total expenditure in environmental protection and water, 3.0 percent in agriculture and rural and urban development and 0.4 percent in energy, infrastructure and ICT. In addition, significant expenditure was devoted to the enabling environment for climate change, including capacity building, training, awareness creation and policy development. The growth in adaptation expenditure was above the growth in total expenditure for environmental protection and water.

Table 12: Actual climate expenditure in three key sectors (KSh billion)

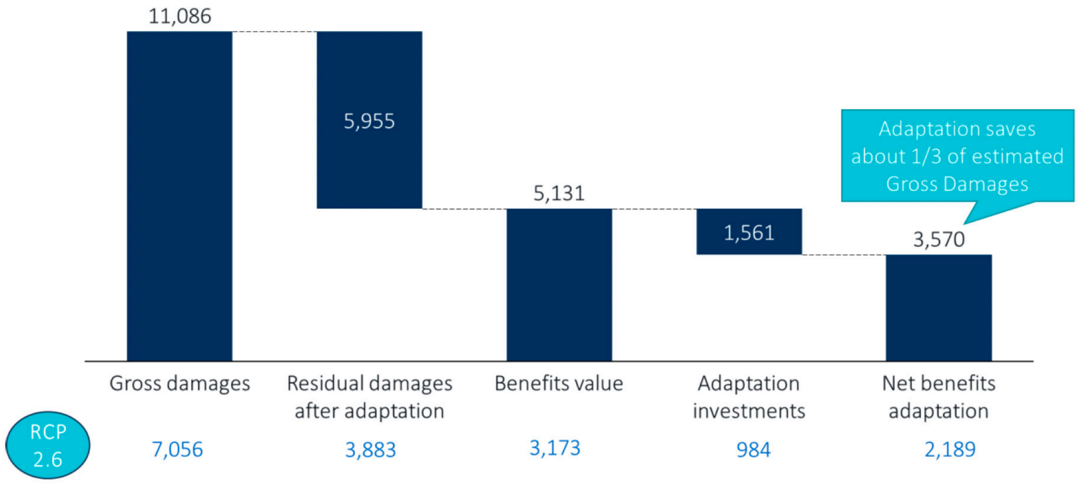
	Agriculture, rural and urban development					Environmental protection and water					Energy, infrastructure and ICT				
	11/12	12/13	13/14	Total	%	11/12	12/13	13/14	Total	%	11/12	12/13	13/14	Total	%
Total expenditure	47.6	50.4	52.4	150.4	100.0%	39.6	47.4	41.7	128.7	100.0%	151.2	167.4	168.1	486.7	100.0%
Adaptation	0.0	0.0	4.5	4.5	3.0%	7.6	8.4	9.8	25.7	20.0%	0.9	0.6	0.5	2.0	0.4%
Enabling environment	1.5	2.6	0.3	4.3	2.9%	3.7	3.4	3.7	10.9	8.5%					
Mitigation	0.0	0.0	0.1	0.1	0.0%	1.5	2.2	1.5	5.3	4.1%					
All climate relevent	1.5	2.6	4.8	8.9	5.9%	12.8	14.0	15.1	41.9	32.5%					

Source: Adapted from the CPEBR (Kenya National Treasury and Planning, 2016).

Adaptation gap

Figure 22 shows gross damages (equivalent to the PAAF concept of EICC) and planned adaptation investment as an annual average over the period 2020 to 2050. Assuming that GDP grows at 3.1 percent over the period, the gross damages of $11.1 billion are 6.7 percent of the average annual GDP over the period, which is slightly higher than the PAAF SRE for Kenya (5.7 percent) perhaps reflecting the higher estimates of the impact of climate related health effects. Figure 22 suggests the adaptation gap is over 50 percent of EICC. This gap relates to the gap after planned adaptation spending and is roughly consistent with the PAAF analysis of pan-African gap after NDC implementation. There is no analysis in the LTS of the potential to increase adaptation and reduce this gap up to the point where all cost-effective adaptation is funded.

Figure 22: Estimated annual investment and losses in eight priority sectors ($ million)



Source: Adapted from the Long-Term Low Emission Development Strategy for Kenya 2021 (Government of Kenya, 2022).

Conclusions and recommendations

There is reasonable agreement between the PAAF analysis and country specific sources, including on the EICC and on the effectiveness of adaptation expenditure, as reflected in BCRs. The adaptation needs registered in the PAAF are several times higher than the costings in the NDC. Work on refining the costings in the NDC is ongoing and may expand the costs, especially for the sectors that have been receiving more attention in recent years, including, in particular, health and labour productivity issues, where much of the adaptation will be undertaken by the private sector.

At present, there is no country level analysis that estimates the adaptation gap using the same definition of the gap as the PAAF analysis. Comparing the PAAF estimate of the coverable adaptation gap (75.4 percent) with country level work does not yet estimate the adaptation gap.

7.2 Niger

Introduction

Niger is one of the least developed countries (LDC) situated in the Sahel region of West Africa, with real GDP per capita of $508. Economic activity is dominated by the agriculture sector, which contributes to 39.2 percent of GDP (AfDB, 2022). More than 80 percent of the population is dependent on the agriculture sector for income generation (World Bank, 2022b). Traditional rainfed agriculture is still the main farming approach followed, making the sector highly vulnerable to changes in the climate. Some of the main climate hazards affecting Niger include rain variability, droughts, extreme temperatures, floods and sand storms. Climate change is negatively affecting agricultural productivity, leading to rising food prices and threatening food security (UNDP, 2023b).

In addition to Niger's NDC, Niger's response to climate change has included three National Communications to the UNFCCC and a **National Climate Change Strategy and Action Plan** (in French) (*Cabinet du Premier Ministre*, 2022). Climate change has been integrated into the **National Policy for Socio Economic Development** (PDES) (in French) (*Ministere du Plan*, 2022). Niger has also developed a national strategy for climate change learning, illustrating the potential value of integrating climate change into the education curriculum.

Sectoral plans related to climate change include: an **Agricultural Climate Change Strategy and Action Plan** (SPN2A) (MESUDD, CNEDD, HC3N, & MAE, 2020); and **National Plan for Environment and Sustainable Development** (PNEDD) (SE-CNEDD, 1998); and a **Social and Sanitation Development Plan** (PDSS) (GdM, 2022) (all in French).

Findings

Table 13 compares country sources of evidence with the Niger SREs from the PAAF analysis.

Table 13: Niger comparison of country sources with Niger SREs

	Niger	
	PAAF SRE for Niger[a]	Comparable country sources
EICC (NPV of GDP to 2050)	8.3%	0.4%[b] (NDC drought/flood only)
Benefit Cost Ratios	4.4	No evidence found
Adaptation needs (%GDP - ABS weighted)	10.8%	7.0% (NDC) 1.8% (PIC-RS)"
Public adaptation spending (%GDP)	0.81%	0.52% (NDC, value of 7 big projects)
Alignment Index	68.2%	No evidence found
Adaptation gap (% needs)	85.0%	No evidence found

a SRE = standard reference estimate produced using PAAF pan-African analytical approach

b 0.9% current average, doubled in 2050 and converted to NPV to 2050.

Exposure to climate risks

There are still quite a wide range of climate change projections. However, in addition to the rise in temperatures affecting all areas of the country, it is likely that Niger will experience an increase in total rainfall that will be more intense and unpredictable.

Potential EICC

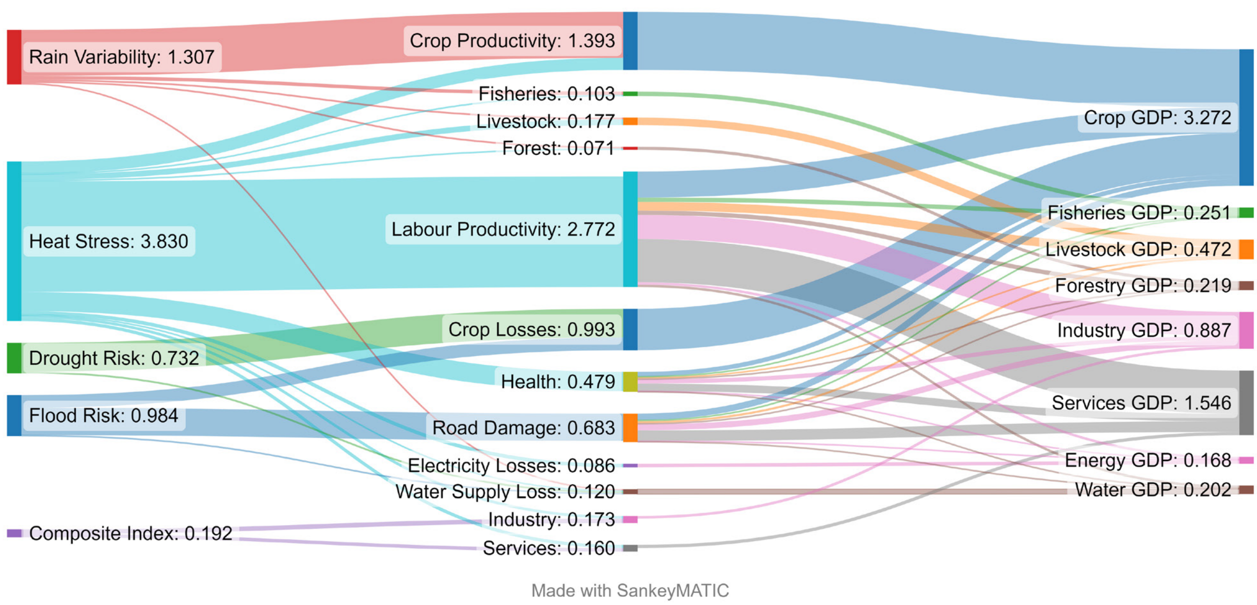
Niger's updated NDC provides a qualitative description of the range of risks facing the country, including those affecting crop and livestock production (as a result of an increase in floods, drought and pests), water supplies and health risks. The only quantitative estimates of EICC are for droughts and floods over the last decade. Based on these figures, if climate change doubled their frequency by 2050, the impact on GDP would be only 0.4 percent of GDP, compared with a total impact on crops and livestock of 3.5 percent of GDP suggested by the PAAF analysis. This may reflect partly the possibility that the NDC estimates of EICC are for major drought and flood events for which losses are recorded, whilst the PAAF analysis includes the full range of EICC in the agriculture sector, including the effects of temperature on soil moisture balance and losses from smaller but more frequent events, including less predictable seasonality.

The SNP2A reports that most sources suggest crop yields will decline from 10 percent to 25 percent by 2050, although it also quotes one recent research paper that suggests some crops could experience an increase in yields. The SNP2A suggests that there are good opportunities for climate smart agriculture, including changes in crops and in cropping calendars, as well as consideration of new ecological systems. For livestock, the SNP2A suggests that an increase in total rainfall could increase total forage production, but that there will be a strong increase in climate variability that will cause increasingly frequent crises amongst pastoral communities.

The **GIZ Climate Risk Assessment** (CRA) reports a wide range in the projections for average rainfall, with most projections showing some increase, although this average increase will be concentrated in increasingly intense rainfall events (GIZ, 2021b). In agriculture, the CRA suggests that the net effect of climate change will be mixed but significantly lower than that suggested by PAAF. There will be some potential for crop yields to benefit with increases in total rainfall and CO2 fertilisation, provided soil moisture can be retained during increasingly frequent dry spells. The CRA also suggests that there will be significant damage to infrastructure (especially roads). The CRA indicates that the net impact of climate change on water availability will be roughly neutral, although increased storage and changes to agricultural and livestock practices will presumably be required to respond to increased intensity and variability. However, the **Third National Communication** (TNC) suggests that there will be a strong reduction in groundwater recharge in the main sedimentary aquifers, although basins that have no outflow will see an increase.

The country evidence on health impacts suggests that the PAAF results may underestimate these impacts. This is the same finding as for the Kenya case study and suggests that further work may be required to understand the reasons for differences and to triangulate between the sources of evidence used for the PAAF analysis and the Kenya and Niger country studies. The CRA finds that exposure to heatwaves of more than 50 days will increase by six times and heat-related mortality by three times. The increase in heat stress is particularly severe in the south of the country. The TNC suggests that climate change will increase the death rate from malaria by 50 percent, from meningitis by 77 percent and from measles by 10 percent.

Figure 23: PAAF estimates of EICC for Niger (% NPV of GDP to 2050)



Source: PAAF estimates.

Effectiveness

There is no direct quantitative evidence on effectiveness. However, several of the national strategy documents (especially the SNP2A) suggest that there are good opportunities for investing in climate smart agriculture and it seems therefore reasonable to expect that the relatively high standard BCRs for agriculture used in the PAAF analysis could be applicable in Niger. Investments in climate smart agriculture are beginning to be made in Niger, albeit at a low scale due to resource scarcity (World Bank, 2021b).

Needs

The NDC lists the annual costs for adaptation at 7.0 percent of GDP, of which about 65 percent is conditional on increased international support. No analysis has been done to assess how this expenditure would be weighted if CPEIR weights were applied. However, if the PAAF pan-African average objective weight of 55 percent were applicable, then the weighted NDC needs would be 3.9 percent of GDP. This is well below the full needs suggested by the PAAF analysis. The SNP2A identifies 33 adaptation actions in eight themes covering the agricultural sector. No costs have been estimated for the SNP2A. The Plan ***d'Investissement Climat pour la Région du Sahel*** (PIC-RS) (in French) included financing for Niger of $2,284 million, over 13 years (*Commission Climate pour la Region du Sahel*, 2018).

Adaptation spending

The PAAF analysis suggests that current spending on adaptation in the budget is a little below the African average at 0.84 percent of GDP. The NDC refers to seven major projects currently being funded that provide about 0.52 percent of GDP, but it is not clear whether they are included in the budget. The OECD DAC database suggests that ODA grants averaged 0.74 percent of GDP, many of which are likely to have been off-budget, significantly increasing existing climate expenditure.

Resource allocations to climate change remain low and are dominated by donor funding. The 2021 budget of the Ministry of Agriculture gets only 4.4 percent of the national budget of which close to 80 percent comes from external funding. According to the OECD DAC database, the average annual ODA commitments for adaptation finance for the period 2015 to 2019 were $121 million, of which $38 million had principle adaptation objectives and $83 million had significant objectives. The DAC weighted adaptation expenditure was $71 million. Over 98 percent of this was in the form of loans and should feature in the budget. The expenditure analysis of the budget suggested that $79 million was spent on adaptation. Both the budget and DAC figures are weighted but the weights used are only roughly comparable and it is reasonable to conclude that most of the adaptation spending in Niger comes from ODA.

UNDP and UNDRR are supporting a Disaster and Climate Public Expenditure and Institutional Review (DCPEIR), including building consensus on methods for classifying public expenditure and using this to estimate and monitor trends in expenditure, either as an occasional review activity or, potentially, as an annual activity, using budget tags. The results of the DCPEIR are not yet available.

Adaptation gap

No comparable country evidence was found that relates to the adaptation gap.

Conclusions and recommendations

Although there is still quite a wide range of projections, Niger is likely to experience an increase in total rainfall, although this rainfall will fall in increasingly intense and unpredictable patterns. There is still considerable uncertainty about the net effect of this on crop yields. The balance of evidence suggests significant reductions, although the likely increase in total rainfall does provide good opportunities for climate smart agriculture that protects crops and livestock from unpredictability of rainfall patterns and increases in dry spells or all levels of severity.

Work on mainstreaming climate change into national and sectoral planning is still at a very early stage. There is an ongoing initiative for reforming public financial management through the introduction of program budgeting, which was adopted officially in 2018. However, the program budgeting reforms are still new and challenges are faced due to low capacity in formulating and executing programs as well as scarce opportunities for capacity building, diminishing human resource and insufficient funding to meet the needs. Climate change is said to be taken into consideration in the formulation of program actions and objectives of key priority sectors, but it is not yet expressly stated or highlighted in planning and budgeting documents.

The existing work on NDC costing can be improved and related more directly to needs, including not only in the natural resource sectors, but also for activities related to health and labour productivity, which affect all sectors.

7.3 Burkina Faso

Introduction

Like Niger, Burkina Faso is located in the Sahel region of West Africa. It is an LDC with real GDP per capita of $591. The contribution of the agriculture sector to GDP is 20.3 percent (AfDB, 2022) and is dominated by subsistence rainfed farming, which employs over 90 percent of the labour force (UNDP, 2023a). Climate change, conflict and the pandemic have negatively affected productivity in the sector, further heightening concerns regarding food security.

Climate change policy in Burkina Faso is guided by the references to climate change in the **National Plan for Socio Economic Development** (PNDES-II) (in French) (GdBF, 2021b), the **National Climate Change Adaptation Plan** (MEFR, 2015), the **NDC** (in French) and about 14 related sectoral plans. Climate change is integrated throughout the PNDES-II, although there are opportunities to strengthen this in PNDES-III, with the emergence of new work on planning and finance. The NAP was prepared in 2015 and improved on the 2007 NAPA by updating the actions and focusing more on the integration of adaptation into development planning. The updated NDC was submitted in 2021.

