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SPARC
Supporting Pastoralism and Agriculture in Recurrent and Protracted Crises

TECHNICAL REPORT

BEARING THE BURDEN

Climate change-attributable losses and damages in the Sahel and Greater Horn of Africa

Florence Pichon, Lena Nur, Vikrant Panwar, Emily Wilkinson, Sita Koné, Sarah Opitz-Stapleton

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About SPARC

Climate change, armed conflict, environmental fragility and weak governance, and the impact these have on natural resource-based livelihoods, are among the key drivers of both crisis and poverty for communities in some of the world's most vulnerable and conflict-affected countries.

SPARC aims to generate evidence and address knowledge gaps to build the resilience of millions of pastoralists, agro-pastoralists and farmers in these communities in sub-Saharan Africa and the Middle East.

We strive to create impact by using research and evidence to develop knowledge that improves how the FCDO, donors, non-governmental organisations, local and national governments, and civil society can empower these communities in the context of climate change.

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ACRONYMS

EEA	extreme event attribution
FAO	Food and Agriculture Organization of the United Nations
FAR	fraction of attributable risk
GDP	gross domestic product
IPCC	Intergovernmental Panel on Climate Change
LDC	least developed country
LIC	low-income country
LMIC	lower-middle-income country
PDNA	post-disaster needs assessment
SGHA	Sahel and Greater Horn of Africa
SLOL	statistical loss of life
SPARC	Supporting Pastoralism and Agriculture in Recurrent and Protracted Crises
UNFCCC	United Nations Framework Convention on Climate Change
VSL	value of statistical life

GLOSSARY

Extreme event attribution: This refers to climate studies to determine if anthropogenic climate change played an attributable role in the intensity and/or frequency, and by how much, of a weather extreme, slow-onset event or groups of events. Ability to robustly detect climate change attribution depends on certain elements, such as having a long-term (ideally 50+ years) record of historical observations.

Extreme weather event: For simplicity, and in alignment with United Nations Framework Convention on Climate Change (UNFCCC) terminology, we are using 'extreme weather event' as a catch-all to refer to both extreme weather and climate events in this report. Extreme weather event refers to a short-duration (hours to weeks) event that is statistically rare for a particular area. It includes heatwaves, abnormal cold snaps and heavy rainfall. Floods may be triggered by unusually heavy rain, storms or glacial lake outbursts. They are not extreme weather events per se but secondary hazards. Extreme climate events are extremes with durations of months or longer, such as meteorological droughts.

Many extreme weather and climate events are still within the range of natural variability. But globally, strong evidence is emerging that the probability and intensity of extremes are increasing because of climate change. It is important to note that losses and damages might occur even if an event is not extreme, as measured statistically. When significant losses and damages are triggered by a low-intensity event, this is an indication of high human-caused vulnerability and exposure.

Direct damage/loss: This is the monetary value of a partially or completely destroyed physical asset, assuming the destroyed asset will be replaced in pre-disaster conditions (in quantity and quality). This damage is usually quantifiable in economic terms and includes damage to buildings, infrastructure and natural resources. However, there can be many losses that are direct but difficult to quantify. For example, in the case of the destruction of a culturally significant site, assigning monetary value for its replacement cannot account for the social and cultural significance lost for a community.

Disaster: This is serious disruption of the functioning of a community or a society at any scale due to hazardous events (such as extreme weather events). It in turn interacts with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts. A disaster can be thought of as the collection of serious negative impacts that occur during and after an event; it is not the climate extreme or slow-onset event.

Economic loss and damage refers to the negative impacts (disasters) triggered by weather extremes or slow-onset events that can be quantified, such as direct loss of livelihoods, agricultural production, assets, or infrastructure and financial costs of these.

Indirect loss refers to the secondary effect of direct damage that arises from the disruption in the flow of goods and services until the destroyed assets are rebuilt, i.e. until the post-disaster recovery period. Indirect losses can also be quantifiable or non-quantifiable, or difficult to quantify.

Loss and damage: There is no agreed, official definition of loss and damage. Broadly, loss and damage (uncapitalised) refers to the harms triggered by specific extreme weather events or slow-onset processes. Loss and Damage (capitalised) usually refers to the political debate and mechanisms under the UNFCCC which aim to address loss and damage that is associated with the impacts of climate change that cannot be avoided through adaptation. This report assesses losses and damages to inform the ongoing discussion on Loss and Damage funding arrangements.

Non-economic loss and damage refers to the climate change-attributable losses that are not expressed in financial terms or traded on markets, such as loss of health, loss of heritage, loss of traditional ways of living and loss of identity, psychological and emotional distress, and loss of biodiversity.

Slow-onset event or process refers to the long-term changes either directly associated with climate change (increasing day and night temperatures or shifting precipitation patterns in seasons, sea-level rise, ocean acidification and glacial retreat); or indirectly (desertification, loss of biodiversity, land and forest degradation, and salinisation of coastal water and soils). Indirect slow-onset processes are also strongly influenced by other human activities such as overdraft of coast groundwater or deforestation. Climate change may only be an exacerbating influence on top of these other activities.

Statistical loss of life, or attributable statistical loss of life (SLOL), is calculated by multiplying value of statistical life (see definition below) estimates with total attributable deaths. Thus, the total attributable loss and damage is a sum of attributable SLOL and economic damages. Agriculture loss and damage estimates do not include SLOL, as they are only linked with economic damage estimates reported in the EM-DAT database.

Value of statistical life is used by Newman and Noy (2023) as the basis to assess the economic cost of human mortality. They use a value of statistical life (VSL) of $7.0837 million per life lost, which is an average of VSL estimates used by governments in the United States ($11.6 million) and the United Kingdom (£2 million). To maintain equity and enable comparison, this study also uses the same VSL value for all countries in the Sahel and Greater Horn of Africa region and all other countries regardless of time and place of demise.

Sources: IPCC (2021; 2022); NAS (2016); Panwar, Wilkinson and Nur (2023); Panwar et al. (2023)

EXECUTIVE SUMMARY

This study assesses the current and potential future loss and damage that is attributable to climate change in the Sahel and Greater Horn of Africa (SGHA), with a specific focus on the agriculture and livestock sectors.

First, this study presents original analysis of the **climate-attributable direct human and economic loss and damage** related to floods and droughts in the SGHA (see Figure 1). It finds that:

- Between 2000 and 2022, climate change contributed to 39% of the total 32,000 recorded human deaths associated with droughts and floods and affected nearly 149 million people through droughts and floods. Most of these impacts were linked to droughts. A peak in climate-attributable deaths occurred in 2010 during Somalia's severe drought, causing 20,000 deaths, of which about half were linked to climate change. Gender-disaggregated data is lacking, however, so it is unclear what the relative impacts were on men and women.

- Climate-attributable human losses in SGHA countries are two to three times higher than in other countries with similar income levels.

- Climate-attributable economic impacts were also significant, representing more than 2% of gross domestic product (GDP) annually in 9 out of 18 SGHA countries over the 22-year period. The agriculture sector suffered severe impacts, with $500 million per year in livestock and crop losses attributable to climate change.

- In the future, climate-attributable loss and damage from floods and droughts collectively could be $159.4 billion under a 2°C warming scenario.

These figures underestimate the true scale of loss and damage, as they omit indirect losses and losses related to slow-onset processes, which cannot be assessed using the same methodology. The study then draws on the literature to review indirect losses, and finds that:

- **Slow-onset processes** related to climate change have significant negative impacts on food production in SGHA countries, with yields for major food crops such as sorghum, maize, rice or wheat declining across the region. Changes in temperature and precipitation may increase the future likelihood of plant pests, which in turn impact crop yields and pasture availability. They may contribute to a rise in the prevalence of desert locusts, past outbreaks of which have resulted in estimated costs of $8.5 billion in East Africa and Yemen in 2020 and $2.5 billion in harvest losses alone in the Sahel in 2003—2005. This illustrates the potential consequences if such events were to become more likely due to climate change.