The *Conseil National de Secours d'Urgence et de Rehabilitation* (CONASUR) is a public entity that brings together 20 ministries, the governors of regions, representatives of NGOs and the Red Cross. CONASUR's mandate includes overseeing the coordination of humanitarian actions, ensuring that disaster risks are integrated into national development plans, adopt these plans and mobilizing resources for DRM.

I addition to national climate change initiatives, Niger has participated in regional initiatives, including the preparation of the Climate Investment Plan for the Sahel (PIC-RS), covering the period 2018-2030 and approved in 2019.

Findings

Table 14 compares country sources of evidence with SREs for Burkina Faso from the PAAF analysis. There is less evidence available for Burkina Faso than for Kenya but the evidence available is broadly consistent with the country SREs prepared through the PAAF analytical framework.

Table 14: Burkina Faso comparison of country sources with SREs for Burkina Faso

Burkina Faso		
	PAAF SRE for Burkina Faso[a]	Comparable country sources
EICC (NPV of GDP to 2050)	7.2%	6.4% (Schelypen et al. 2019) 2.1% (GIZ, heatwaves only)
Benefit Cost Ratios	3	4.2 (WB ARCP Appraisal 2019)
Adaptation needs (%GDP - ABS weighted)	9.6%	3.67% (NAP 2015) 2.36% (NDC 2021), if over 10 years
Public adaptation spending (%GDP)	0.18%	UNDRR review
Alignment Index	84.6%	No evidence on sectoral impact
Adaptation gap (% needs)	93.0%	No direct evidence

a SRE = standard reference estimate produced using PAAF pan-African analytical approach

Exposure to climate risk

The **GIZ Climate Risk Assessment** (CRA) for Burkina Faso provides downscaled projections for temperature and rainfall patterns (GIZ, 2021a). This suggests that the SREX doubling rule of thumb is roughly applicable for drought and heatwaves, although it is significantly worse in the south. However, intense rainfall events are likely to increase only moderately (by about 10 percent) and there is little impact on total rainfall. Temperature increases cause a reduction in soil moisture and an increase in potential evapotranspiration. These underlying climate risks are consistent with the analysis in PAAF, which gives high exposure indices for Burkina Faso for heat, drought and rainfall variability. The PAAF exposure index for flood is not high, but is perhaps higher than suggested by the GIZ evidence.

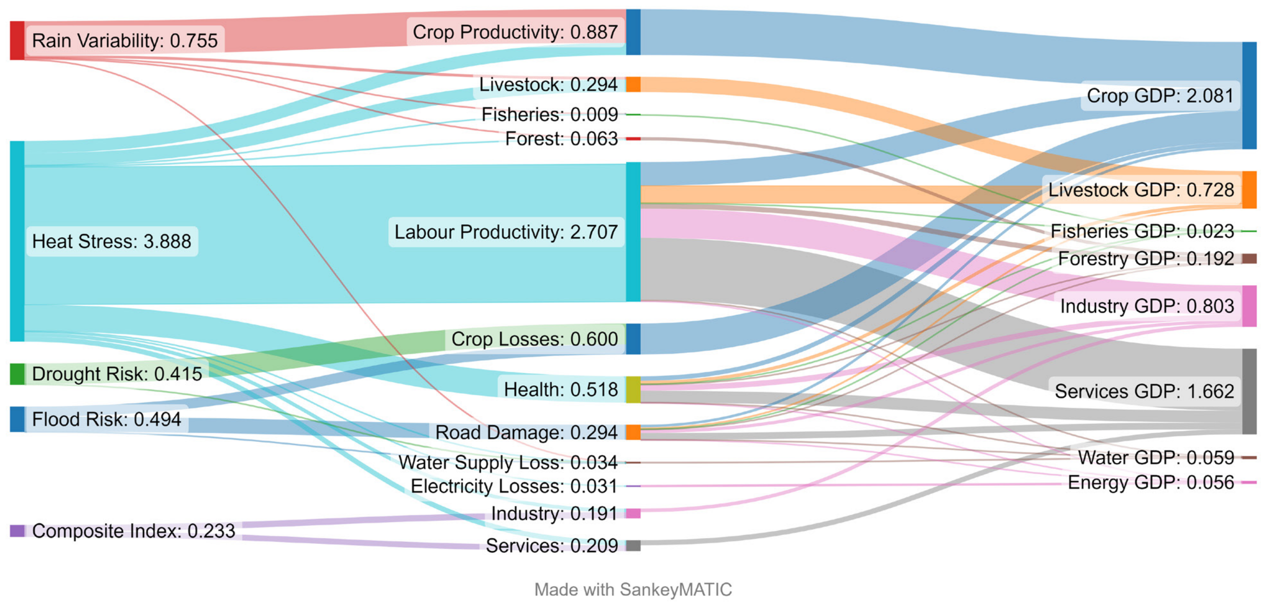
Potential EICC

Bilali (2020) undertook a literature review on evidence of the impact of climate change on agriculture and identified 217 relevant papers, of which 98 related to sub-Saharan Africa as a whole, 69 were multi-country (including Burkina Faso) and 50 related specifically to Burkina Faso. Examples of these sources include: the GIZ 2021 Risk Profile, which suggests agricultural yields could be 30 percent lower in 2080; and the CEH 2021 Policy Brief on climate change impacts in Burkina Faso, which suggest yields will be 20 percent lower in 2050 with high emission scenarios (UK Centre for Ecology and Hydrology, 2021). These are roughly consistent with the PAAF SREs for Burkina Faso.

The GIZ CRA also reports that 10.5 percent of GDP could be exposed to heatwave risks by 2080. This figure relates to 'exposure to heatwaves' but it is not clear whether this is simply exposure or EICC. The PAAF analysis considers that all of the Burkina Faso economy will be affected by heatwaves, with labour productivity declining by 10 percent for sectors requiring heavy manual labour (agriculture and construction), 5 percent for light manual labour (manufacturing) and 1 percent for services. Without knowing the definitions used in the CRA it is not possible to compare the two estimates.

A study of the EICC in Burkina Faso used regression analysis to estimate the impact on the GDP of three principal sectors (agriculture, industry and services) of three climate variables (average temperature, deviations from average temperature, and an index of rainfall intensity) (Schleypen, Saeed, Dayamba, Coulibaly, & D'haen, 2019). The study suggested that total GDP would be 15.6 percent lower in 2050, using a climate change scenario that is roughly comparable with the 2°C rise by 2050 assumed in the PAAF analysis. This equates to a loss in NPV of GDP to 2050 of about 6.4 percent. The impact affected all three principal sectors with particularly high impacts on crop production. All areas would be affected, with mean rainfall affecting especially the centre, temperature effecting the north and east and extreme rainfall the southwest. Because this is an econometric study, it should pick up all climate risks and impact pathways, without specifying those pathways or being able to explore the individual impact of each pathway.

Figure 24: PAAF estimates of EICC for Burkina Faso (% NPV of GDP to 2050)



Source: PAAF estimates.

Effectiveness

No review evidence was found on the effectiveness of public adaptation expenditure. The **Project Appraisal Report** for the World Bank Agricultural Resilience and Competitiveness Project (2019) estimated that the economic rate of return of the project was 26.2 percent, equivalent to a BCR of 4.2 (World Bank, 2019b).

Needs

The NAP defines 33 objectives in seven sectors (agriculture, livestock, environment, energy, infrastructure, health and water). Up to ten measures are defined for each sector, with associated cost estimates that total $6.5 million. Financing is expected to come from a mix of public (both domestic and international) and private, although the relative shares are not specified. Institutional arrangements for coordinating the NAP are defined.

The NDC identified 63 adaptation actions (in agriculture, livestock, environment, infrastructure and water), with a total cost of $2,788 million, of which $1,641 million were conditional on additional financing. While no time period is given for NDC implementation and there is no standard international approach, NDCs are updated every 5 years and the implementation horizon is generally 10 years.

According to the National Communication on Adaptation (2021), a budget of $1.8 million was included in the NDC for technical assistance and $36.3 million for research, although this is not included in the main NDC. A recent review of the state of scientific evidence for climate policy-making described the needs for research (Theokritoff & Lise D'haen, 2021).

Whilst these estimates of funding needs appear consistent with the PAAF SREs for Burkina Faso at first sight, they are two very different estimates. The SRE refers to the ABS weighted expenditure required to avoid all EICC whilst the NAP and NDC figures are unweighted and refer only to a specific set of priority actions, with no assessment of the extent to which these actions address the full EICC faced by the country.

Adaptation spending

The PAAF analysis suggested that funding within the budget was low, at only 0.18 percent of GDP ($33 million, using CPEIR-weighted expenditure). The OECD DAC figures for average loan commitments over the period 2015 to 2020 gives a DAC weighted total of 0.23 percent of GDP. The *Direction Generale de la Cooperation* published an analysis of international assistance in 2020 which suggested that public assistance from international partners was a total of $2,142 million, of which $419 million was in sectors that could contribute to adaptation (i.e. agriculture, livestock, forestry, water and sanitation). Comparing aid coordination data with budget data is notoriously difficult, given differences in categorisation and timing issues between government and international partners. However, the scale of the difference between these figures suggests that Rio markers in the OECD DAC database may not be picking up all adaptation assistance and that much of this assistance is outside the budget. The PAAF conclusions that Burkina Faso has low levels of adaptation spending should therefore be treated with caution until there is more clarity on this issue.

In 2020, Burkina Faso received $2,142 million in aid, of which 0.3 percent went to food aid, 5 percent to emergency relief, 8.3 percent for environment and WASH, 8 percent for agriculture and 7 percent for transport. Between 2019 and 2020, there was a slight fall in environment, WASH and agriculture expenditure and a slight rise in transport expenditure. The OECD DAC Rio markers suggest that the average annual commitment to adaptation between 2015 and 2019 was $192 million, of which $66 million had principle adaptation objectives and $127 million had significant adaptation objectives. The DAC weighted total was $116 million, almost all of which was in loans. This is much higher than the $33 million of adaptation spending in the budget analysis. Direct comparison between the budget and ODA records is very complex and relates both to classification issues and the way in which commitments registered in OECD DAC are reflected in expected disbursements in the budget.

The World Bank has conducted a Climate Public Expenditure Review in Burkina Faso but the report is not yet public. UNDP and UNDRR are supporting DCPEIR, including building consensus on methods for classifying public expenditure and using this to estimate and monitor trends in expenditure, either as an occasional review activity or, potentially, as an annual activity, through the use of budget tags. The results of the DCPEIR are not yet available.

The 2022 UNDP stocktake of climate budget mainstreaming reported that Burkina Faso includes reference to climate change in the budget circular (UNDP, 2022). It also has a national environment fund that covers climate change (*Le Fonds d'Intervention pour l'Environnement*) and is a member of the Africa Risk Capacity initiative. No other climate mainstreaming initiatives are currently planed.

No work has been found on private adaptation finance in Burkina Faso. Given the importance of the agricultural sector and the dominance of private investment in the agricultural sector, this is likely to be important. Wider investment in the economy, especially in protecting enterprises from challenges with labour productivity arising from increased heat stress, is also likely to be an important focus for private adaptation.

Adaptation gap

No separate estimates of the adaptation gap have been made for Burkina Faso.

Conclusions and recommendations

There is limited comparable evidence available for Burkina Faso. However, the case study confirms that the limited evidence that is available is broadly consistent with PAAF SREs.

Burkina Faso is in the early stages of developing a comprehensive approach to adaptation financing. The 2021 **National Communication on Adaptation** (in French) (MEEVCC, 2021) proposes the preparation of a coherent NDC financing plan, including reference to the following national and international sources: the 2019 **NDC investment plan** (in French) (GdBF, 2021a); the 2020 **World Bank Climate-Smart Agriculture Investment Plan** (World Bank, 2021a); the 2019 **Sahel Regional Climate Investment Plan** (CCRS, 2018); and the 2021 **CEDEAO Climate Strategy** (CEDEAO, 2021). The PAAF analysis provides an outline analytical framework that could be used to ensure that such a financing plan is based on evidence and is appropriately scaled and balanced, to match full needs, whilst also being realistic about potential sources. To prepare an adaptation financing plan, the following key tasks are required:

1. Clarity on responsibility for institutional leadership, including coordination between the *Ministère de l'Économie, des Finances et de la Prospective and the Ministère de L'Environnement, de l'Economie Verte et du Changement Climatique*. Several changes have been recently made with the merging of ministries and a revision of their mandates, which highlights even more the need for institutional leadership.
2. Building a national consensus on the EICC in each sector of the economy, including all the climate risks and impact pathways.

3. The link between EICC and the financing needed to avoid that EICC needs to be established. This involves developing practical methods for defining and understanding the effectiveness of adaptation expenditure and building a library of evidence on this.
4. The DCPEIR could be used as a basis for deciding on a system for building consensus on the methods for defining adaptation finance and using these methods to review adaptation expenditure, either as an occasional review/evaluation activity or as part of the annual budget.
5. The above recommendations should make it possible to develop a country-based and country-owned estimate of the adaptation gap which can be used to guide and justify the comprehensive adaptation financing plan.

7.4 Overall conclusions from the three case studies

The country case studies demonstrate the value of having country specific PAAF SREs as a point of reference that can provide the full picture and guide more detailed work. They can throw the spotlight on areas where further work is most urgent, such as the uncertainty over the impact of climate change on agriculture in Niger. They also encourage country work to cover the full range of potential climate risks, including those that are sometimes neglected (e.g. livestock and labour productivity and health risks).

The main limitation to the country case studies is that they were conducted very rapidly and did not have sufficient time to investigate problematic areas in any depth. This applies especially to the water sector, which would require detailed study of sectoral evidence and plans.

The country case studies broadly confirm the PAAF finding that the adaptation expenditure needed to fully avoid all EICC is much higher than can be addressed by even the most optimistic scenarios of public adaptation expenditure. The needs are also two to three times higher than the latest costs in the NDCs of the three countries, which appears to be typical of developing countries in general (see section 6.3). The practice of making unconditional and conditional cost estimates is a useful way of demonstrating that the current availability of funds will meet only a small part of needs and increased international support is required to meet all needs. Recent reviews of NDCs suggest that there is steady progress in expanding the scope of NDCs, which carries with it steadily expanding estimates of associated costs (Fransen, O'Connor, Alayza, & Caldwell, 2022; IPCC, 2022b; UNEP, 2022a). The country case studies suggest that the ongoing elaboration of NDC scope could include more explicit assessment of the total need as part of the synthesis of evidence on EICC and loss and damage. It would also be useful for some countries to improve the way that NDCs cover all issues affecting needs, including, in particular:

- The adaptation needs that can be covered by the private sector, perhaps distinguishing between reasonable expectations with current policies and the acceleration that could be possible with more proactive government policies; and
- The range of EICC for which there is no cost-effective preventive adaptation and which therefore need to be addressed by reactive adaptation, such as social welfare, insurance and migration.

Kenya is about 5 to 10 years ahead of Niger and Burkina Faso in managing their response to climate change. Kenya therefore illustrates the increased confidence and precision that is possible as the evidence base available improves.

8 Conclusions and recommendations

This chapter presents key conclusions and recommendations following the PAAF objectives and the structure of the report. This PAAF review indicates that governments across Africa are already making significant efforts to reduce the potential economic impact of climate change and that the private sector are also making contributions. It seems likely that as much as 30 percent of the potential impact will be avoided, if current levels of public and private adaptation expenditure are maintained, when expressed as a percent of GDP. This still leaves a major coverable gap and section 6.4 reviewed the options for closing this gap. This chapter brings together conclusions about the challenges and recommendations for further work, especially on developing country strategies for closing the adaptation gap. Recommendations are presented for different types of stakeholders. Box 11 summarises the key steps in preparing a Country Adaptation Gap Closing Strategy.

8.1 Conclusions

The PAAF analysis of the EICC suggests that GDP will be 9.3 percent lower because of climate change. In NPV terms, the value of GDP from 2020 to 2050 will be 3.8 percent lower. Using SREs of expenditure effectiveness to address EICC, the analysis found that 10.4 percent of Africa-wide GDP is needed to avoid all avoidable EICC. Existing adaptation spending is 3.3 percent of GDP. If NDC actions are fully implemented, they would cost a further 2.4 percent of GDP, in combination addressing 55 percent of adaptation expenditure needs. The remaining 45 percent will need to be included in NDC costings as new actions, and the distribution and scale of actions are refined. The remaining existing and further new NDC actions can be financed through a mix of domestic revenue, international assistance and greater participation of the private sector, provided that past GDP growth is maintained. In the short- and mid-term, most African countries are close to debt ceilings and will be dependent on international grants. The PAAF analysis has implications for the scale of New Collectively Quantified Goals for adaptation funding, and of the Loss and Damage Fund agreed at COP27. The PAAF methodology and analysis also has implications for how countries assess their adaptation expenditure needs and gap, and the strategies they develop for closing the gap. At country level, the PAAF analysis shows that there is wide variation in the gap between needs and existing supply of adaptation funding, and different degrees of alignment between sector adaptation needs and available funding supply. Work on refining NDCs could include a strategy for closing the adaptation gap, covering all potential sources of finance.

8.2 Recommendations relating to EICC

Exposure to climate change

Some international indices of exposure to climate change are based on reported past climate-related events. Climate scientists generally agree that past trends can be used as a proxy indicator of future trends if downscaled models of future trends are not available. However, reporting on past events in Africa may be incomplete, especially for smaller events, and there are often wide variations in the results of the different indices. **Future country-based work should triangulate between all sources of country evidence on exposure to climate change. An international review of the reasons for variations in indices would be valuable.**

Transparency in methods and metrics

Chapter 2 of this report showed that there is some tendency of estimates of EICC to converge but that there are still quite wide variations. These variations occur partly because of differences in methodology and partly because of changes in projections about the likely severity of climate change. **All estimates of EICC should be rigorous and transparent about what methods and metrics used (e.g. GDP in 2050, NPV of GDP to 2050, growth rate of GDP, etc.). This applies to international and country analysis.**

Increased country level analysis of the adaptation gap will make use of country-specific evidence and statistics. Subnational authorities may be able to add further detail on exposure and sensitivity. **Government could review county statistics related to climate risks and economic, social and environmental sensitivity to establish whether there are gaps that need filling to improve the assessment of EICC and, hence, of adaptation financing needs. Pan-African institutions could usefully conduct a pan-African review of the economic, climate change and public finance statistics available for estimating adaptation needs and use this review to identify priorities for filling gaps and building quality and consistency.**

Private sector engagement in EICC analysis

The PAAF review was able to find no coherent evidence from private enterprise on the expected sectoral EICC. **As the private sector will often have undertaken work to understand EICC in their sector, this private sector expertise could be integrated into the national database as much as is possible, taking into account that some of the evidence may be commercially sensitive.**

Build public awareness of EICC

CSOs could expand their work on the potential EICC in the sectors in which they are working and disseminate the conclusions from their analysis so that it is in the public domain.

8.3 Recommendations relating to effectiveness

Distinguishing between adaptation and development benefits

This report describes a growing international body of evidence on adaptation effectiveness. However, this rarely distinguishes between the benefits associated with development and those associated with reduced EICC, which is needed for estimates of adaptation financing needs. **International institutions and governments could encourage the emergence of common CCIA methods that clearly define and estimate the adaptation benefits of reducing EICC. Governments could incentivise and support line ministries to apply these methods when designing programs and submitting them for funding in the budget.**

Integrate climate change into existing appraisal methods

It is unrealistic to expect concerns about climate adaptation to drive major advances in appraisal methods, given the significant capacity requirements for the appraisal of development and adaptation programs. **The growing use of CCIA methods adopted in each country should build on existing appraisal methods. International partners should ensure that all development assistance that makes a contribution to adaptation is appraised using methods that support country systems.**

Libraries of evidence on effectiveness

The evidence on effectiveness is scattered in many places, although there are a few initiatives to synthesise this evidence. **International institutions could support the creation of an international library of evidence on CCIA. Country libraries can also be created. CSOs can play an important role in participatory CCIA and in building the evidence base on effectiveness.**

Coherence between public CCIA and private risk analysis

CCIA methods cover many of the same issues as private sector risk analyses. **The public and private sector could collaborate to build common approaches to climate risk analysis, that draw on public experience with CCIA and private sector risk analysis. These approaches should include comparable analytical methods and share use of evidence.**

Participatory CCIA

CSOs could promote awareness of CCIA and capacity for participatory CCIA. They could offer these services to government who should have the ability to integrate the evidence into CCIA.

8.4 Recommendations relating to adaptation needs

Consistent and transparent definition of adaptation needs

International work on adaptation needs uses different concepts, which are often not directly comparable. The UNEP AGR provides a review of this evidence. This PAAF report demonstrates a method for estimating adaptation expenditure needs by dividing EICC by the adaptation BCR of expenditure. This requires the use of conversion factors because EICC and BCRs have different metrics. **All governments and international bodies working on adaptation**

needs should ensure that they define explicitly their interpretation of adaptation needs. In particular, it should be clear whether needs refer to the full needs required to avoid EICC or more specifically to the needs for implementing a particular work program.

Uncoverable needs

One of the main areas of confusion in defining adaptation needs relates to the EICC that cannot be avoided by any cost-effective adaptation options (i.e. what this report terms 'uncoverable needs') and which therefore has to be addressed by responsive policies. The terminology for this is not consistent. **International institutions should encourage a single agreed terminology for referring to uncoverable needs and need to focus more on how the scale of these needs is estimated.**

8.5 Recommendations relating to adaptation expenditure

Definitions of adaptation expenditure

Inter- and intra-country dialogue on adaptation expenditure is fragmented because it lacks a common language and framework. Analysis of existing climate expenditure typically reports results in terms of weighted expenditure, using weights that reflect the relative importance of adaptation in the objectives of the expenditure. However, government planning for adaptation, as reflected in NDCs, normally reports planned adaptation expenditure in an unweighted form. To help bridge these two approaches, the PAAF analysis reports needs and gaps in both weighted and unweighted adaptation expenditure. The main challenges involve adaptation expenditure that is an integral but minor part of large development programmes (e.g. roads, health and education). **Future work on the adaptation gap should be explicit in the way it uses weighted expenditure and the implications of this for the comparability between the estimates of needs and of supply.**

UNFCCC/SCF, OECD DAC and CPI all play an influential role in reporting on adaptation expenditure. **UNFCCC/SCF could ensure comparability on adaptation reporting** (e.g. using common or mappable definitions and weights for adaptation expenditure and using percent of GDP for cross-country comparability). **In their guidance on Rio markers, OECD DAC could usefully cross-reference other approaches and illustrate how these can be mapped onto Rio markers. CPI should participate in efforts to build comparability of Climate Finance Landscapes with other work on adaptation financing, including the UNEP AGR and country reporting.**

Using CBT and CPEIRs to improve data on expenditure

Information on existing adaptation spending (however defined and weighted) is not strong enough. This PAAF study has shown that country budget data is not always structured in ways that are helpful to determine existing spending. CBT guides the annual budget process and CPEIRs guide the revision of adaptation strategies. **Government policy makers could use CBT and CPEIRs as tools for helping to map the budget structure onto the sectoral structure of adaptation needs. The information from this work needs to be gathered in a sustainable manner, which may require capacity from outside government. Policy makers could maximise the effectiveness of CPEIRs by ensuring that they relate to the categories of expenditure in adaptation strategies.**

Analysing budget contributions to adaptation strategies

CBT may be guided by adaptation strategies but it is complex to operate a CBT system in which the tag registers the contribution of expenditure to actions defined in a climate strategy. **If policy makers are interested in annual monitoring of the expenditure on actions in the adaptation strategy, a CBT system will normally need to be supplemented by analytical capacity outside the budget.** Ideally, this could be integrated with other program or results-based budget reforms that register contribution to adaptation actions through key performance indicators, although this is challenging and would normally be suitable only if budget reforms were well-established and well-resourced. **More substantive analysis of expenditure should normally be undertaken in the context of occasional evaluation (e.g. in CPEIRs) where additional capacity can be mobilised. Definitions and analysis used in annual CBT and occasional CPEIRs should be comparable.**

Green taxonomies for private investment

Government and the private sector could collaborate to develop a green taxonomy for public and private sector expenditure (for sectors, projects, activities and assets). This will promote public private coordination in reducing the adaptation gap and will facilitate eligibility of adaptation expenditure for green investment, in line with accepted international practice.

Integrating international adaptation in the budget

International partners have adopted a range of methods to recognise adaptation expenditure in their own spending. Governments cannot expect international partners to change these methods but **they could request their international partners to collaborate in mapping the evidence from international to national systems for monitoring adaptation finance. International partners should, wherever possible, allow their ODA support for adaptation to be registered in government financial systems, ideally within the budget but, if not, then in aid coordination mechanisms.**

Off-budget international finance for adaptation

It is very difficult to assess off-budget adaptation spending and there are well-known problems with aid coordination for off-budget adaptation as a result of issues with naming and phasing. **Analysis of adaptation expenditure will benefit from aid coordination initiatives but cannot be expected to drive those initiatives.**

Subnational and public enterprise adaptation

This review revealed that the evidence on expenditure by subnational bodies and public enterprises is limited. Subnational and public enterprise spending was available in only three countries (Egypt, Seychelles and South Africa). **Policy makers could consider a phased approach to CBT and CPEIRs starting with an initial phase that focuses on the core central line ministries that make the most important contributions to adaptation, with further phases expanding to subnational government, public enterprises and off-budget expenditure.**

8.6 Recommendations relating to the adaptation gap

Country work to improve adaptation gap analysis

This PAAF study was conducted rapidly with limited resources and with access only to data that is freely available on the internet. The country-specific results can be viewed as standard reference estimates (SREs), which provide a reference point for further country work. **National governments could improve on the PAAF SREs for their country and make their own estimates of their adaptation gap, using any more detailed country evidence available.** Chapter 7 illustrates the potential added value of country-specific analysis.

Governance of adaptation strategies

NDCs and other adaptation strategies provide a good basis for stronger, more strategic efforts on climate change adaptation. **Government should ensure that governance structures for the formulation, review and revision of adaptation strategies include expertise that can guide effectively the strengthening of the strategies, including reference to the way in which the strategy reduces the adaptation gap.**

Content of adaptation strategies

Recent reviews of NDCs suggest that there is growing attention to work on financing, although this focuses mainly on estimating the costs of the actions in the strategy, without demonstrating that the scale of the actions are sufficient to reduce all EICC.

Government policy makers could require NDCs and other adaptation strategies to:

- **Demonstrate that the sectoral balance of adaptation expenditure planned in the NDC is informed by an analysis of the sectoral composition of EICC;**
- **Include a mid- to long-term adaptation financing framework (AFF) which matches funding sources to proposed strategy actions, and which identifies further actions to close the remaining gap, including innovative sources (see** Box 11 **for more details);**
- **Define and estimates the uncoverable gap, the actions that respond to it (i.e. disaster relief, probability-based contingency funds, insurance, etc.) and the appropriate share of adaptation expenditure devoted to this; and**
- **Have an explicit strategy for enabling private adaptation, including identifying critical enabling policy/regulations and collaborating on public and private risk analysis.**

International partners could indicate how their country support for adaptation fits within the country's AFF. Pan-African institutions could usefully maintain a library of country AFFs and promote comparability within this library. UNFCCC/SCF could ensure that guidance on reporting for BTRs should encourage reference to EICC and AFFs. The UNEP AGR should continue to promote transparency and comparability in reporting on the adaptation gap and UNDP should continue to provide technical support to countries to strengthen the way EICCs and AFFs are included in NDC.

Covering all impact pathways

NDCs are guided by an understanding of the scale of EICC in each sector. The NDCs for most African countries include qualitative descriptions of the EICC that is expected to occur because of different climate change scenarios. These often focus on the more obvious impact pathways, including the effects of floods, drought, less predictable seasonality and sea level rise. The impact of heat on labour productivity and health is less widely considered and may be as important as other impact pathways. Further work is required to develop clear methods for cross-sectoral impact pathways, notably for water supply and sanitation. **Governments could ensure NDCs cover the full range of impact pathways.**

Adaptation in development planning

The PAAF analysis shows that the majority of adaptation expenditure is primarily development expenditure that delivers additional adaptation benefits. Good adaptation policy formulation and planning therefore requires adaptation to be integrated into the arrangements for development policy and planning.

To improve the adaptation benefits of development expenditure governments could:

- **Strengthen the leadership, coordination, oversight and institutional roles regarding sector and subnational development planning to ensure that plans recognise the adaptation benefits of public development expenditure;**
- **Mainstream adaptation into development strategies and plans at national, sector and subnational (local) levels, guided by evidence from analysis of EICC and CCIA; and**
- **International partners and pan-African institutions should ensure that their development plans refer to the contribution of actions to adaptation.**

Legislators

Legislators have an important role in the planning and management of public adaptation expenditure. **Legislators could require an estimation of the adaptation gap and to use that gap to guide adaptation expenditure planning. They could also develop legal and regulatory requirements for public participation mechanisms and for sufficient and useful public information flows on adaptation planning from executive government.**

Government could build a formal committee and research capacity in national and subnational legislative/representative bodies to provide oversight on adaptation strategies, on mainstreaming adaptation in policies and plans, on levels and balance of adaptation expenditure, and on improving the effectiveness of public adaptation expenditure.

Civil Society Organizations

Civil Society Organizations (CSOs) have an important role in the evolution of evidence-based adaptation policy and planning in countries, both to improve the quality of adaptation expenditure and to contribute to appropriate political discourse. The PAAF review found some evidence of this work, but it is scattered and it seems likely that CSOs have a lot of evidence that is not publicly available.

CSOs could:

- **Collect and disseminate evidence from community consultation, notably on exposure to climate change and the effectiveness of adaptation;**
- **Comment on adaptation budget reports and adaptation expenditure reviews, both as members of steering groups and as independent commentators; and**
- **Prepare citizen's versions of adaptation strategies and expenditure reports.**

Private sector

The PAAF analysis suggests that the private sector is expected to provide the majority of financing for adaptation in the mid- to long-term, motivated by the need to reduce the impact of climate change on profits. **Private enterprises could:**

- **Use existing industry-government working groups to ensure government understands private sector priorities and the potential value of enabling adaptation policy such as regulations, public-private partnerships, insurance, contingency and information services; and**
- **Collaborate with government to provide indicative scenarios of likely private sector investment in adaptation in the mid- to long-term.**

Box 11: Key steps in preparing a country adaptation gap closing strategy

1. Form a Steering Group including representatives from, a minimum, the ministries responsible for finance, planning and climate change and any cross-cutting bodies responsible for coordinating climate change policy. Consider working with existing climate change coordination mechamisms, such as NDC Coordination Committees.
2. Agree the short-, mid-, and long-term urgency of key objectives (i.e. awareness, strategy refinement, budget influence, tracking expenditure, promoting effectiveness, fundraising).
3. Prepare a review table, comparing PAAF SREs with other country work. Explain differences. Decide consensus estimates for key evidence and, hence, total Adaptation Gap, triangulating all sources.
4. Agree any steps needed to improve estimates (e.g. climate economic impact studies, use of climate budget tagging, private sector adaptation investment evidence, civil society contribution to effectiveness, etc.).
5. Consider sector Adaptation Gaps and any issues of alignment of sectoral spending with sectoral needs.
6. Prepare the Country Adaptation Gap Closing Strategy (AGCS), assessing the potential contribution of key sources (i.e. revenue share, effectiveness, grants, loans, sovereign debt instruments, growth in private adaptation, etc.), both in scale and comparative advantage of each source.
7. Agree on steps required to reflect AGCS in future policy statements and mainstreaming initiatives, including in future NDC revisions and NDC investment and/or financing strategies.
8. Agree steps to obtain support for the AGSC to build confidence amongst international partners and the private sector (the SCF, potential funders and investors and civil society).

8.7 Institutional roles

Table 1 provides a summary overview of the recommendations, mapped to the roles that can be played by the main stakeholders in adaptation planning.