- In the SGHA region, people are already experiencing broad **non-economic loss and damage**, covering loss of physical and mental health, livelihoods, traditional knowledge, home and cultural identity, among others. Between 2011 and 2022, climate-related temperature extremes were responsible for an additional 12,000—19,000 deaths of children per year across sub-Saharan Africa. In the Sahel, up to 32 million people could be displaced within their own countries due to climate change by 2050, in the absence of any adaptation or resilience-building measures. Extreme weather events are one factor exacerbating the ability of pastoralists in SGHA to migrate seasonally; in the Greater Horn of Africa, the sheer difficulty of maintaining livelihoods for farmers in the face of climate variability is placing traditional social safety nets under severe strain; while in West Africa, accumulated years of drought are tied to a decrease in economic activity, which is correlated with higher rates of extremist violence and conflict. Mental health impacts of extreme weather events are understudied, although some literature points to significant emotional distress experienced by agro-pastoralists facing severe drought events.

The report's findings stretch further than the SGHA region. They should contribute to our understanding of how to measure the impacts of climate-attributable loss and damage in data-poor countries, many of which are also affected by fragility and conflict, and where vulnerabilities to extreme weather events and slow-onset processes are amplified by displacement, insecurity, poverty and low investment in basic services.

Recommendations

On the basis of these findings, this study puts forward the following recommendations. We hope they will help the members of the Loss and Damage Fund Board, loss and damage negotiators from SGHA countries, and the entities supporting loss and damage finance mechanisms in their efforts to establish the details of the Fund.

1. Speed up the establishment of the Loss and Damage Fund, resource it adequately and ensure access for vulnerable countries in the SGHA region.

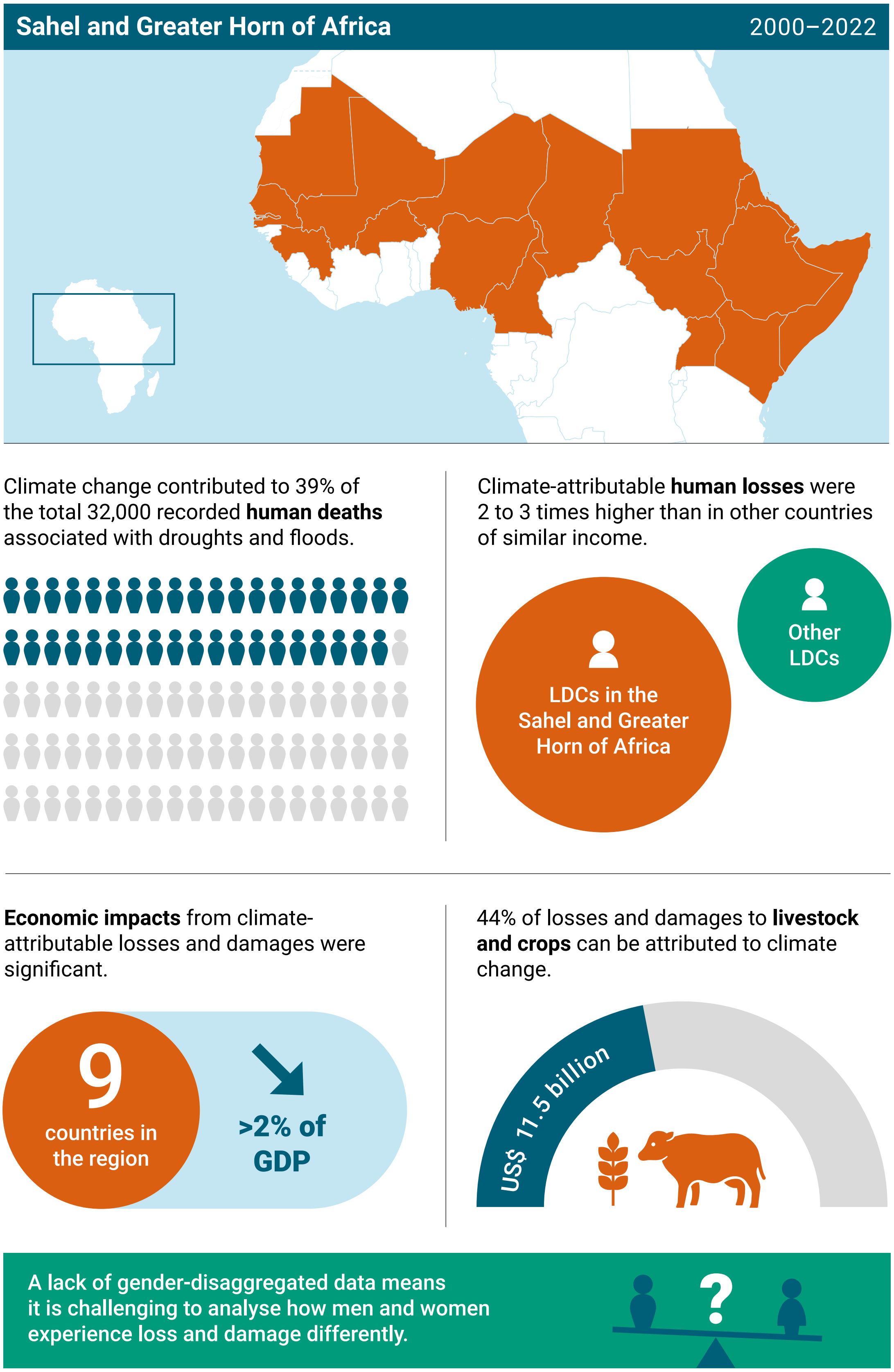
2. Increase adaptation and anticipatory humanitarian finance to complement loss and damage finance. This is to avert and minimise the disproportionately high human cost of climate change in the SGHA region.

3. Invest in more comprehensive loss and damage data collection in fragile and conflict-affected states.

4. Expand beyond the standard data collection and assessment methodologies to better quantify indirect, non-economic and slow-onset loss and damage.

5. Prioritise understanding how loss and damage affects women, children, elderly people and marginalised groups to determine the true distribution of costs, and design targeted measures to address them.

FIGURE 1: HUMAN AND ECONOMIC LOSSES AND DAMAGES IN THE SAHEL AND GREATER HORN OF AFRICA AT A GLANCE, 2000—2022



Source: Authors' own, based on EM-DAT (n.d.)

1. INTRODUCTION

A good understanding of loss and damage is essential to helping least developed countries (LDCs) secure the support they need to address the adverse impacts of climate change, and in particular, the extent to which loss and damage can be attributed to climate change. This will ultimately help ensure climate finance under international frameworks can be allocated equitably.

This study assesses the current and potential future losses and damages that are attributable to climate change in the Sahel and Greater Horn of Africa (SGHA), with a specific focus on the agriculture and livestock sectors. These sectors are major economic pillars for countries in both regions (Box 1).

BOX 1: AGRICULTURE AND LIVESTOCK IN THE SAHEL AND GREATER HORN OF AFRICA

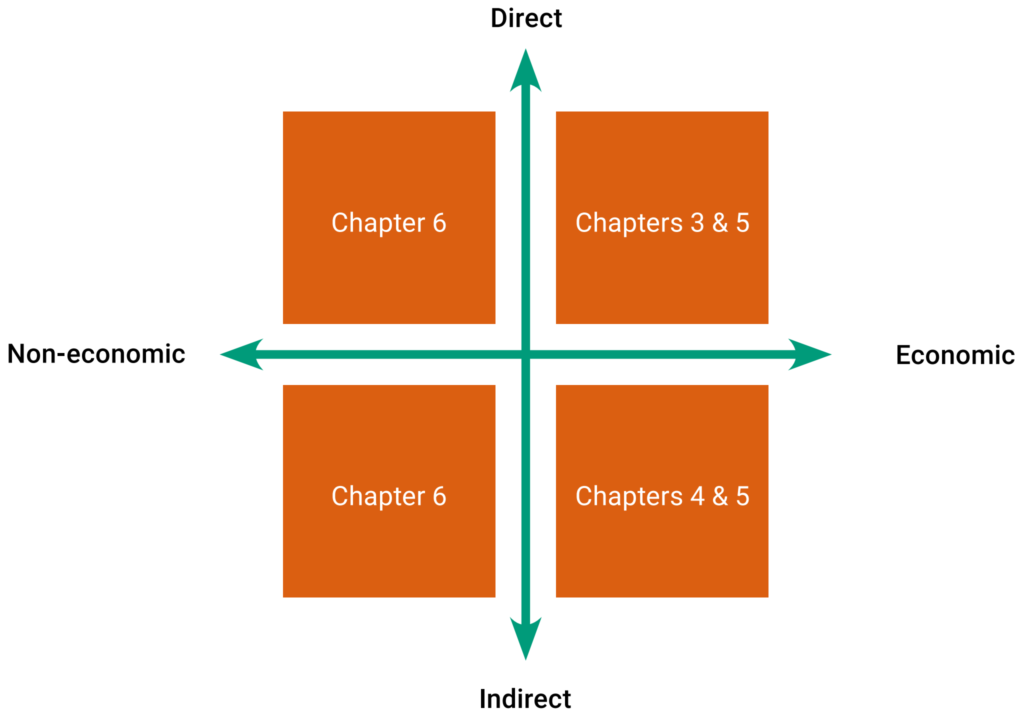
In the Sahel, over half of total employment is in agriculture and livestock herding. This contributes between 10% and 15% of the gross domestic product (GDP) in Burkina Faso, Chad, Mali and Niger (World Bank, 2022). Similarly, in many countries in the Greater Horn of Africa, one third or more of the total employed population is estimated to work in agriculture. This includes Eritrea, Ethiopia, Kenya, South Sudan, Sudan and Uganda (see Supplementary Annex). Despite rapid urbanisation, especially in East Africa, the sector still employs large shares of the population (USAID, 2020). Agriculture across both regions is largely rainfed. In Senegal, for example, more than 70% of all agricultural production was rainfed as of 2017 (USAID, 2017a). This illustrates these regions' particular vulnerability to increasing temperatures and more variable precipitation (USAID, 2017b; 2020).

It is important to note that the impacts of climate change are not distributed evenly, and in the SGHA, countries and people are at high risk of experiencing loss and damage even for lower-intensity climate-related events. This is because people's vulnerability to climate impacts is determined by poverty, social marginalisation, lack of access to basic services, conflict and political instability.

Losses and damages from extreme weather events and slow-onset processes manifest in a variety of ways. This can include everything from intensely personal losses, such as death of a loved one or loss of livelihood, to broad societal losses, such as declines in GDP or the gradual erosion of traditions and culture.

To make sense of this diversity, our study uses the framework described in Figure 2 to understand and categorise loss and damage in a more digestible manner. This typology situates different kinds of loss and damage along two axes. The first, economic and non-economic, is among the most common in the loss and damage literature and climate negotiations. Losses are then further subdivided along a second axis of direct and indirect losses and damages (Figure 2).

FIGURE 2: ECONOMIC, NON-ECONOMIC, DIRECT AND INDIRECT LOSS AND DAMAGE IN THIS REPORT



Source: Adapted from UNDRR (www.preventionweb.net/understanding-disaster-risk/key-concepts/direct-indirect-losses)

The study covers the following countries across the SGHA regions: Burkina Faso, Cameroon, Chad, Djibouti, Eritrea, Ethiopia, the Gambia, Guinea, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Somalia, South Sudan, Sudan and Uganda. Accompanying this analysis are two country studies, Burkina Faso and Somalia, which offer a deeper dive into each country's loss and damage and policy landscape.

The report presents information on climate change-attributable losses and damages from **new preliminary estimations** of direct loss and damage from extreme weather events (Chapter 3); and **synthesises existing literature** on indirect economic loss and damage from extreme events (Chapter 4), loss and damage from slow-onset processes (Chapter 5) and non-economic loss and damage (Chapter 6).

2. METHODOLOGY

This report follows Newman and Noy (2023) and Panwar et al. (2023) in using information from extreme event attribution (EEA) studies to estimate the plausible climate change-attributable direct economic loss and damage triggered by extreme weather events in the SGHA region that are presented in Chapter 3.

A probabilistic indicator called the 'fraction of attributable risk' (FAR) is often calculated in EEA studies. The FAR represents the ratio of the probability of the climate extreme occurring with and without climate change. A FAR value of '1' means that the climate extreme would have been highly improbable without climate change, whereas a value of '0' indicates that climate change likely did not affect the probability of that event (Jézéquel et al., 2018; Newman and Noy, 2023; Panwar et al., 2023).

The FAR estimates in this report are derived from a meta-analysis of attribution studies over the period 2000—2022 for different event types and across different regions of the world (drawing on Newman and Noy, 2023 and Panwar et al., 2023; see Supplementary Annex for more details on data and attribution studies). For the SGHA region, we focus on floods and droughts because of their relative impact (in comparison to, say, storms) and due to limited to no availability of socioeconomic cost data on other event types.

FAR estimates are then multiplied with total socioeconomic costs from the historical extreme weather events with a degree of climate change attribution. This quantifies the plausible share of loss and damage linked with climate change. This socioeconomic cost data on human and economic losses is extracted from the EM-DAT database (EM-DAT, n.d.). Agriculture loss and damage figures are estimated from the total economic damage records of EM-DAT. The extrapolation of agriculture losses and damages is based on the average share of the agriculture sector in total economic losses and damages reported across the post-disaster needs assessment (PDNA) studies/surveys conducted between 2008 and 2024 in the SGHA region.

This preliminary estimation is necessary, as EM-DAT does not specify impact by economic sector, and a global or regional database on agriculture loss and damage triggered by extreme weather events is not available.[1] Furthermore, countries in the SGHA region do not have consolidated datasets (at national level) on agriculture losses due to such events.

1 The Food and Agriculture Organization (FAO) estimates 'potential' crop and livestock production losses due to disasters. However, these estimates are not publicly available other than the overview presented in FAO's flagship reports published at infrequent intervals (see FAO, 2023).

2.1 Estimating future climate-attributable risks related to extreme climate events: approach, considerations and limitations

Section 3 of the report looks at climate change-attributable direct losses and damages from extreme weather events.

The projections of the increased frequency of floods and droughts are derived from meta-analyses presented in the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC, 2021). For the purposes of the FAR analysis, we are assuming that the area-average, median probability of the 1-in-50-year, 1-day extreme rainfall event across the entire region could increase by 7% (1.5°C) and 8.3% (2°C). While recognising that there is not a direct relationship between heavy precipitation and some types of flooding, and that adaptation measures might be put in place, we are using a one-to-one FAR value in this study for the sake of clarity.

Calculating changes in drought probabilities is also challenging. The authors assumed greatest impacts for agriculture and livestock to be 20% (1.5°C) and 25% (2°C). These probabilities are in fact for southern Africa and not the SGHA region but are being used here because of the absence of drought probability estimates for the study region. Based on these assumptions, a new FAR value is calculated for floods and droughts using two different warming scenarios from the Coupled Model Intercomparison Project Phase 6 (CMIP6) model set: a 1.5°C warming and a 2°C warming. The projected climate-attributable loss and damage is thus a product of linearly extrapolated projected FARs and the average annual total economic losses[2] (including damages and statistical loss of life (SLOL)) between 2000 and 2022.

2.2 Caveats

There are some important caveats to this study. In the FAR analysis on losses and damages presented in this report, phrases such as 'climate-attributable deaths' and 'climate change-attributable economic losses and damages' do not imply that climate change was solely responsible for those impacts, only that it influenced the probability of occurrence of the flood or drought event that triggered such impacts.

By extension, a proportion of the losses and damages are attributable to climate change. As noted in reports by the IPCC, the climate risks (the negative impacts that might occur) and the climate impacts (the negative disaster impacts that actually occurred) are not just due to the climate hazard. Impacts and risks also significantly depend on human-mediated vulnerability and exposure, as well as responses to manage climate risks that may inadvertently create additional risks (IPCC, 2022).

Having a high degree of confidence that climate change contributed to the increased likelihood or intensity of a specific hazard event requires sufficiently long, historical observation sets. Weather station coverage is sparse across many parts of Africa and has decreased since the 1980s. This makes it difficult to develop FARs for individual events. Furthermore, there are

2 Average annual total economic loss and damage in 2000–2022 for floods is $4.4 billion and for droughts is $8.1 billion.

comparatively fewer attribution studies conducted for Africa than for other parts of the world. It is likely that FARs are higher in SGHA, particularly for heatwaves and droughts, than we are able to estimate from the scarce literature.

The report focuses on one economic sector and uses existing aggregate datasets. These aggregate datasets disguise social differentiation within the aggregation, for example how losses and damages within a sector differ on the basis of gender, age, disability and other social identifiers. Despite global commitments through the Sendai Framework for Disaster Risk Reduction to collecting sex-, age- and disability-disaggregated data, progress towards this is still inadequate (UNDRR, 2022).