Table 15: Recommended focus of institutional engagement

Recommendation	Government	International partners	Private sector	Civil society
EICC				
Review evidence on exposure to climate change				
Transparency on methods and metrics used for EICC				
Private engagement in EICC				
Build public awareness of EICC				
Effectiveness				
Distinguish adaptation and development benefits				
Build capacity in CCIA especially in line ministries				
Integrate CC into existing appraisal methods				
Create libraries of CCIA evidence				
Align public sector CCIA and private sector risk analysis				
Support participatory CCIA				
Needs				
Consistency in how needs are defined and reported				
Better definition and evidence on uncoverable needs				
Expenditure				
Clear definitions of adaptation expenditure and weights				
Use CBT to monitor trends and CPEIRs/CCIAs to evaluate				
Analyse budget contributions to adaptation strategies				
Green taxonomy spanning public and private sector				
Improved international reporting (eg DAC, CPI ...)				
Integrate international adaptation in the budget				
Climate citizen's budget				
Legislature to oversee climate budgeting				
International partners to refer to country strategies				
Collaborate with country aid coordination efforts				

Recommendation	Government	International partners	Private sector	Civil society
Gap				
Improve country level adaptation gap analysis				
Review of adequacy of statistics				
Governance of adaptation strategies consider the gap				
Adaptation strategies to refer to gap and AFF				
Sectoral spending balance informed by sector gaps				
NDCs cover all pathways				
Integrate adaptation in development planning				
Legislators to require gap analysis in strategies				
Clear short/mid term horizon for international funds				
Adaptation strategies use country strategies				
Use gap analysis in international negotiations (L&D Fund)				
Discuss private adaptation scenarios with government				
CSOs to participate in preparation and monitoring AFFs				

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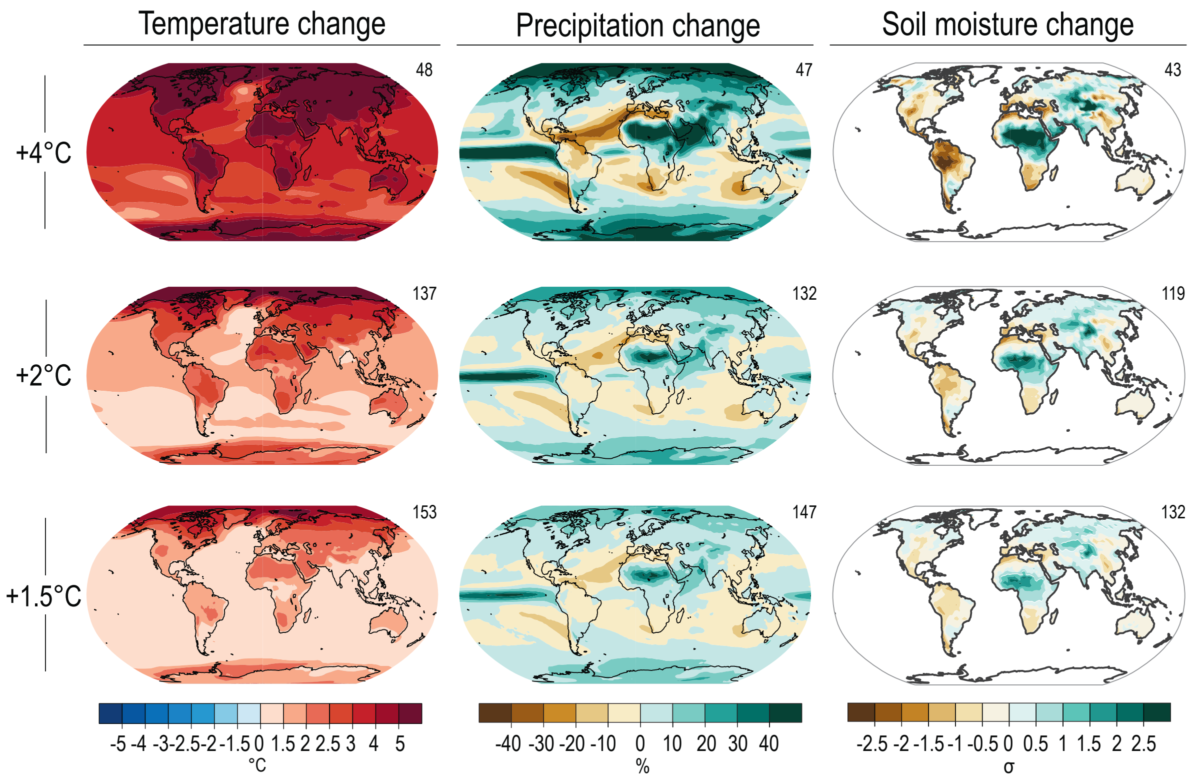
Annexes

Annex 1 Exposure maps

IPCC climate change maps. The maps below give a broad indication of the differences across Africa of changes in temperature, precipitation and soil moisture. The maps suggest that temperature in Africa will rise roughly in line with global temperatures in all parts except Central Africa, which will see smaller rises. All areas except Southern Africa and the Mediterranean coast will become wetter. Soil moisture will decline in Northern and Southern Africa but improve in West, Central and East Africa.

Figure 25: IPCC climate change projections



Source: IPCC, 2021.

Key global data on exposure to extreme events includes the following. The map for Africa from each of these is presented in the first row of Figure 26 below.

- **EM-DAT** is a database of extreme events that is maintained by the Centre for Research on the Epidemiology of Disasters at Leuven University. It includes some data at national, and in some cases subnational, level although the data is in numbers of events, which makes it more difficult to use for impact analysis. This suggests that the East and South coasts, plus the Sahara have been exposed to most climate related disasters, although some other countries have also experience large numbers of climate related disasters.
- **Maplecroft** produce a composite Climate Change Vulnerability Indicator that uses 26 indicators covering exposure, sensitivity and adaptive capacity. The data is available only by subscription and the latest published evidence comes from the Climate Change and Environmental Risk Atlas (Maplecroft, 2014). The Maplecroft Index suggests that Africa is less at risk than parts of Asia, with most African countries in the mid-risk category. The index picks out Madagascar and Mozambique as especially high risk.
- **Germanwatch** produce a Global Climate Risk Index based on extreme weather events since 1992 based on data from the Munich Re NatCatSERVICE (Kreft & Eckstein, 2014). The latest version of the index is based on data from 2000 to 2019. There is little regional pattern to the results and an analysis of the data suggests that country exposure varies greatly over time. Data is not available below national level.
- UNEP and UNISDR maintain a **Global Risk Data Platform**. This includes data from a range of primary sources not covered in other sources, but the platform appears to be relatively old and the website was not fully functional when consulted.

There have also been a number of research studies that develop composite indices of vulnerability, which are summarised in the second row of Figure 26 below. These involve a variety of component variables, some of which include sensitivity, as well as exposure.

- **FERDI**. *The Fondation pour les Etudes et Recherche dur le Developpement International* prepares an index of physical vulnerability to climate change (PVCCI). The composite PVCCI is based on five components (sea level rise, aridity, rainfall, temperature and storms) with data from a range of studies. The index focuses on exposure to climate change risks and does not take into account sensitivity or adaptive capacity.
- **CCAPS**. The Climate Change and African Political Stability initiative at the Strauss Centre in Texas has developed a Climate Change Security Vulnerability Model (CSVM) which presents an index of vulnerability which includes: exposure to risk; population density; household/community resilience; and governance and political violence (Busby et al., 2015). The PAAF analysis uses the index of exposure to risk. The latest data on the website is from 2015.
- **ND-GAIN**. The University of Notre Dame produces a suite of related indices of climate change vulnerability, covering exposure to risk, sensitivity and adaptive capacity (Chen et al., 2015). Exposure is static over time (although updated with new evidence) and sensitivity and adaptive capacity changes as countries address risks. The latest data on exposure is for 2019.
- **UNICEF**. UNICEF have produced a composite index of exposure to nine climate and environmental shocks, including: water scarcity, riverine flooding, coastal floods, tropical cyclones, vector borne diseases, heatwaves, air pollution and soil/water pollution (UNICEF, 2021). The original sources of data include many of those identified within this chapter (e.g. Aquaduct).

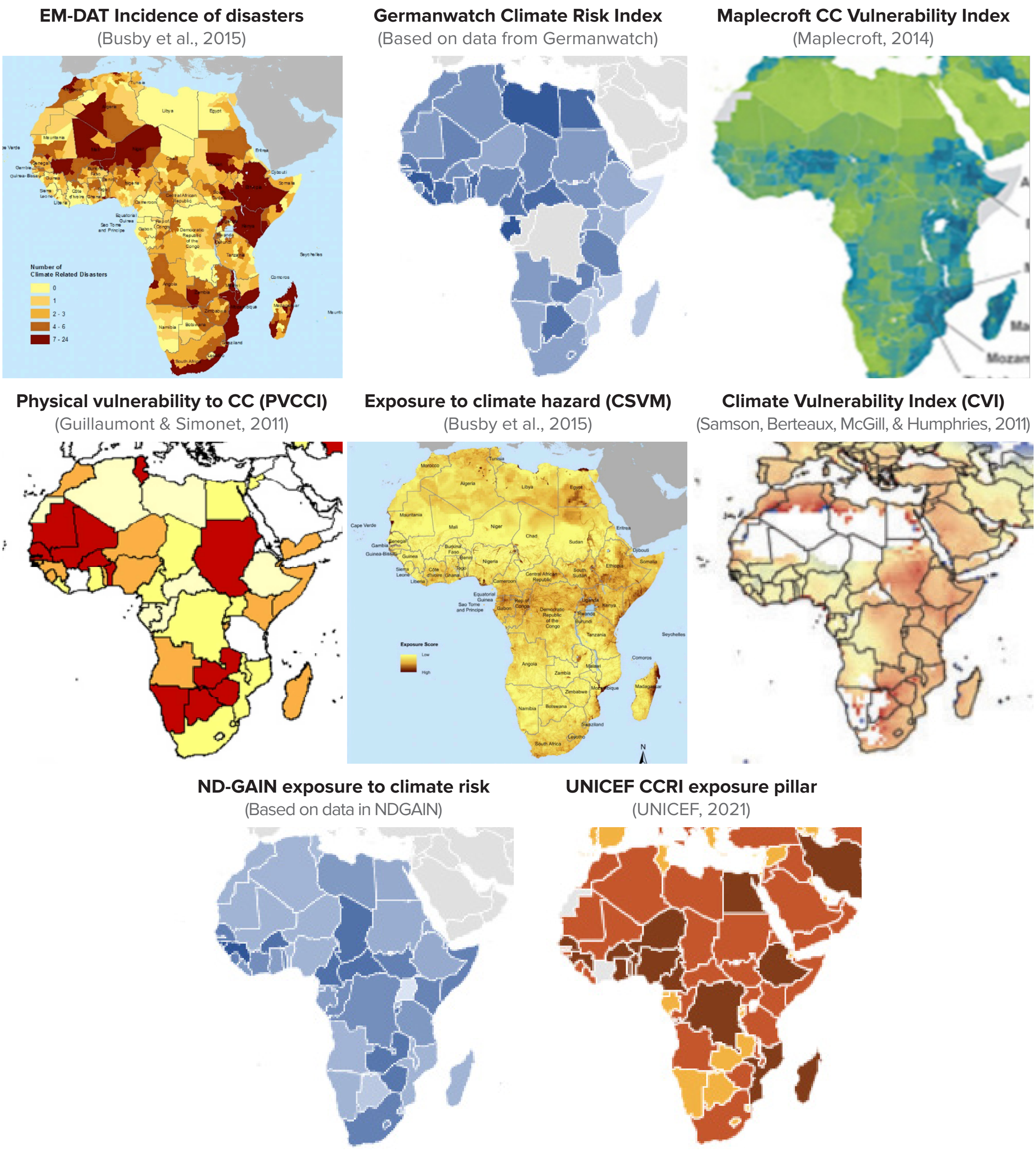
- A research paper in 2011 produced a climate vulnerability index that combined projected exposure to climate change risks, based on the results of the WorldClim climate model, with projections of population density. Although this research is now old and new data is available, exposure to risk should be fairly stable and it seems reasonable to include this assessment, albeit with a low weight in the overall composite index.

Figure 26 below shows the wide range of results achieved from different approaches to measuring vulnerability. The purpose of the figure, at this stage, is to illustrate the range of different sources that will need to be investigated, rather than to provide clear evidence on the details of each source. Although the range of results may seem diverse, some conclusions are possible.

1. The maps that focus exclusively on exposure to climate change risks are those from EM-DAT, PVCCI and CSVM. These suggest that East Africa and the Horn of Africa will be exposed to relatively high risks. Two out of three suggests that Mozambique and the southeast coast of South Africa will also have high risks and two also suggest that the Sahel will have high risks. There is, however, little agreement on the relative exposure to risk in Central and Southern Africa or to the more coastal countries of West Africa.

2. The Germanwatch, Maplecroft and CVI maps include criteria that consider the sensitivity to climate change risks, which are dominated by population density and hence give higher risk values for eastern and southern countries.

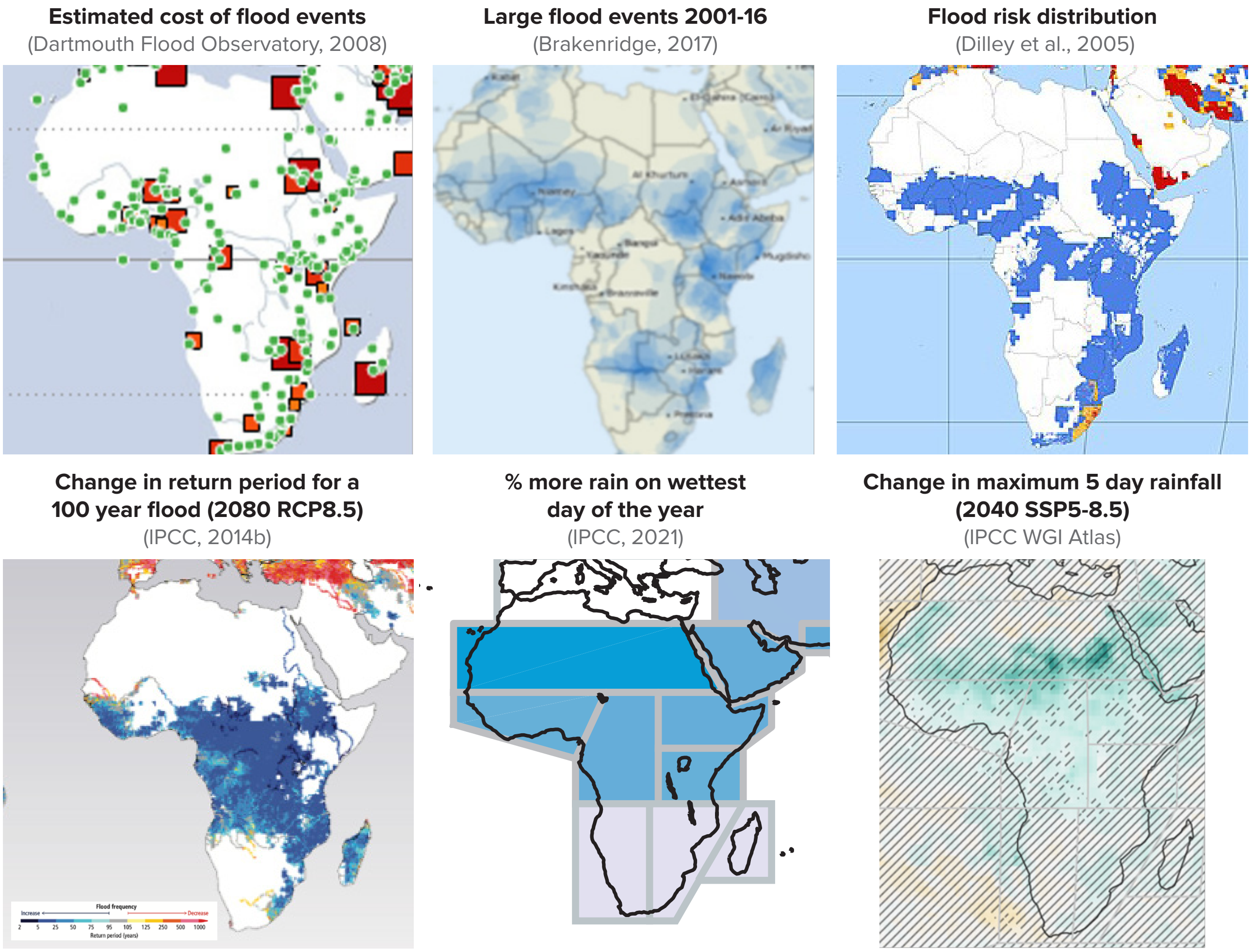
Figure 26: Comparison of different vulnerability indices



To provide further insight into the vulnerability, the various sources of evidence on temperature, floods and droughts have been reviewed.

Flood risk. Most of the international work on flood risks is based on the **Dartmouth Flood Observatory** data which has a database going back to 1988. This data provides evidence of past flooding and does not directly provide evidence of future flooding. However, it can be combined with the evidence from SREX, which suggests that flooding in the southern half of Africa will become 80-120 percent more frequent, whilst flooding in the northern half will become 10-50 percent more frequent. AR5 includes a map of the change.