For reasons of comparability and equity, this study follows Newman and Noy (2023) and Panwar et al. (2023) in using the value of $7 million per life no matter where or when those lives were lost. SLOL values are highly context dependent (Keller et al., 2021), so estimates of loss and damages in specific contexts should be treated with caution.

The Supplementary Annex describes data and methodology used in this analysis and discusses their limitations in more detail.

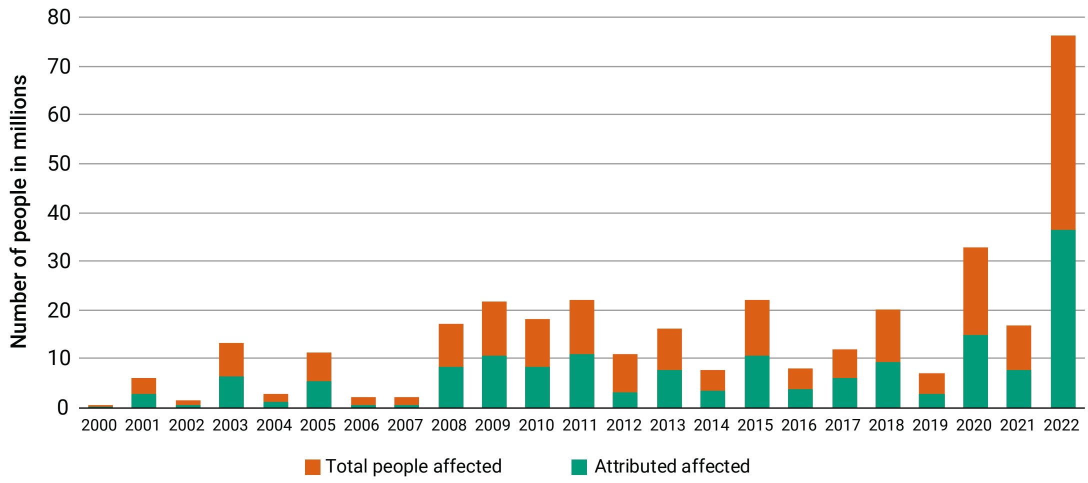
3. CLIMATE CHANGE-ATTRIBUTABLE DIRECT LOSSES AND DAMAGES FROM EXTREME WEATHER EVENTS

3.1 Climate change-attributable human losses

Climate change-attributable human losses can be divided into deaths and numbers affected. Between 2000 and 2022, over 32,000 deaths were recorded and associated with droughts and floods across the 18 countries in the SGHA region that were selected for the analysis. Of these, climate change could have played a role in nearly 40% (about 12,600) of the total human deaths.[3] Droughts and floods with an attributable climate change influence affected[4] nearly 149 million people during the same period. The majority of attributable human deaths (84% of total attributable) and people affected (93% of total attributable) were associated with drought events.

On average, 587 human deaths were linked with climate-attributable extreme events annually between 2000 and 2022. Droughts accounted for 84% of the deaths, while floods accounted for 16%. (Please see Figure 3 for a detailed look at the annual distribution of people affected by climate change-attributable human losses in the SGHA region.)

FIGURE 3: ANNUAL DISTRIBUTION OF PEOPLE AFFECTED BY CLIMATE CHANGE-ATTRIBUTABLE HUMAN LOSSES IN THE SAHEL AND GREATER HORN OF AFRICA REGION, 2000–2022



Note: Analysis is based on EM-DAT disaster damage records, using global average FARs.

Source: Authors' own, based on EM-DAT (n.d.).

3 These are 'direct' loss and damage estimates based on regional FARs for droughts (46%) and global FARs for floods (23%). Using the global FAR average for droughts (50%) increases the estimates to 13,506 attributable human deaths. See the Supplementary Annex for further details on the methods of obtaining FARs by event type and region.

4 In the EM-DAT database, 'people affected' includes people who were injured, displaced or otherwise affected by disasters.

Extreme weather events with a possible attributable climate change signal are estimated to have impacted 7 million people annually across SGHA, equivalent to 25% of the average annual population of the selected 18 countries in the region during the period 2000—2022. For a country-specific example, please see Box 2.

BOX 2: COUNTRY-SPECIFIC LOSSES AND DAMAGES

A peak in climate-attributable human deaths was observed in 2010 during the severe drought in Somalia that caused 20,000 human deaths, as per the EM-DAT database. More than 250,000 deaths were caused by the famine to which the drought contributed.[5] Of these, about 10,000 could be attributable to climate change.[6] Excluding Somalia from the low-income SGHA group changes the results, making levels of attributable deaths in low-income SGHA countries similar to non-SGHA low-income countries. Similarly, for the LDCs excluding Somalia, the proportion of climate-attributable deaths – one per 1 million people – is similar to non-SGHA LDCs. In both SGHA low-income countries (LICs) and LDCs, climate-attributable numbers of affected people remain higher than in non-SGHAs, even when Somalia is excluded from the group.

The majority of climate-attributable human deaths in SGHA are in the Greater Horn of Africa region, largely due to the drought in Somalia, and the country's acute level of vulnerability, fragility and decades of instability. Similarly, Nigeria experienced 58% of total climate-attributable deaths in the Sahel region, mainly concentrated in its north-eastern and north-western states. These areas face ongoing insecurity, violent conflict and large numbers of internally displaced persons – vulnerability factors that leave populations less able to cope with extreme weather events. In 2022, climate-attributable drought in Uganda and flood in Nigeria accounted for around 1,200 and 150 deaths, respectively.

The number of affected people peaked in 2022, largely due to climate change-attributable severe drought events in Ethiopia (12 million attributable affected) and Sudan (6 million affected), and climate change-attributable heavy rainfall triggering flooding across West Africa, with Nigeria most affected (9.6 million people affected).

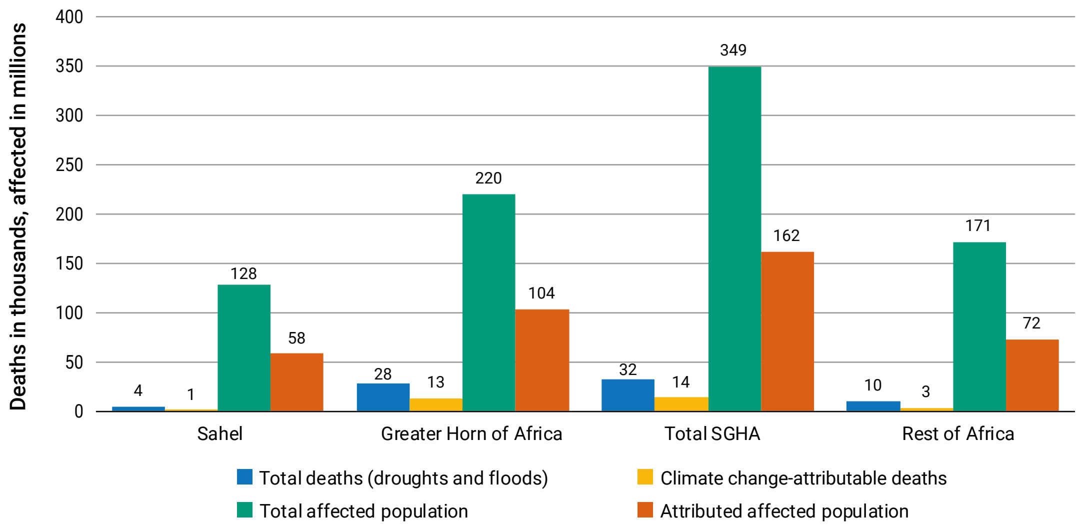
In terms of agricultural loss and damage, collectively, Ethiopia, Kenya, Nigeria, Somalia and Uganda account for about 95% of the agriculture loss and damage in the SGHA region. Likewise, the livestock and crop losses are also higher in these countries, accounting for more than 90% of total livestock and crop loss and damage. Four of these five countries are in the Greater Horn of Africa, which collectively accounts for 87% of the attributable agriculture losses across the SGHA region.

5 Following two consecutive failed rainy seasons across East Africa during 2010—2011, Somalia suffered particularly high mortality (approximately 250,000 deaths, significantly higher than EM-DAT records). This was due to famine arising from the combined interaction of political instability, difficulties in securing and distributing humanitarian aid because of and in response to the ensuing insecurity, border closures and the drought (Slim, 2012). While the other countries experienced high rates of food insecurity and malnutrition, only Somalia officially experienced famine (ibid.).

6 The climate science literature is unclear as to whether the two failed rainy seasons have an attributable climate change influence. EEA studies indicate that the first failed season (the short rains from October to December 2010) was caused by a La Niña event without a climate change signal. The failed long rainy season (roughly April to July 2010 in Somalia, similar months across the Horn of Africa) could possibly have been made drier because of climate change. But confidence in the EEAs is not high due to lack of observation data (Lott et al., 2013; Otto et al., 2018). The persistent, strong La Niña event appears primarily responsible for the delayed onset and failure of the long rains as well (Gebremeskel et al., 2019). It is very clear, however, that political instability and fragility played the most significant roles in driving the famine and contributing to the deaths.

Overall, the SGHA region experienced 4.7 times more human deaths that can be attributable to climate change, and 2.3 times more people were affected, compared with all other countries in the Africa region combined, between 2000 and 2022 (Figure 4).

FIGURE 4: REGIONAL DISTRIBUTION OF CLIMATE-ATTRIBUTABLE HUMAN LOSSES (DEATHS AND AFFECTED), CUMULATIVE 2000–2022



Note: Analysis is based on EM-DAT disaster damage records, using global average FARs for floods and droughts for selected 18 countries in the SGHA region.

Source: Authors' own, based on EM-DAT (n.d.).

Climate-attributable human losses (deaths and people affected) from droughts and floods are two to three times higher in SGHA countries than in other countries across their respective income groups,[7] except for lower-middle-income countries (LMICs) in the case of people affected (see Annex). For example, the climate-attributable average affected population among LDCs is about three times higher in the SGHA group of countries than in other countries that are classified as LDCs.

3.2 Climate change-attributable economic loss and damage

In terms of total economic loss and damage from droughts and floods in the SGHA region in 2002–2022 ($290 billion), approximately 41% ($118 billion) is attributable to climate change. This is made up of direct economic costs and the economic costs of human life, which is estimated using an SLOL measure of $7.08 million per life lost (see Chapter 2.2 for more detail).

The SLOL represents approximately 81% of attributable loss and damage in the SGHA region. This demonstrates that economic damages are significantly under-reported, as there are a large number of missing estimates for such damages in the EM-DAT database for the SGHA

7 All 18 countries in the SGHA region that are part of the analysis in this report are either LICs (12 countries) or LMICs (6 countries). Out of the 18 countries, 15 are classified by the United Nations as LDCs, including all 12 LICs and 3 LMICs from the SGHA region.

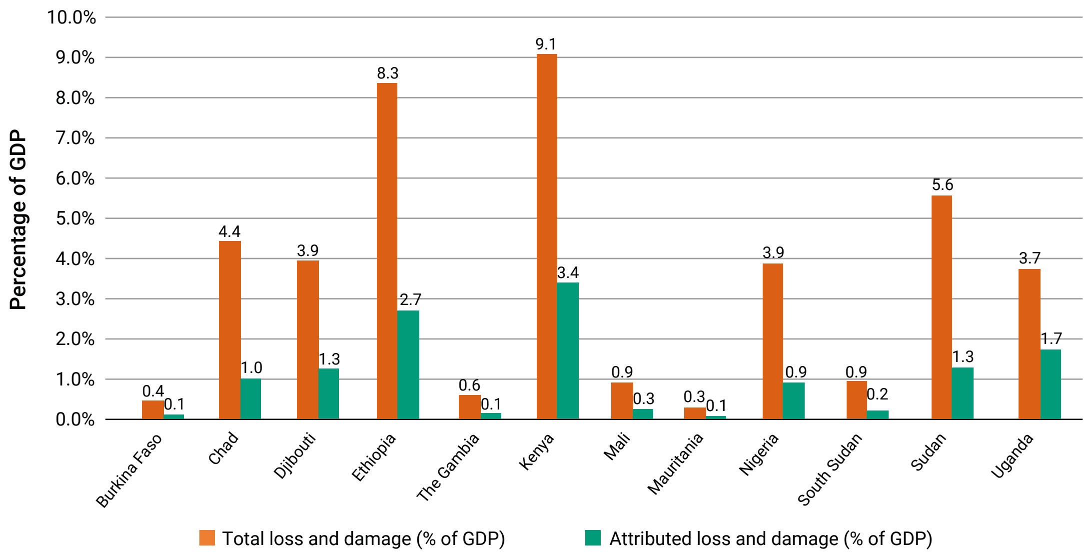
region.[8] Climate-attributable droughts are responsible for 80% of estimated loss and damage, partly because the high mortality from droughts relative to floods translates into higher SLOL estimates.

Every year, climate-change attributable economic loss and damage across the region constitutes 29%, on average, of total economic loss and damage, or $5 billion. As before, a peak in attributable loss and damage was observed in 2010. This was largely due to the high mortality count (and thereby higher SLOL) from the East African drought, which particularly affected Somalia. Excluding Somalia, the average annual loss and damage was $1.9 billion.

Figure 5 presents total and attributable loss and damage expressed as a percentage of GDP in the SGHA countries. Together, the average annual climate-attributable economic loss and damage is around 0.8% of the SGHA countries' collective GDP in 2000–2022 (excluding Somalia). The highest total and attributable loss and damage occurred in 2010, at 9.9% of GDP.

Somalia is not included in Figure 5 because the losses of the 2010 drought made it such an extreme outlier. The large number of lives lost impute average attributable loss and damages of 60.8% of GDP per year over the study period. If SLOL is excluded, however, economic damages in Somalia still amount to 1.8% of GDP per year. This is followed by Kenya (3.4% of GDP), Ethiopia (2.7 %) and Uganda (1.7%). Overall, 8 out of 18 SGHA countries experienced attributable loss and damage greater than the SGHA average of 0.8% of GDP. When expressed

FIGURE 5: AVERAGE ANNUAL CLIMATE-ATTRIBUTABLE LOSS AND DAMAGE AS A PERCENTAGE OF GROSS DOMESTIC PRODUCT ACROSS THE SAHEL AND GREATER HORN OF AFRICA REGION, 2000–2022



Note: Analysis is based on EM-DAT disaster damage records, using global average FARs. Estimates for Somalia are excluded to make the graph presentable.

Source: Authors' own, based on EM-DAT (n.d.).

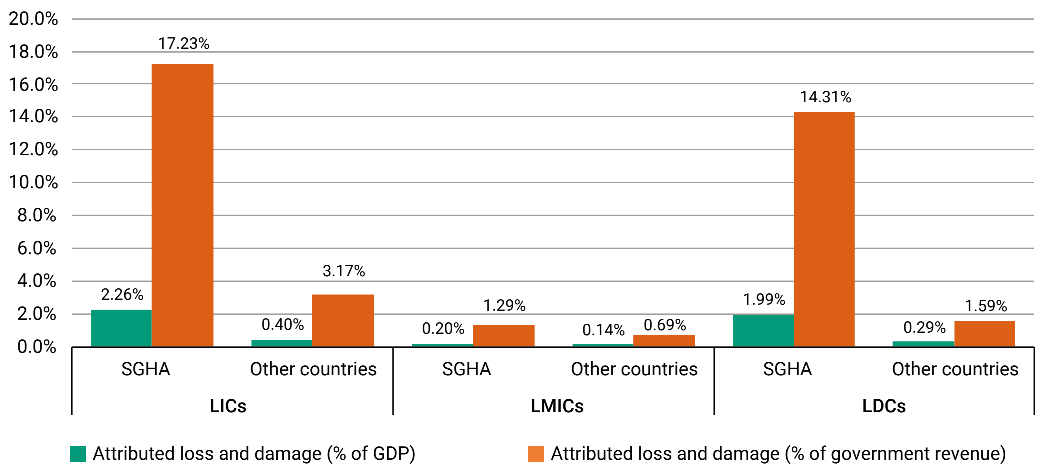
8 Of the 399 flood and 88 drought events recorded in the EM-DAT database between 2000 and 2022 for the SGHA region, economic damage costs were recorded for only 60 events. The problem of missing observations for economic damages in EM-DAT is also true for other regions of the world (see Panwar and Sen, 2020).

as a percentage of government revenues, the proportion of climate-attributable loss and damage is even higher, averaging 6% of government revenue across SGHA countries (excluding Somalia).