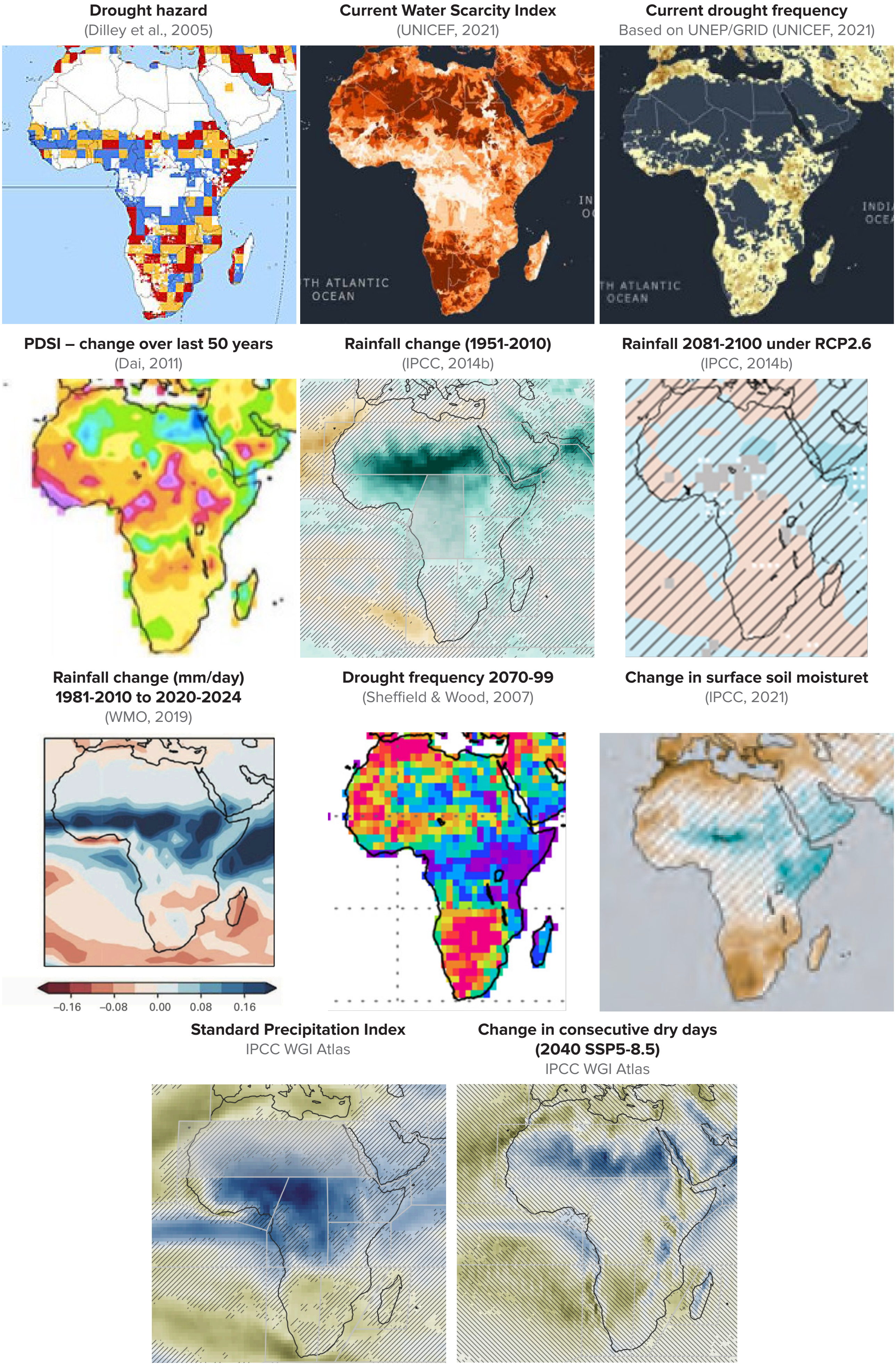
Figure 27: Flood risk maps



Drought. There are a wider variety of sources looking at the current severity of drought. The first two sources in the figure below shows the current frequency of drought hazard and reflect widely know rainfall patterns. The third and fourth shows change in drought severity[23] and rainfall over the last 50 years and suggest significant drying has occurred across most of Africa, particularly in West and Central Africa. The fifth shows change in rainfall in recent decades and present somewhat different patterns that is contrary to the change in drought severity, perhaps reflecting the fact that drought risk is a composite index that includes several dimensions of water balance. The last source shows predictions of future change in drought frequency in the long term and suggests that already dry areas will be hardest hit.

23 The Palmer Drought Severity Index (PDSI) varies from +10 (wet) to -10 (dry) with values of less than -3 reflecting severe to extreme drought.

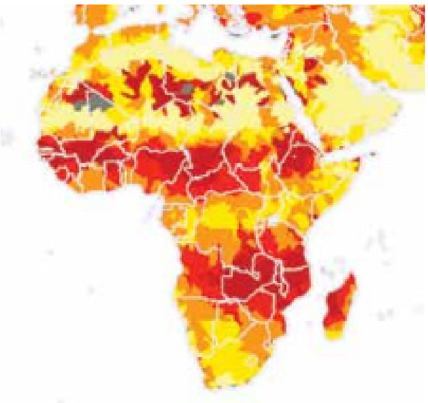
Figure 28: Drought risk maps



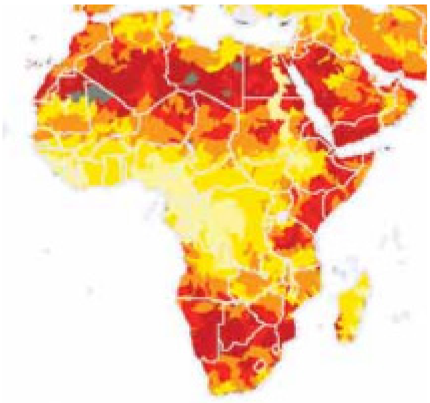
Rainfall variability. Direct indices of exposure to worsening variability of rainfall are difficult to find because climate models have only recently been reporting on rainfall variability. However, there is clear global evidence that rainfall variability will increase. Indices of water insecurity therefore provide a reasonable proxy for exposure to the widespread risks of worsening rainfall variability.

Figure 29: Rainfall variablility, seasonal variability and water risk maps

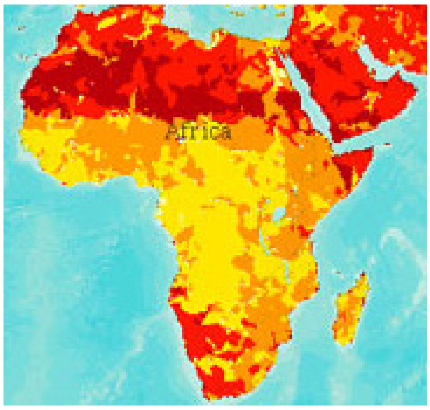
Seasonal variability
WRI AQUADUCT Water Risk Atlas



Variability between years
WRI AQUADUCT Water Risk Atlas

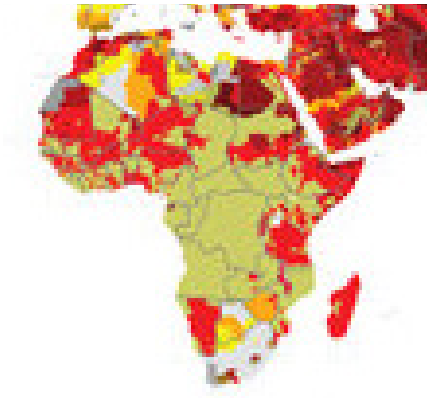


Overall water risk
WRI AQUADUCT Water Risk Atlas

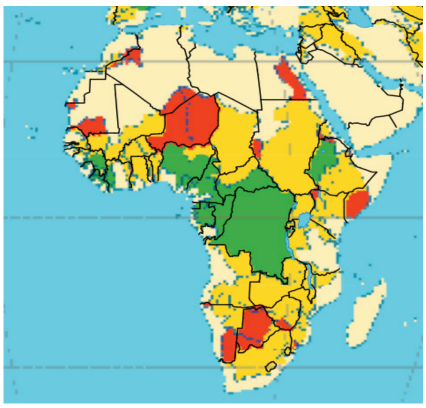


Water security risk map
(Maplecroft, 2014)

Change in water stress to 2025
(Intelligence Community, 2011)



River basin rainfall variability
(Stefano et al., 2010)



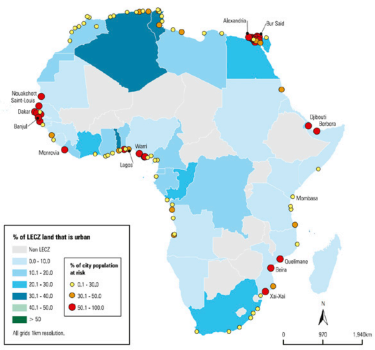
Sea level rise. The three main sources of evidence for the potential impact of sea level rise are presented in the figure below.

Figure 30: Sea level rise maps

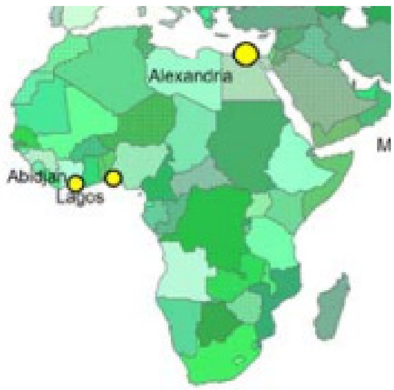
Sea level costs (DIVA Model)
(Brown et al., 2011)

ADAPTATION COSTS				
Rank	**Socio-economic Change and No Climate-induced SLR (Millions US$/year)**	**Socio-economic and Climate-induced Sea-Level Rise (SLR) (Millions US$/year)**	**Marginal Change due to Climate-induced Sea-Level alone (Millions US$/year)**	**Relative increase (With SLR/ No SLR)**
1	Nigeria (39.4)	Mozambique (191.0)	Mozambique (154.0)	Western Sahara (128.0)
2	Somalia (38.8)	Nigeria (164.1)	Guinea (126.0)	Guinea (53.5)
3	Mozambique (37.0)	Somalia (156.4)	Nigeria (124.7)	Cameroon (26.7)
4	Madagascar (33.4)	Madagascar (148.3)	Guinea-Bissau (122.4)	Namibia (21.5)
5	Egypt (27.8)	South Africa (139.8)	Somalia & South Africa (117.6)	Reunion (19.0)
6	South Africa (22.2)	Guinea-Bissau (137.3)	---	Sierra Leone (14.7)
7	Guinea-Bissau (14.9)	Guinea (128.4)	Madagascar (114.9)	Libyan Arab Jamahiriya (12.2)
8	Tunisia (13.9)	Tunisia (113.2)	Tunisia (99.3)	Gabon (12.1)
9	Kenya (10.7)	Egypt (104.7)	Gabon (91.8)	Angola (11.3)
10	Mauritania (10.0)	Gabon (100.1)	Cameroon (84.8)	Cape Verde (10.2)
Africa Total	*326.0 Millions US$ per year*	*2.23 Billions US$ per year*	*1.90 Billions US$ per year*	---

Cities most at risk
(UN-Habitat, 2010)



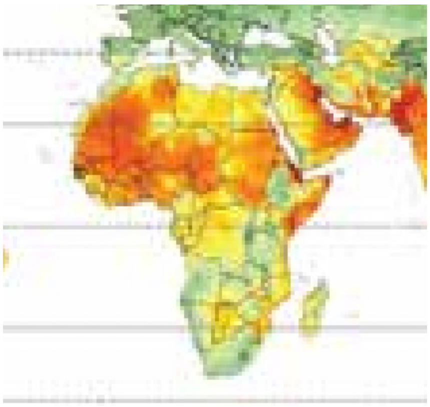
Top 20 cities (globally) at risk
(Nicholls et al., 2007)



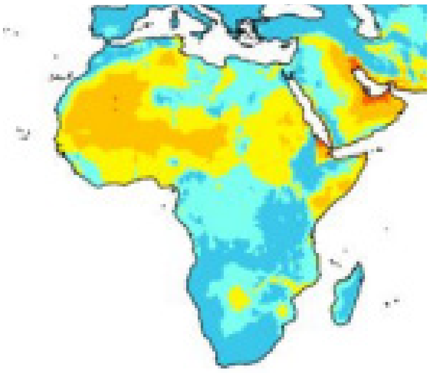
Heat stress. Recent studies have suggested that the impact of heat stress on health and labour productivity could be amongst the most serious effects arising from climate change in tropical countries.

Figure 31: Heat stress maps

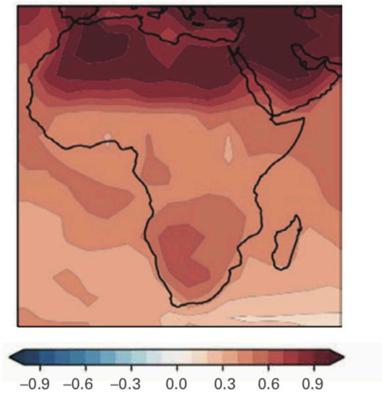
Current heat stress
(UNDP, 2016)



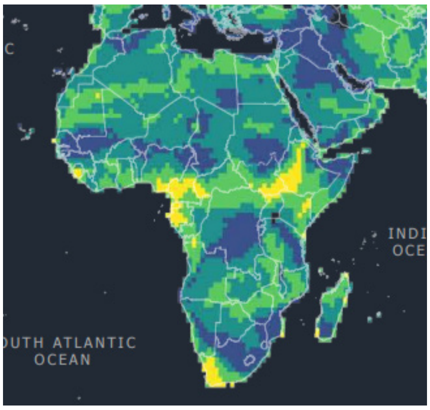
2085 hottest months
(HEIT, 2016)



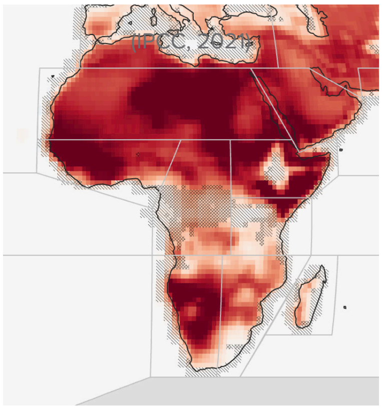
Change 1981-2010 to 2020-2024
(WMO, 2019)



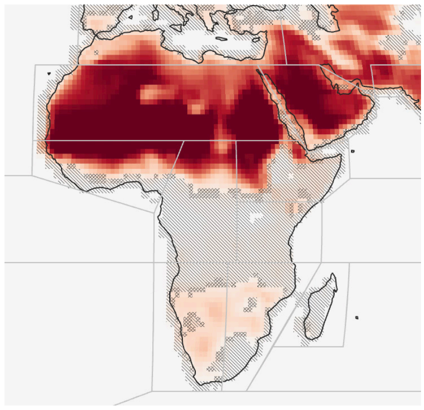
Current heatwave frequency
https://climatedataguide.ucar.edu/
referenced in (UNICEF, 2021)



Increase in days >35°C
(IPCC WGI Atlas)



Increase in days >40°C
(IPCC WGI Atlas)



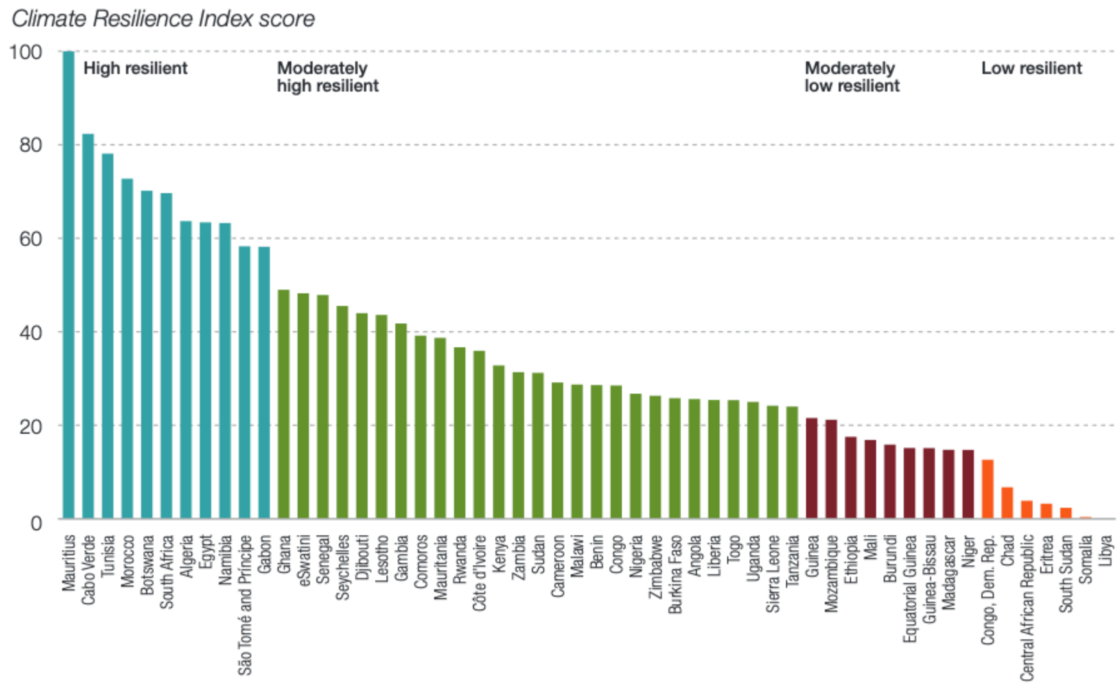
Annex 2 Comparative work on economic impact

Nordhaus and Muller review 27 studies that report on the global economic impact of climate change, mostly using Integrated Assessment Models (IAM) models (Nordhaus & Moffat, 2017). Most of them are from before 2010 and show the relatively low estimates in the older literature. None give estimates of over 3 percent loss of GDP with a rise in temperature of 2°C and the average is below one percent loss.