It is notable that climate-attributable loss and damage only represents about one third of the total economic loss and damage from droughts and floods. This represents 2.5% of GDP across SGHA countries (excluding Somalia). Similarly, average annual total loss and damage was about 19% of government revenues in the SGHA region – more than three times that which is climate-attributable. For most LICs in the SGHA region characterised by a large proportion of poor population and competing budgetary priorities, climate-attributable loss and damage of such magnitude is extremely significant.

Across income groups, climate-attributable economic loss and damage as a percentage of GDP is significantly higher for SGHA countries compared with other countries. This is especially true of SGHA LICs and LDCs, where such losses are about six times higher than in other countries (Figure 6). This points to the acute levels of climate vulnerability and exposure, which in part may be driven by fragility. Such challenges are the result of underinvestment in basic services and infrastructure, lack of diversified economies and variable governance. In parts of some countries, violent conflict also contributes to climate vulnerability. There is an urgent need to support resilience-building and adaptation measures to reduce the underlying causes of vulnerability in these contexts.

FIGURE 6: AVERAGE ANNUAL CLIMATE-ATTRIBUTABLE ECONOMIC LOSS AND DAMAGE IN THE SAHEL AND GREATER HORN OF AFRICA AND OTHER COUNTRIES, 2000–2022



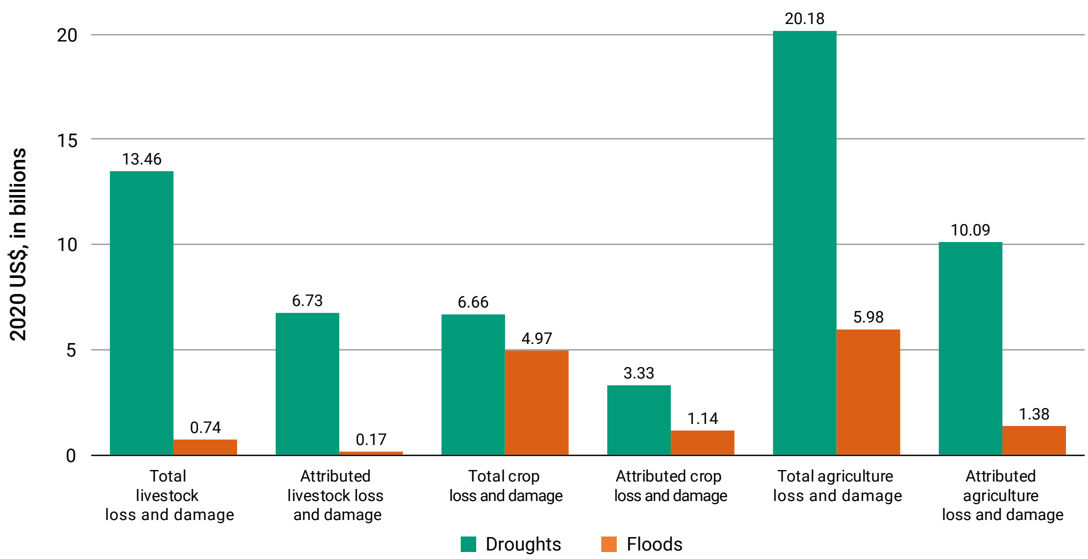
Note: Analysis is based on EM-DAT disaster damage records, using global average FARs. Attributed loss and damage includes SLOL estimates.

Source: Authors' own, based on EM-DAT (n.d.).

3.3 Agriculture (including livestock and crop) loss and damage attributable to climate change

The total estimated agriculture loss and damage from droughts and floods for all SGHA countries combined between 2000 and 2022 amounts to $26.2 billion, of which 44% ($11.5 billion) could be attributable to climate change (Figure 7). In the case of drought events specifically, almost 50% of the total livestock and crop losses and damages could be attributable to climate change. On average, between 2000 and 2022, agriculture loss and damage to the tune of $499 million (of $1.14 billion total) per year, including $300 million average annual livestock loss and damage and $195 million crop-related loss and damage, could be attributable to climate change.

FIGURE 7: PRELIMINARY ESTIMATES OF CLIMATE-ATTRIBUTABLE AGRICULTURE LOSS AND DAMAGE ACROSS THE SAHEL AND GREATER HORN OF AFRICA REGION, CUMULATIVE 2000–2022

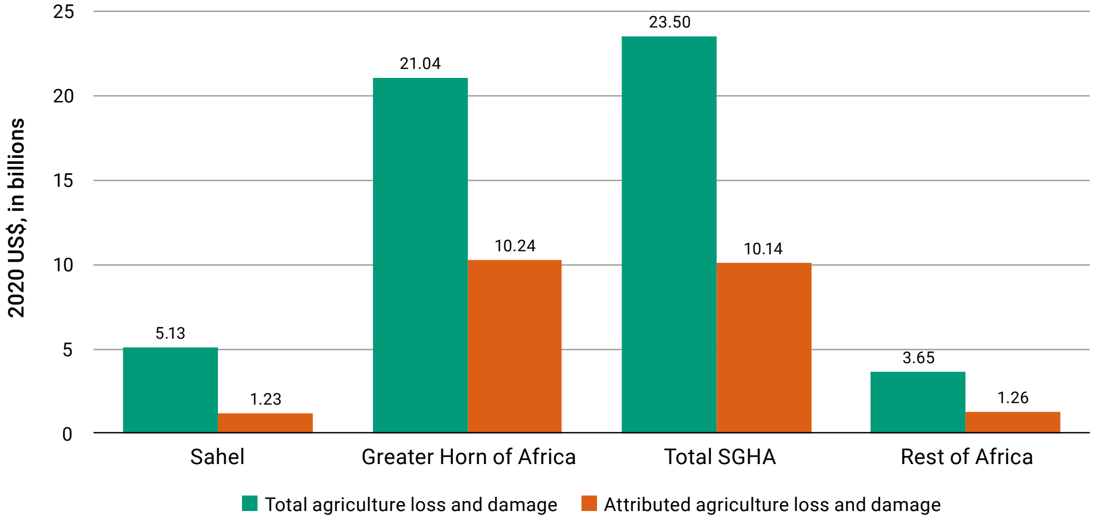


Note: Agriculture loss and damage figures are estimated from EM-DAT total economic damage records. The extrapolation of agriculture losses and damages is based on the average contribution of the agriculture sector to the total economic losses and damages reported across the PDNA studies between 2008 and 2024 in the SGHA region. See Annex for more details. L&D: losses and damages.

Source: Authors' own, based on EM-DAT (n.d.).

Climate-attributable agriculture loss and damage is more than three times higher in the SGHA region compared with all other countries in the rest of Africa (Figure 8). Climate-attributable agriculture loss and damage as a percentage of GDP from agriculture is also disproportionately higher in SGHA countries compared with other countries across income groups (see Annex).

FIGURE 8: REGIONAL DISTRIBUTION OF THE PRELIMINARY ESTIMATES ON CLIMATE-ATTRIBUTABLE AGRICULTURE LOSS AND DAMAGE DUE TO FLOODS AND DROUGHTS COMBINED, 2000–2022



Note: Agriculture loss and damage figures are estimated from EM-DAT total economic damage records. The extrapolation of agriculture losses and damages is based on the average contribution of the agriculture sector to the total economic losses and damages reported across the PDNA studies conducted between 2008 and 2024 in the SGHA region. See Annex for more details.

Source: Authors' own, based on EM-DAT (n.d.).

3.3.1 Qualifications for this data

It is important to note that the agriculture loss and damage estimates are directly linked with economic damage records. They are therefore likely to be an underestimation of the 'actual cost' of direct agriculture loss and damage. This is because of the high number of missing observations (mainly due to under-reporting) for economic damages reported in the EM-DAT database (see discussion on the limitations of the data in the Annex).

The EM-DAT database provides a starting point for estimating direct economic loss and damage from extreme weather events. However, there are a multitude of ways in which these direct (and indirect) losses and damages can manifest in the agriculture and livestock sectors that are not captured in the database.

For example, disruptions in feed and water availability during extreme weather events can compromise the nutritional status and general well-being of animal populations (Thornton et al., 2009). In the Horn of Africa, Rift Valley Fever disease outbreaks may worsen, as outbreaks are linked to widespread flooding events that facilitate the hatching of infected mosquito eggs (Muga et al., 2021; Richardson et al., 2022). Rift Valley Fever can be devastating for pastoral livelihoods, affecting both human and livestock health and potentially resulting in lost income.

These are examples of indicative pathways for direct and indirect loss and damage that are not captured in hazard-based loss data. This further reinforces the point that these estimates likely conceal much greater loss and damage than is recorded, which affects both the pastoral sector and the agriculture sector as a whole.

3.4 Projected future climate-attributable risks related to extreme climate events

This section presents preliminary estimates of the projected risks related to floods and droughts in the SGHA region. The approach for deriving estimates, related assumptions and limitations is discussed in the Methodology section above. Under a 2°C warming scenario, floods could cause a cumulative loss and damage of $32 billion (Table 1).

Compared with the average annual attributable loss and damage of $999 million between 2000 and 2022, an average 50-year flood event could cause attributable loss and damage of $1.3 billion under a 2°C warming scenario. Climate-attributable loss and damage due to droughts could reach $127.4 billion under a 2°C warming scenario. Collectively, climate-attributable loss and damage from floods and droughts could be $156 billion under a 1.5°C warming scenario and $159.4 billion under a 2°C warming scenario.

These projections are only indicative of the potential future direct cost of extreme weather events, because the calculations do not include factors that may decrease risk, such as potential adaptation investments and future dynamics of income and population in SGHA countries. The projections also do not include factors that may increase risk, such as increasing exposure, income inequality or median age. Nevertheless, the projected climate-attributable losses and damages from extreme weather events in this report are still underestimates, given the limitations of the data (with missing observations/under-reporting), as well as the absence of 'indirect' impacts, 'slow-onset events' and 'non-economic' loss and damage from the calculations.

TABLE 1: PRELIMINARY PROJECTION OF CLIMATE-ATTRIBUTABLE LOSS AND DAMAGE DUE TO FLOODS AND DROUGHTS IN THE SAHEL AND GREATER HORN OF AFRICA BY 2050

Climate extreme	Average FAR (2000–2022)	Projected new FAR under different warming scenarios	Projected cumulative attributable loss and damage per scenario
Floods			
1.5°C warming scenario: median ~7% increase in probability of occurrence (1-in-50-year Rx1day)	23%	28%	$31 billion
2.0°C warming scenario: ~8.3% increase in probability of occurrence (1-in-50-year Rx1day)		29%	$32 billion
Droughts			
1.5°C warming scenario: 20% increase in probability of occurrence (1-in-10-year soil moisture drought)	50%	58%	$125 billion
2.0°C warming scenario: 25% increase in probability of occurrence (1-in-10-year soil moisture drought)		60%	$127.4 billion

Note: No specific projections for droughts in IPCC (2021). The ranges for droughts are indicative based on the authors' assumptions of using probabilities for Southern Africa as a proxy for the SGHA region.

Source: Authors' own, based on EM-DAT (n.d.).

4. INDIRECT ECONOMIC LOSSES AND DAMAGES FROM EXTREME WEATHER EVENTS

The damages triggered by extreme weather events, including those that manifest in agriculture and livestock sectors, are not only direct but also have many cascading, indirect effects (illustrated in the Annex). They may cause disruptions to the flow of production of goods and services, which in turn has social and economic consequences (UNDRR, 2024). Indirect loss and damage in agriculture and livestock sectors may include the following: decline in crop yield, household income loss, increased soil erosion, a decline in water quality, animal performance loss, market and supply chain disruptions, volatility in the prices of agricultural products, food insecurity, health impacts and cultural impacts. While this chapter focuses on the indirect economic loss and damage from extreme weather events, non-economic losses and damages such as environmental, health and cultural impacts are covered in Chapter 6.

The direct impacts of extreme weather events are relatively well documented and are also estimated as part of this analysis (see Chapter 3). The indirect impacts, some of which may persist for years according to testimony, are not. However, many of the loss and damage studies assessed do not distinguish between the two types of impacts. Nor do they distinguish between extreme weather events that are within the boundaries of natural climate variability and those for which a climate change attribution signal is detectable. Recognising these challenges, this chapter aims to provide a nuanced understanding of indirect impacts in the context of SGHA countries. It focuses specifically on indirect losses and damages in the agriculture and livestock sectors, and on macroeconomic impacts.

4.1 Indirect impacts from extreme weather events on agriculture and livestock sectors

Extreme weather events place considerable economic pressure on agriculture and livestock farming in vulnerable African countries. The impacts of extreme weather events, some of which are influenced by climate change, are particularly pronounced in the SGHA's agriculture sectors (Coulibaly et al., 2020). This includes damage to farmland and livestock, lower yields and higher input costs, which significantly affect farmers' incomes and livelihoods (Nkonya et al., 2016).

Droughts have also been found to reduce the quality and quantity of feed from grasslands for livestock (Bogale and Erena, 2022). In addition, market disruptions triggered by extreme weather events may lead to cascading price volatility because of commodity shortages, affecting both producer and consumer behaviour (FAO, 2018). For example, Traore and Owiyo (2013) found that 95.4% of respondents in Burkina Faso indicated that droughts lead to higher prices of food and other products. On the producer side, livelihoods may shift from crop cultivation to increased reliance on livestock in areas where the likelihood of failed seasons is high, such as Somalia (Jones and Thornton, 2009). Studies have also shown that prolonged droughts and floods have long-term economic consequences, including the total loss of productivity and yield of agricultural land (Ouedraogo, 2012; FAO, 2019).

Rural people and national economies in the Horn of Africa have been deeply affected by severe, large-scale, frequent and persistent droughts. From 2008 to 2011, a series of large-scale droughts hit the region, triggering a cycle of heightened food insecurity that still persists (Lung et al., 2021). In southern Ethiopia, herd size decreased following the 2010–2011 drought, due to a 26% increase in mortality and a 19% forced off-take of livestock (Megersa et al., 2014). The total cost of the 2011 drought has been estimated at $384 million for southern Ethiopia (Shitarek, 2012), while in Kenya, the 2009–2012 droughts cost the national economy approximately $12.1 billion (OCHA, 2012).

Following the same patterns, the 2016–2017 drought associated with La Niña forced 20 million people into acute food insecurity in Ethiopia, Kenya and Somalia (Lung et al., 2021). The drought severely affected the crop and livestock sectors in Somalia, causing estimated crop and livestock production losses of $1.7 billion and damages to crops and from deceased livestock of $350.7 million over the drought period (Government of Somalia, 2018).

Somalia was hit again with an extended drought over five failed rainy seasons between 2021 and 2023. Farmers and herders lost large shares of their agricultural income, plunging entire communities into poverty. Over eight million people, almost half the country's population, have been left acutely food insecure. Currently, the lack of gender-disaggregated data within the economic and non-economic losses and damages impedes a disaggregation of findings by gender (or other social identifiers). Literature on gendered impacts of climate impacts shows that there is likely to be social differentiation within these loss and damage figures (Box 3).

BOX 3: GENDER AND SOCIAL DIFFERENTIATION IN LOSSES AND DAMAGES FROM SLOW-ONSET EVENTS AND PROCESSES (CURRENTLY DISGUISED BY LACK OF SOCIALLY DIFFERENTIATED DATA)

Losses and damages from slow-onset events and processes in the agriculture sector do not affect everyone in the same way, but this is typically disguised in sector-wide analyses. Gender and other social inequities lead to differential impacts between men and women. Women are typically more negatively impacted relative to men. Gender differences are also observed through multiple domains, including agricultural production, food and nutrition security, health, water and energy, and climate-related disaster, migration and conflict (Awiti, 2022).

Gender differences lead to unequal control over access to resources (e.g. land, credit), and women often have the least formal protection from these factors (Eastin, 2018). For example, in the agriculture sector, women represent 43% of the agricultural labour force globally, but only 15% of agricultural landholders (OECD, 2019).

The impacts of climate on agriculture often create significant additional labour burdens on women. For example, changes due to drought in herd composition of animals (cattle, camels, sheep or goats), which women are typically responsible for, increase women's labour burden (Walker et al., 2022). Changing gender roles among agropastoralists in Karamoja has also led to women taking on new productive labour roles, such as petty trading, which increases their labour burden (Ayub et al., 2023).