AfDB/UNEP/UNECA 2019 study. AfDB, UNEP and UNECA commissioned a study on 'Climate Change Impacts on Africa's Economic Growth' (AfDB, 2019b)[24]. The study used a macroeconomic model (AD-Africa), developed from RICE, one of the IAMs most frequently used for assessing adaptation needs. The model works with five African regions and the report also presents a limited number of country level results identifying those countries with the most severe economic impact. West and East Africa are most impacted by climate change, with GDP around five to eight percent lower in 2050 with a low emissions climate change scenario consistent with implementation of the Paris agreement. Economic impact increases exponentially with temperature rises[25]. The impacts in Central and Northern Africa are about half the levels in West and East Africa and impacts in Southern Africa are about three quarters of the West and East Africa levels. Whilst these levels of impact are significant[26], the report finds that they would be much worse if countries they were not following development paths with a declining share of activity dependent on agriculture and other natural resources.

Africa Economic Outlook 2022 includes a focus on climate resilience, which incorporates indicators of both exposure and sensitivity to climate change. The report uses a composite Climate Resilience Index for African countries compiled by the AfDB. The Climate Resilience Index should produce similar results to the analysis of economic impact by country.

Figure 32: Climate Resilience Index by country



Source: Africa Economic Outlook 2022 (AfDB, 2022).

24 The study was led by Climate Analytics working with eight universities, including three in Europe and five in Africa.

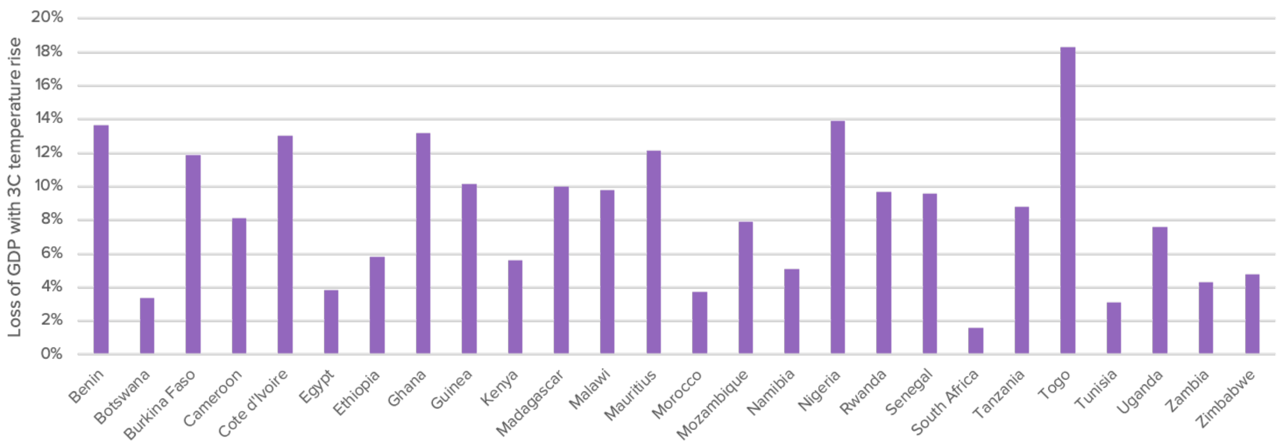
25 If temperature rises are about 30 percent higher than with the low emission scenarios, economic impact is about 50 percent higher.

26 These losses should be compared with development gains that would increase GDP by about 150 percent, assuming an average growth rate of 3 percent over 31 years.

- A **2019 stochastic macroeconomic model** estimated that the global economic impact of climate change was to reduce end-century GDP by only seven percent under high emission scenarios (Kahn et al., 2019). This result is low by recent modern estimates, but higher than older estimates. As expected, the impact in hot countries was greater than in cold countries but, surprisingly, low-income countries were less affected than high-income countries.
- UK Department of Business, Energy and Industrial Strategy (BEIS) 2021 'Social Cost of Carbon'.
- **SwissRe** modelled the economic impact of climate change by mid-century and concluded that the impact was highly sensitive to the rise in temperature. The analysis uses a dynamic macroeconomic model with six impact pathways. GDP was only 4.2 percent lower if Paris Agreement targets are met, but 18 percent lower if the temperature rise is 3.2°C (Swiss Re Institute, 2021). The economic impact on Africa was up to 50 percent higher than the global average. Country level impact is estimated but only for 48 larger economies, with only two African countries: South Africa (ranked 35) and Egypt (30).

Roson and Sartori estimated climate change damage functions, based on an analysis of multiple evidence sources for six impact pathways: sea level, agricultural productivity, heat and productivity, heat and health, energy demands and tourism flows (Roson & Sartori, 2016). The damage functions are globally applicable and generate estimates of sectoral EICC associated with changes in temperature and rainfall in relevant sectors. Their approach is similar to that taken in this paper, although their damage functions have a more complex mathematical form. The paper estimates the first order impact of a 3°C rise in temperature for 140 countries, including 26 African countries (see Figure 30). It does not seem to take into account the differential exposure of African countries to rising temperatures or the second order effects that would be picked up in a macroeconomic model (e.g. multiplier effects and trade and price responses).

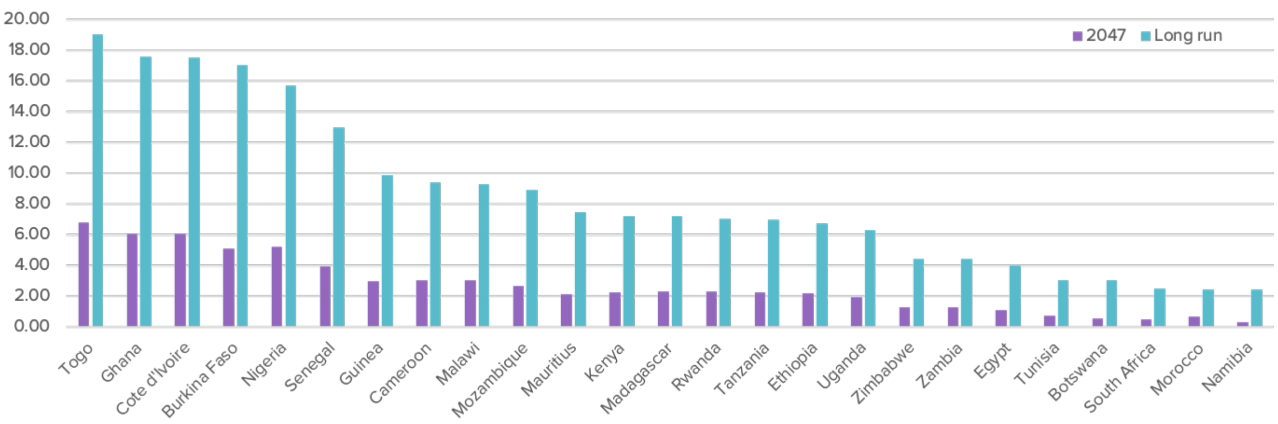
Figure 33: Impact on GDP of 3°C temperature rise



Source: Roson & Sartori, 2016.

Kompas et al. use the GTAP Computable General Equilibrium (CGE) model to estimate the economic impact of failing to adhere to the Paris targets (Kompas, Pham, & Che, 2018). Unusually for CGEs, the analysis is disaggregated to country level and includes estimates for 25 African countries (see Figure 34). Damage functions are taken from Roson and Sartori paper and both papers assume a rise of 3°C, so the difference between the results for long-run change from Kompas et al. and Rosen and Sartori reflect the net effects of the CGE modelling. The two studies produce roughly similar results, but suggest that the CGE model picks up the moderating effects of the market response, allowing prices to influence production shifts between sectors and countries.

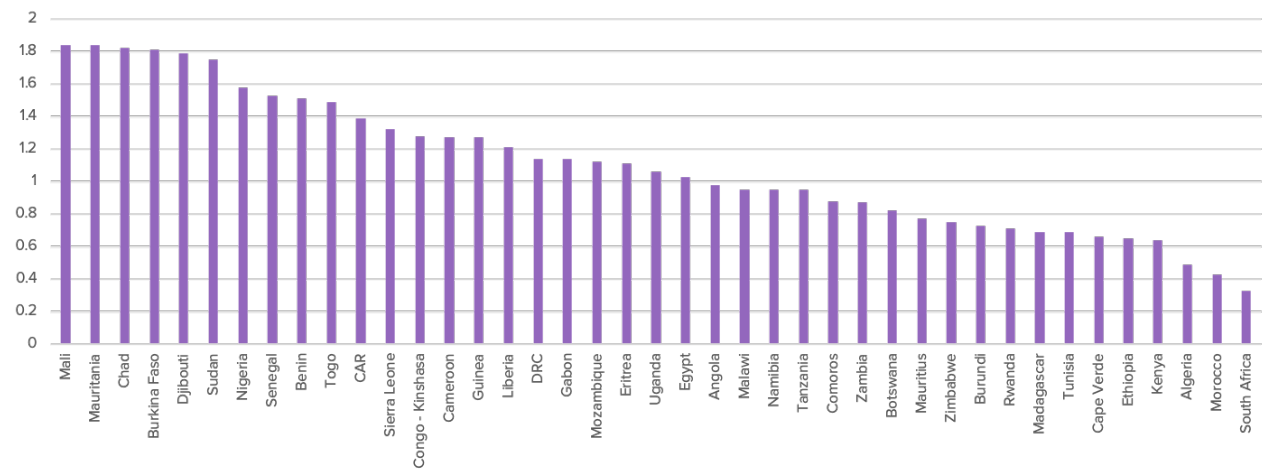
Figure 34: Loss of GDP in 2047 and in the long run for 3°C rise by 2100



Source: Kompas et al., 2018.

Pretis et al. There is increasing interest in the empirical evidence of the impact of historical climate change on economic growth. One recent empirical study suggested that a temperature increase of 2°C would lead to reductions in GDP growth rate by 2047 of up to two percent for African countries, with the highest losses in Africa and parts of South America and South Asia (Pretis, Schwarz, Tang, Haustein, & Allen, 2018). Assuming this reduction in growth occurs linearly over the period, the reduction in NPV of the GDP is up to 6.1 percent. Although this approach has the advantage of being grounded in historical data, it is has several challenges for applied country work: firstly, data for calibration is likely to be weak in most developing countries, especially if the analysis uses control variables to isolate the effect of variables other than temperature; and it can be difficult to relate it to adaptation planning because there is no identification of impact pathways or of the mechanisms by which climate change affects economic activity.

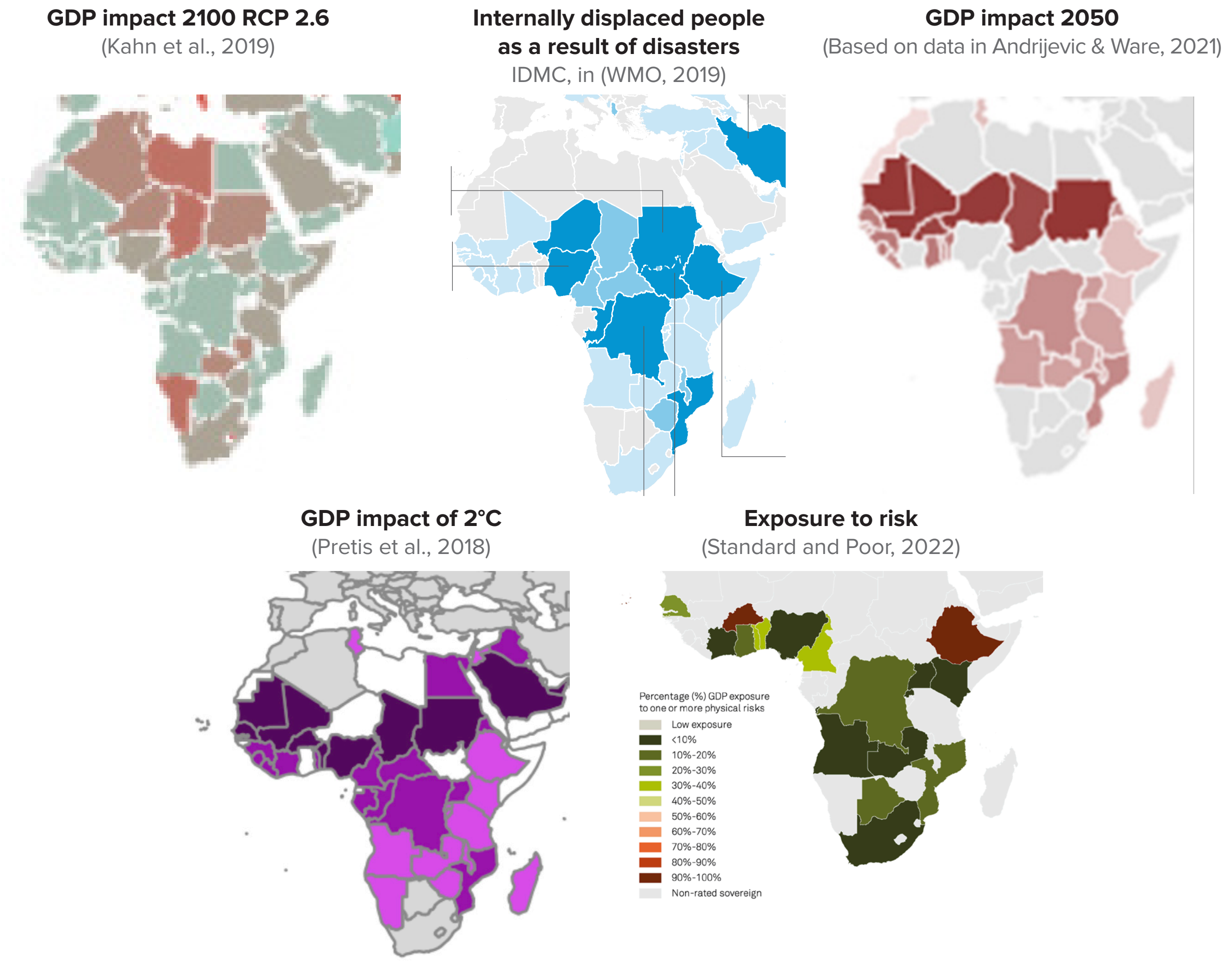
Figure 35: GDP impact of 2°C rise in temperature



Source: Pretis et al., 2018.

- **Christian Aid** produced an assessment of the potential economic impact of climate change using a simple econometric model that observed a correlation between temperature and per capita GDP (Andrijevic & Ware, 2021). The analysis concluded that developing countries are likely to lose 13.1 percent of GDP by 2050 if Paris targets are met and 19.6 percent if temperatures rise by 3°C.
- The **Grantham and Potsdam Institutes** published a policy brief drawing attention to the possibility that some climate risks may not have been fully taken into account in some modelling (DeFries et al., 2019). Whilst the criticism seems to overstate the extent to which models ignore risks, it is consistent with a general trend for estimates of the economic impact to be rising, even if Paris targets are met. This is also consistent with the steady rise in recommended values for the Social Cost of Carbon being adopted in country guidance for policy appraisal. The increase in the UK is particularly dramatic, with recommended levels that are ten times higher than frequently used only a few year ago.

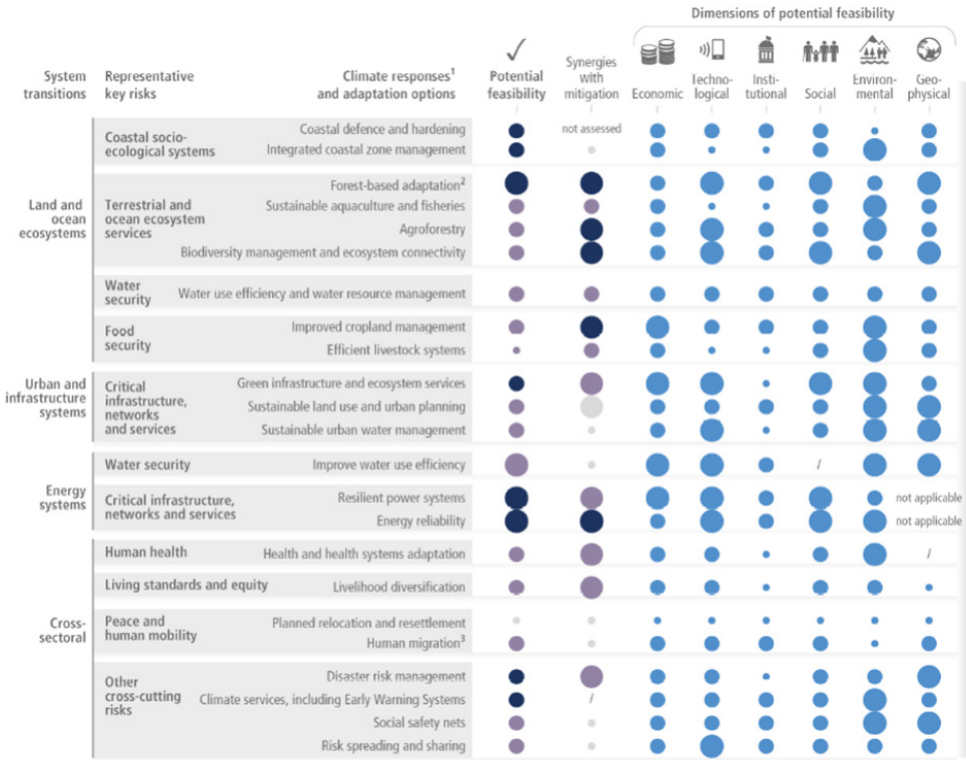
Figure 36: Maps of socio-economic impacts from climate change



Annex 3 Evidence on effectiveness

The latest draft of the **IPCC Working Group II full report** describes the multiple dimensions of adaptation effectiveness, as summarised in Figure 37. Chapter 9 of the full WGII report focuses specifically on Africa and addresses the factors that determine effectiveness.

Figure 37: The complexity of adaptation effectiveness



Source: IPCC, 2022b.

Despite the evident complexity of adaptation, strategic planning of adaptation requires measures of adaptation effectiveness that relate to the overall challenge of responding to the potential economic impact of climate change. The most commonly used economic measures are the Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Incremental Capital Output Ratio (ICOR). One of the objectives of PAAF is to establish a framework within which program specific estimates on adaptation BCRs are taken into account in the planning system. While the sector and country specific evidence base is being developed, there are several reasons why it is reasonable to use a 'placeholder' BCR value of 2.0 as a working default value:

1. It is impossible to estimate the adaptation gap without an estimate of the effectiveness of adaptation expenditure in reducing the economic impact of climate change.

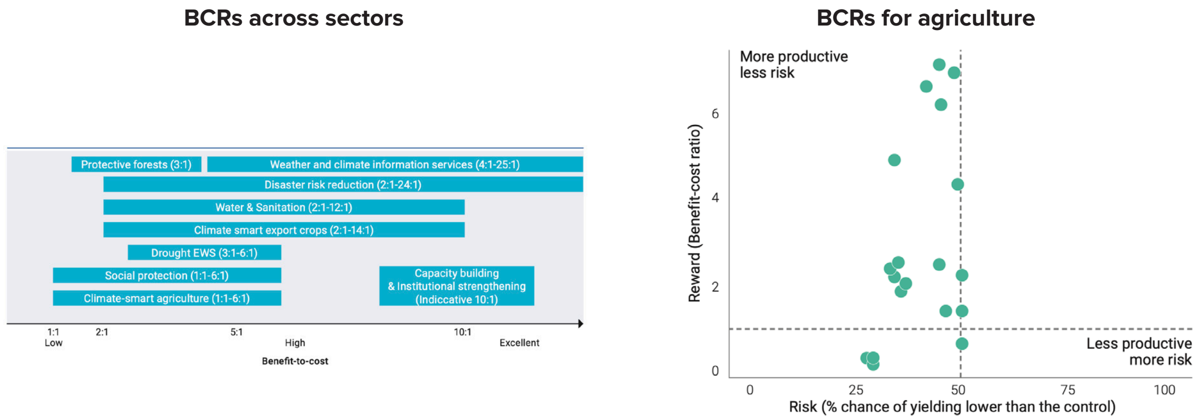
2. All planning systems incorporate some process for prioritising public expenditure which takes effectiveness into account. This process is usually complex and primarily qualitative, relying on expert opinion and political judgement, but it will also take into account any quantitative evidence. Whatever combination of evidence is used, expenditure is only approved if it is believed that it will be 'strongly positive'. Where quantitative evidence is available, the interpretation of 'strongly positive' is often linked to exceeding threshold levels (e.g. a BCR of 2.0 or an IRR of 15 percent).

3. Much of the global work on adaptation needs, as reflected in the UNEP AGRs, is based on economic models that require assumptions about the effectiveness of adaptation expenditure. These assumptions are often deep in technical annexes and are rarely presented explicitly using metrics that are used in applied planning (like BCRs or IRRs). In practice, calibration of these functions is based on a combination of literature and expert judgement. One of the formative early reviews of adaptation costs used sector and region specific functions of adaptation effectiveness in two models (RICE and WITCH) that delivered a global average BCR for adaptation expenditure of between 1.80 and 2.03 (Agrawala et al., 2011)[27].

Since 2017, a number of international reviews have been undertaken on the effectiveness of adaptation expenditure.

GCA 2021 State and Trends Report. The 2021 GCA State and Trends Report reviewed a wide range of evidence on effectiveness in the academic and grey literature. Figure 38 is taken from the report and summarises the results. A few 'soft' adaptation actions (information services and capacity building) have very high BCRs, although these benefits are presumably associated with relatively low expenditure on establishing essential standards and there may be a relatively rapid decline in BCRs as the scale of spending increases. Disaster risk reduction has a very wide range of BCRs. High BCRs are achieved for water and climate smart export crops. Agriculture, forestry, social protection and early warning have BCRs that are more typical of public expenditure.

Figure 38: Range of estimates for BCR in GCA 2021 State and Trends Report



(From Figure 4 on pg. 117)

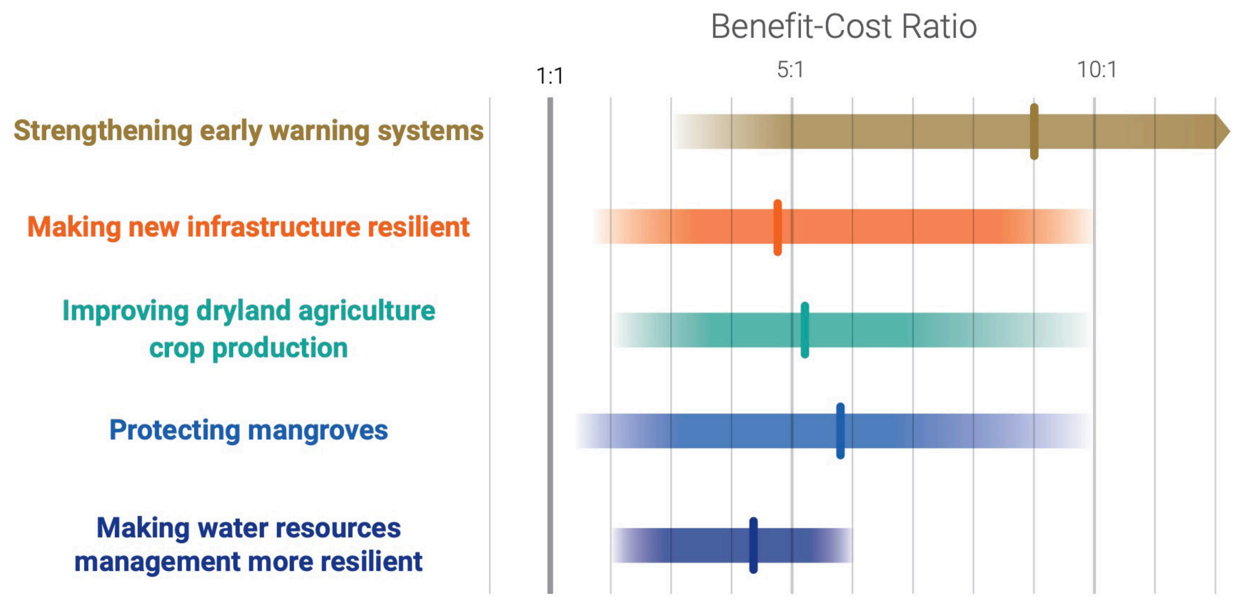
(From Figure 12 on pg. 275)

Source: GCA, 2021.

GCA 2019 Adapt Now Report. The Global Commission for Adaptation (GCA) produced an appeal for increased investment in adaptation and suggested that spending $1.8 trillion in five areas (early warning, infrastructure, dryland agriculture, mangrove protection and water) would deliver net benefits of $7.1 trillion, suggesting an average BCR of 3.9 (see Figure 35). These figures include avoided losses, economic benefits and social and environmental benefits.

27 These models typically base adaptation needs on the optimal level of adaptation spending, taking into account alternative uses of public expenditure (e.g. for development or mitigation). In order for the models to generate results, the form of the function describing the effectiveness of adaptation needs to be non-linear and show declining effectiveness with scale of expenditure.

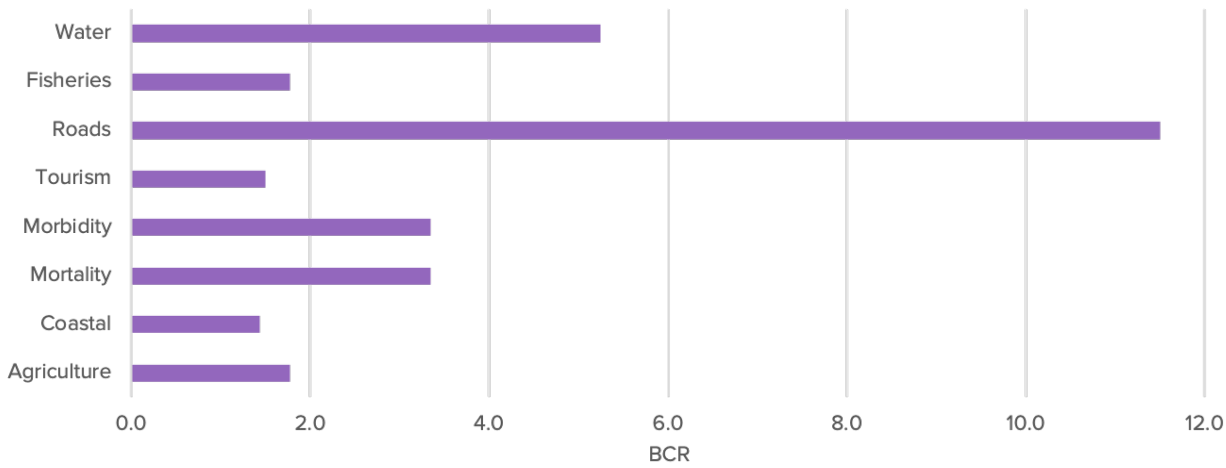
Figure 39: Illustrative BCRs for types of adaptation expenditure



Source: Global Commission for Adaptation, 2019.

AfDB/UNEP/UNECA 2019 Study. The 2019 CCIAEG study estimated the adaptation costs and benefits by sector for five African regions (AfDB, 2019b). The study used the AD-Africa IAM model which includes assumptions about effectiveness curves, which reflect how the BCRs of adaptation expenditure decline with the level of expenditure. Figure 40 shows the average BCRs for eight impact pathways. Adaptation spending on roads, water and health show high BCRs with other sectors are levels of between 1.5 and 2.0.

Figure 40: Benefit Cost Ratios (BCRs)



Source: Prepared from Figure 33 of the CCIAEG study, using visual estimation of values in the graph (AfDB, 2019).

World Bank Irrigation Performance Review. A World Bank review of the performance of investment in irrigation in sub-Saharan Africa found that, whilst there were serious and frequent problems in the early decades of World Bank investment, since 1990, lessons have been learned and performance of investments has improved dramatically (World Bank, 2008). The seven projects supported since 1990 had an average IRR of 23.5 percent, which is equivalent to a BCR of 3.8, using a discount rate of 5 percent.

Aktion Deutschland Hilft. ADH reviewed the results of CBA for 117 case studies over 20 years, covering all types of disaster (Aktion Deutshland Hilft, 2016). Of these, 39 were for flood-related disasters, which are probably the most frequent climate disasters. The mid-range results ranged from 0 to 15, with an average of about 4.1. Results for 13 case studies of DRM in coastal protection were significantly higher. Results were roughly similar for prevention and preparedness. An estimate of about five is reasonable, taking into the account the fact that results with very high BCRs are probably safest treated as outliers.

Doswald et al. study. A recent study reviewed 464 evaluation studies that assessed the effectiveness of adaptation expenditure in programs funded by the Green Climate Fund (GCF) and German Cooperation (Doswald et al., 2020). About three quarters of these (i.e. 343) included estimates of economic benefits, of which 282 were in agriculture, fisheries and forestry.

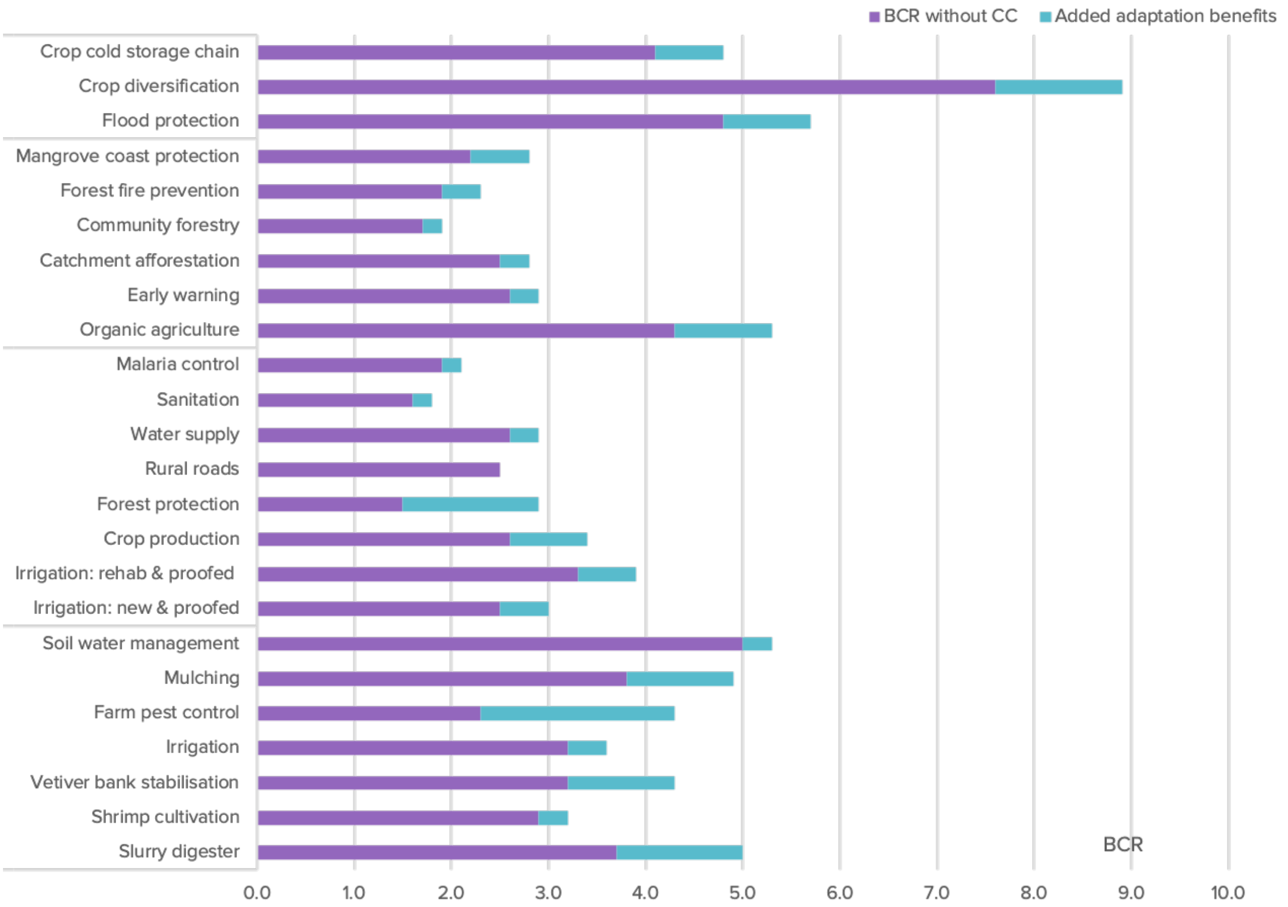
Nkonya et al Study. A 2016 study of the economics of land degradation across Africa suggested that the BCR for expenditure that protects against land degradation averages 4.2 for sub-Saharan Africa as a whole, varying from 3.9 in Southern Africa to 4.7 in West Africa (Nkonya, Johnson, Kwon, & Kato, 2016).

Shikuku et al. A case study in Nairobi county suggested the BCR of 2.8 for piped water storage system and 2.03 for rainwater harvesting systems (Shikuku et al., 2021).

CCIA. Some governments have focused on analysing the effectiveness of adaptation expenditure as part of a CPEIR or CCFF and related follow-up work using CCIA methods. This has generally focused on the extent to which benefits increase when adaptation benefits are taken into account (i.e. the ABS percent). However, four governments have done work that also includes an estimate of BCRs, both when climate change is not taken into account and when the added benefits from adapting to climate change are included. The results of this work are summarised in Figure 41. The sources are the following:

- Thailand, which was one of the five countries in the first CPEIRs and chose to focus follow-up work on analysing effectiveness using CCIA methods;
- Cambodia, which conducted a group of CCIA studies as part of it's CCFF;
- Maharashtra, India, which prepared a Climate Change State Action Plan (SAP) and then chose to focus on analysing the effectiveness of the actions; and
- Assam, India, which conducted CCIA analysis for three actions in its SAP.

Figure 41: Adaptation effectiveness BCRs from CPEIRs/CCFFs/CCIA



Sources: Maharashtra SAPFIN, Cambodia CFFF, Thailand CPEIR follow-up.

Annex 4 Comparative evidence on adaptation needs

The UNEP Adaptation Gap Reports. A comprehensive review of adaptation cost estimates was undertaken as part **UNEP's Second Adaptation Gap Report** (AGR2) in 2016 (UNEP, 2016). This estimated that global annual adaptation financing needs in all developing countries in 2050 would be between $280 billion and $500 billion, for emission pathways leading to a 2°C and 4°C rise by 2100, respectively. This was a substantial increase on the IPCC AR4 estimates of $70 billion to $100 billion as an average for the period between 2050 and 2100 (IPCC, 2014a), which were based largely on the **World Bank report** that reviewed investment costs (World Bank, 2010).

The **AGR6 in 2021** suggests that the latest evidence is that needs will be near the top of this range, even if Paris Agreement targets are met and warming is reduced to well below 2°C. For higher emission scenarios, some models estimate annual adaptation costs in 2050 at over $1,000 billion[28]. This is 2.75 percent of low and middle income GDP of $36,315 billion, which is extraordinarily similar to the 2.65 percent for Africa estimated by the PAAF. Some of the more important issues affecting these results include the extent to which they take account of the current 'adaptation deficit' (i.e. the extent to which expenditure addresses current climate challenges) and whether they consider that adaptation is limited only to economically beneficial adaptation, leaving a significant 'residual adaptation' for which it is more cost-effective to accept the impact of climate change.

The **World Bank 2019 Beyond the Gap** report reviewed climate related infrastructure needs for all developing countries in five sectors, two largely mitigation (energy, transport) and three largely adaptation (water and sanitation, flood protection and irrigation) (World Bank, 2019a). Three levels of investment were defined, ranging from low (but high efficiency) to high (lower efficiency). None of these relate directly to the PAAF concept of expenditure required to reduce all EICC, but the high expenditure scenario is the closest. This scenario involves spending in the three adaptation sectors with the highest needs, and is closest to the concept of full needs used in PAAF. The World Bank report suggested climate infrastructure needs in the three adaptation sectors of 1.85 percent of GDP annually.

28 ARG6 reports that this evidence comes partly from improvements in well-established Integrated Assessment Models (IAMs), such as DICE and PAGE, and partly from new models, including dynamic Computable General Equilibrium (CGE) models and econometric methods that take into account the cumulative impact of reduced annual GDP on investment and growth.

Annex 5 Analytical framework

Figure 42 presents a screenshot of the PAAF spreadsheet that was utilized for this analysis. It contains the following worksheets:

- **Country** extracts the key country data from the worksheet;
- **AG** is the main synthesis worksheet which draws together evidence from the other worksheets and calculates the adaptation gap;
- **Exposure** contains the international indices of climate risks for each country and calculates the weighted average exposure for flood, drought, variability and heat;
- **Sensitivity** contains sector and subsector national accounts, plus evidence on assets value for roads and power and the indices of EICC arising from sea level rise;
- **Risk** includes the maximum potential EICC for countries with exposure indices of 1.0 and the relative contribution of each climate risk to GDP loss;
- **LnD** calculates the EICC for each country, based on the evidence in the previous three worksheets;
- **BCR** presents the evidence on BCR from different sources and calculated the average subsector BCRs used in PAAF, based on this evidence;
- **Exp** contains the expenditure list, with about 2,500 line items for the 51 countries, each classified according to the standard PAAF climate subsectors;
- **OECD** presents the data for Africa, extracted from the OECD DAC database;
- **CCode** contains the standard PAAF adaptation subsectors and their associated weights;
- **GDP** contains the sectoral GDP data for each country and also includes data on investment and, hence, the estimates of ICORs;
- **Asset** contains the evidence used for estimating the value or roads and power assets;
- **ER** contains exchange rates; and
- **Factors** contains the workings for the conversion factors used in the analysis, as described in more detail in this annex.

Figure 42: Overview of the PAAF data analysis spreadsheet

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
					Adaptation Needs																			
Country	Code	LDC	FY	PL&D 2050	PL&D (NPV)	Avg BCR	Needs (%GDP)				CC expenditure in budget					Public Adapt. Benefits	Private Adapt. Benefits	Gap		GDP		AG		
bsector weight							ABS wtd	AOS wtd	Unweighted		ABS Weighted			AOS Wtd				ABS Wtd	AOS Wtd	USDbn	Uncove rable	Coverab le	Public Adaptat	Private Adapta
Subsector BCR									$m	%GDP	$m	%GDP	ABS	$m	%GDP									
Algeria	DZA		2020	11.4%	4.6%	3.0	2.2%	8.0%	11703	8.1%	328	0.23%	2.8%	1221	0.84%	0.49%	0.37%	1.3%	4.8%	145	23.2%	61.7%	10.5%	4.6
Angola	AGO	1	2020	8.2%	3.3%	2.5	1.8%	6.8%	4074	7.6%	132	0.25%	3.3%	489	0.91%	0.45%	0.14%	1.3%	4.6%	54	20.3%	64.1%	13.5%	2.0
Benin	BEN	1	2018	18.5%	7.5%	2.4	4.4%	16.4%	1109	7.8%	40	0.28%	3.6%	150	1.05%	0.48%	0.58%	3.3%	12.4%	14	26.9%	63.1%	6.5%	3.5
Botswana	BWA		2019	7.0%	2.9%	2.4	1.7%	6.1%	4441	26.6%	184	1.10%	4.1%	672	4.03%	1.88%	0.04%	0.0%	0.0%	17	17.5%	15.9%	65.9%	0.7
Burkina Faso	BFA	1	2020	17.6%	7.2%	2.1	4.8%	9.9%	1199	6.7%	16	0.09%	1.3%	33	0.18%	0.13%	0.53%	4.2%	8.6%	18	25.1%	67.6%	1.9%	5.3
Burundi	BDI	1	2019	11.5%	4.7%	2.5	2.7%	10.1%	478	18.5%	15	0.57%	3.1%	55	2.14%	0.99%	0.24%	1.4%	5.4%	3	28.0%	47.6%	22.0%	2.4
Cabo Verde	CPV		2019	8.4%	3.4%	2.1	2.2%	4.3%	265	13.4%	4	0.18%	1.4%	7	0.35%	0.28%	0.25%	1.7%	3.3%	2	21.2%	63.9%	9.0%	5.9
Cameroon	CMR		2018	17.3%	7.1%	2.2	4.5%	15.8%	2020	5.1%	51	0.13%	2.5%	179	0.45%	0.20%	0.36%	4.0%	13.8%	40	25.7%	69.2%	2.9%	2.3
Central African	CAF	1	2019	18.7%	7.6%	2.9	3.6%	14.2%	91	4.1%	6	0.27%	6.6%	24	1.07%	0.57%	0.19%	2.9%	11.3%	2	25.7%	64.6%	8.4%	1.4
Chad	TCD	1	2020	13.3%	5.4%	2.6	2.9%	11.2%	869	8.1%	26	0.25%	3.0%	101	0.94%	0.45%	0.25%	2.2%	8.5%	11	25.2%	64.0%	8.7%	2.2
Comoros	COM	1	2020	11.7%	4.8%	2.0	3.3%	11.3%	79	6.5%	6	0.51%	7.9%	21	1.75%	0.74%	0.16%	2.4%	8.2%	1	27.1%	54.9%	16.7%	1.4
Congo Democr	COD	1	2020	13.6%	5.5%	2.8	2.8%	12.6%	960	2.0%	40	0.08%	4.2%	178	0.37%	0.16%	0.10%	2.6%	11.4%	49	23.7%	72.5%	2.9%	0.8
Congo Brazzav	COG		2020	9.2%	3.7%	2.4	2.2%	7.7%	1103	10.5%	35	0.33%	3.1%	120	1.15%	0.56%	0.19%	1.5%	5.1%	10	19.3%	63.1%	15.1%	2.5
Cote d'Ivoire	CIV		2020	14.2%	5.8%	2.5	3.3%	9.7%	5380	8.8%	140	0.23%	2.6%	413	0.67%	0.40%	0.24%	2.7%	7.9%	61	25.9%	64.8%	6.9%	2.4
Djibouti	DJI	1	2013	10.2%	4.1%	2.6	2.3%	8.2%	90	4.4%	5	0.23%	5.3%	17	0.83%	0.42%	0.03%	1.8%	6.5%	2	19.5%	65.8%	14.3%	0.4
Egypt	EGY		2019	8.7%	3.5%	2.5	2.0%	8.2%	27852	9.2%	1130	0.37%	4.1%	4724	1.56%	0.67%	0.11%	1.2%	4.9%	303	23.3%	56.3%	19.0%	1.3
Equatorial Guir	GNQ		2017	10.1%	4.1%	2.0	2.9%		0		0			0	0.00%	0.00%	0.09%			12	18.1%			
Eritrea	ERI	1	2017	10.5%	4.3%	2.0	3.0%		0		0			0	######	0.00%	0.00%			0	23.7%			
Ethiopia	ETH	1	2019	11.4%	4.6%	3.2	2.0%	6.8%	5194	5.4%	318	0.33%	6.1%	1053	1.10%	0.75%	0.34%	1.0%	3.2%	96	27.6%	51.2%	16.2%	5.0
Gabon	GAB		2020	9.6%	3.9%	2.3	2.4%	9.6%	208	1.4%	19	0.13%	9.3%	77	0.50%	0.21%	0.10%	2.1%	8.3%	15	18.6%	75.0%	5.3%	1.1
Gambia	GMB	1	2019	15.3%	6.2%	2.9	3.1%	10.7%	344	19.0%	15	0.82%	4.3%	52	2.88%	1.67%	0.22%	1.2%	4.1%	2	23.3%	45.8%	28.8%	2.1
Ghana	GHA		2019	15.8%	6.4%	2.8	3.3%	10.3%	5356	7.8%	126	0.18%	2.3%	396	0.58%	0.36%	0.39%	2.5%	7.9%	68	25.7%	64.8%	5.7%	3.8
Guinea	GIN	1	2020	13.0%	5.3%	2.2	3.4%	14.8%	1288	9.1%	51	0.36%	3.9%	222	1.57%	0.56%	0.40%	2.4%	10.6%	14	25.2%	61.4%	10.7%	2.7
Guinea-Bissau	GNB	1	2020	20.2%	8.2%	2.5	4.7%	17.5%	186	13.0%	7	0.51%	3.9%	27	1.91%	0.90%	0.10%	3.6%	13.7%	1	28.1%	59.4%	11.9%	0.6
Kenya	KEN		2019	14.1%	5.8%	2.7	3.0%	9.8%	7159	7.1%	272	0.27%	3.8%	894	0.89%	0.52%	0.38%	2.1%	6.8%	100	27.4%	59.7%	9.1%	3.9

Country | AG | Exposure | Sensitivity | Risk | LnD | BCR | Exp | OECD | CCode | GDP | Asset | ER | Factors | ...

Exposure indices and sectoral EICC. Figure 43 presents the relative contribution of each exposure index to the EICC for each sector. The five specific exposure indices determine the first six subsectors and the wider industry and services impact is determined mainly by the overall vulnerability index, with some contribution from the impact of heat on labour productivity.

Figure 43: The relative contribution of exposure indices to sectoral EICC

	Crops	Live stock	Forestry	Fisheries	Energy	Water	Other industry	Services	Total
Max 2050 impact	25.0%	10.0%	5.0%	10.0%	10.0%	15.0%	2.0%	1.0%	0.5%
Exposure indices									
Overall vulnerability							70%	60%	
Flood	20%	5%		20%	20%	30%			
Drought	35%	50%	30%	30%		40%			
Variability	35%	10%	40%	40%		20%			
Heat	10%	35%	30%	10%	80%	10%	30%	40%	100%
Check	100%	100%	100%	100%	100%	100%	100%	100%	100%

Discount rate. The discount rate is used to reflect the fact that costs and benefits in the future are worth less than in the present. There is a large amount of literature on appropriate discount rates. The PAAF analysis uses five percent, which is roughly mid-way between the lower rates increasingly used to encourage more long-term policy appraisal and the higher rates typically used when funding is limited and needs to be used for the most attractive purposes.

Box 12: Conversion factors

Models of the economic impact of climate change typically report the results in terms of the reduction in the NPV of the GDP growth path over a period (typically 2050 and/or 2100). But the various sources of evidence used in reaching these estimates use a variety of different indicators and conversion factors are needed to ensure that a common approach is used.

A. **EICC in 2050 to NPV.** Evidence on the effect of climate change in reducing sectoral GDP comes in different units but the most common is the EICC that would happen if the climate change instantaneously from the current climate to a future (e.g. 2050) climate. Assuming that the EICC grows linearly between 2023 and 2050, the NPV of all EICC over the period is 6.07 times the EICC in 2050.
B. **Annual expenditure to NPV.** The analysis of adaptation spending starts with the assumption that the current level is maintained (as a percent of GDP) until 2050. The NPV of this constant spending stream is 14.9 times the level in each year.
C. **'Truncated BCR'.** The analysis of effectiveness assumes that BCRs are derived from investment in a single year, followed by a constant stream of benefits, the level of which is determined by the BCR. Some of the benefits will therefore occur after 2050, especially for adaptation spending later in the period. The NPV of the benefits up to 2050 is 0.71 times the total benefits, including those after 2050.

Box 12: Conversion factors (cont.)

D. **Asset damage to GDP loss.** The damage to assets is not a direct loss of GDP. In the PAAF analysis, the assets considered are: roads, power, urban assets and coastal assets. The impact on GDP occurs because investment that could have been used for development has to be diverted to reconstruction, which reduces economic growth. As with other evidence for EICC, the damage to assets is typically estimate comparing the level of damage in 2050, assuming an instantaneous change to the 2050 climate. Assuming that there is a linear increase to this level of damage, and that the investment diverted from development would have had an ICOR of 6.9 (i.e. the pan-African average for the last 10 years), the cumulative effect on GDP in 2050 will be 2.36 times the damage to assets in 2050. (This needs to be multiplied by Factor A to estimate the NPV of GDP loss arising from damage to assets in 2050.)
E. **Growth effect.** The gradually increasing loss of GDP reduces savings and investment which has a second-round effect on economic growth. This growth effect would be built into a CGE model, which would also consider many other second round effects, including those associated with changing prices associated with market response. The growth factor provides a simple way of recognising growth effects, without requiring complex modelling. Assuming average pan-African levels for the ICOR (6.9) and for the investment rate (21.8 percent of GDP), the growth factor increases the NPV of EICC by 34 percent.

Balance between development and adaptation. Models of the adaptation gap assume that both development and adaptation expenditure generate benefits with diminishing returns. In other words, the expenditure (both development and adaptation) starts with the programs delivering the highest returns and gradually works through all programs until any new programs give returns that are below a threshold rate. That threshold rate is based on whether society prefers a future stream of consumption generated by investment more highly that using the resources for investment for consumption now.

The benefits of development expenditure are measured in GDP growth (which may come directly from increased incomes and profits or indirectly through social and environmental development). Over the last 10 years, Africa's GDP has grown at an average annual rate of 3.1 percent and the average investment rate has been 21.8 percent of GDP, including both public and private. The ratio of investment to growth (i.e. the Incremental Capital Output Ratio or ICOR) was 6.9. Using a discount rate of five percent and assuming that this investment generates a constant stream of growth for 25 years, the average BCR was 2.1.

If Africa continues to growth at 3.1 percent, GDP will be 129 percent higher by 2050. Estimates of the economic impact of climate change on developing country vary widely, but most are in the range of 5 percent to 15 percent lower GDP in 2050. Assuming a mid-range value of 10 percent loss of GDP in 2050, climate change would reduce GDP from 2.29 times higher to 2.06 times higher and wipe out 22 percent of the gains generated by development. The models assume that the marginal returns to both development and adaptation expenditure will be the same when they are both at optimal levels. If this also applied to the average returns, then we would expect adaptation expenditure to about one tenth of development expenditure. This, in theory, Africa would shift the patterns of investment so that one tenth is used for adaptation and nine tenths is used for routine development (i.e. 2.18 percent and 19.62 percent of GDP respectively, if total investment remains at 21.8 percent of GDP).

This logic is useful in providing rough guidelines about ideal levels of adaptation expenditure, without requiring detailed modelling. It is also useful because it suggests that one option for defining development and adaptation expenditure is on the basis of the relative importance of the contribution of the expenditure to economic growth (i.e. development) and reduced EICC (i.e. adaptation).

Market moderation. In an open economy, markets will respond to climate shocks by adjusting prices and moderating the initial shock. More sophisticated models, including CGEs, take this into account and the moderation typically reduces the initial shock by a quarter to a third. More work is required to establish whether it would be realistic to apply a simple adjustment factor, where sophisticated models are not feasible, because of a shortage of data, skills, time or funds.

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