Negative impacts can also extend to girls, who are often removed from school to replace their mothers in gender-determined household roles (Maertens and Swinnen, 2009). Other gendered roles, such as fetching water, place greater risk of burden on women who have to travel further when resources are scarce (Graham et al., 2016).

As well as impacts on women through changing agricultural roles, climate impacts on agriculture affect women and girls through food and nutrition security (e.g. Botreau and Cohen, 2020). When food is scarce, women are more likely to go without, creating risk of malnutrition (Salm et al., 2021). Tibesigwa et al. (2015) observed a statistically significant consumption gap, of up to 21%, between female- and male-headed households, where female-headed households were more likely to be food insecure.

Gender differences also mean that some intended adaptations can have differential impacts on men and women. Crop diversification and the use of technology, for example, are two oft-cited adaptation options in the agriculture sector. But both place additional labour demands on women (Teklewold et al., 2013).

While gender inequality among the pastoral Afar in Ethiopia means that women typically have lower levels of adaptive capacity relative to men, differential assets and decision-making powers mean they repeatedly make higher contributions to household-level adaptation to recurrent drought and weather variability (Balehey et al., 2018). Recognising these gender differences has highlighted the need to address the needs of both men and women equitably in different environments and agricultural systems (Kristjanson et al., 2017).

Currently, the lack of gender-disaggregated data within the economic and non-economic losses and damages impedes a disaggregation of findings by gender (or other social identifiers). However, this existing literature, which illustrates the socially differentiated effects of climate impacts, shows that, within the sector-wide analyses, there will be differences in how losses and damages are experienced. Better availability of gender-disaggregated data in the future will help to enable better quantification of the social differentiation of loss and damage within the sector-wide analyses.

4.2 Indirect macroeconomic impacts from extreme weather events

There is significant evidence that climate change will profoundly hinder economic development worldwide, especially in African countries (IPCC, 2021; 2022). Moreover, there is growing consensus about the adverse macroeconomic impacts of disasters, which are seen as a potential obstacle to the economic development of countries.

This section summarises findings from various empirical studies that have explored whether and how disasters, including those related to extreme weather events, have contributed to significant indirect macroeconomic impacts in different countries and over different time periods, focusing where possible on the SGHA region. However, empirical analyses and case studies, particularly for SGHA countries, or African countries more broadly, are relatively scarce. The Annex provides a list of relevant studies, the extent to which they include SGHA countries in their analysis, and an overview of their findings.

Numerous global studies using various econometric methods have explored the effects of disasters on economic growth in the short to medium term, often drawing on the EM-DAT database. Generally, they find that disasters negatively impact macroeconomic indicators such as GDP per capita growth, though this relationship is nuanced (Noy, 2009; Loayza et al., 2012; Panwar and Sen, 2019; Cavallo et al., 2022).

A few of the short- to medium-term analyses argue that the impacts of extreme weather events on the economy may be negligible or positive under certain conditions, depending on the hazard type, its intensity and the socioeconomic context (Hochrainer-Stigler, 2015; Zhao et al., 2023; Panwar and Sen, 2019). For example, disasters have been found to minimally influence GDP volatility in LICs (Raddatz, 2007). However, temperature fluctuations affect African countries' economic growth differently across different climatic zones (Zhao et al., 2023). Different types of disasters (e.g. floods versus droughts) can also have varying effects. For example, moderate floods might boost GDP per capita growth, while droughts have a negative effect, especially on the agricultural growth level of countries (Fomby et al., 2013). Similarly, low- to moderate-intensity hazards have been found to have positive spillovers for the economy at large (Schumacher and Strobl, 2011).

Overall, however, many studies show that the short-term impact of climate-related extremes negatively affects GDP, including in countries of the SGHA region (Shabnam, 2014; Abidoye and Odusola, 2015; López et al., 2016). Climate-induced losses are estimated at 10–15% of GDP per capita growth in selected African economies, with debt and remittances negatively related to GDP per capita during extreme weather events (Baarsch et al., 2020). Typically, countries with a high risk of extreme weather events, such as in the Horn of Africa, are more likely to be unable to meet their debts in the case of a disaster. This means that debt can increase while countries are managing the fiscal impacts of climate-related disasters (Cavallo et al., 2022). This puts fiscal stress on governments and restricts their ability to mobilise resources for reconstruction and recovery (Noy, 2009).

In the long term, the relationship between economic growth and extreme weather events is generally found to be negative (Noy and Nualsri, 2007; Klomp, 2015; Owusu-Sekyere et al., 2021; Diop et al., 2024, among others). For example, droughts and high temperatures have been shown to significantly curb economic growth, especially in less developed countries (Berlemann and Wenzel, 2016; Dell et al., 2012; Ali, 2012).

However, as was the case for medium- to short-term disaster impacts, variations in the type and intensity of the hazard can influence long-term outcomes. For instance, severe flooding is considered the most devastating hazard globally (Mukherjee and Hastak, 2018). But several studies show that moderate-intensity flooding can have a positive or no effect on long-term growth (Cavallo et al., 2013; Klomp, 2015; Panwar and Sen, 2019). Moreover, precipitation variability can have a positive effect on productivity in specific regions, such as Burkina Faso and Nigeria (Ayinde et al., 2011; Kone, 2021).

Projections by the African Development Bank suggest severe economic consequences for African countries due to rapid climate changes by mid-century, with significant GDP per capita declines of around 15% by 2050 in East Africa and West Africa under high-emissions scenarios (AfDB, 2019). This is supported by studies showing lasting negative impacts of extreme weather events on economic growth, particularly in sub-Saharan and Southern African countries (Adjei-Mantey and Adusah-Poku, 2019; Owusu-Sekyere et al., 2021).

Overall, while most of the literature indicates negative effects of disasters on economic growth, moderate-intensity events can sometimes have positive spillover effects. Mixed findings may arise from the unique nature of disasters, measurement imprecision and an excessive use of control variables in studies, which can mask the real effects of disasters on GDP growth (Berlemann and Wenzel, 2016).

Furthermore, it is important to note that the studies reviewed in this chapter generally looked at the average annual impact of disasters and did not consider cascading/compounding impacts of frequent events, which are a significant risk in the SGHA region. Yet, it is clear from this review that developing countries face disproportionate disaster impacts, with severity and type of hazard being crucial factors in determining their direction and magnitude.

5. LOSSES AND DAMAGES FROM SLOW-ONSET EVENTS AND PROCESSES

In addition to the impacts of extreme weather events, losses and damages from slow-onset processes add to the total cost of climate change. However, unlike extreme weather events that tend to occur within hours, days, weeks or months, slow-onset processes and their effects unfold gradually, over much longer periods of time, but they can generate immense cumulative and potentially irreversible impacts (Schäfer et al., 2021).

Some slow-onset processes are directly associated with climate change. In the SGHA, this concerns especially increases in temperature, as well as sea-level rise and ocean acidification in coastal countries. Other processes observable in the region are in turn indirectly associated with climate change. These include land and forest degradation, desertification, loss of biodiversity and salinisation of coastal waters and soils. Thus, they can also be heavily influenced by human behaviour, for example through land management and water-use practices. This makes it more difficult to attribute the specific contributions of climate change to the total losses and damages that such processes may cause.

As in the case of extreme weather events, slow-onset processes can result in direct loss and damage or contribute to cascading indirect impacts that are also shaped by anthropogenic drivers and pre-existing patterns of vulnerability and exposure.

5.1 Direct damage to crops, loss of livestock and reduced agricultural production

There is considerable agreement in the literature that climate change, including through its related slow-onset processes, is resulting in significant negative impacts on food production across Africa (IPCC, 2022). One widely quoted study has found that climate change has already reduced growth in agricultural productivity on the continent by 34% since 1961, a rate that is higher than that of any other region globally (Ortiz-Bobea et al., 2021).

The economic consequences of slow-onset events for African farming systems are particularly severe, with net farm incomes negatively affected by warmer and drier climates (Nhemachena et al., 2010). Future global warming is projected to further contribute to water stress and shorten growing seasons, with yields for staple crops such as maize, rice and wheat expected to decline over most of Africa – including in West and East Africa – under a scenario with global warming above 2°C (IPCC, 2022). While adaptation measures may help offset yield losses, this potential reduces with increasing global warming (ibid). A large share of food crop production in many SGHA countries is rainfed, thus contributing to its high vulnerability to changes in temperature and precipitation (USAID, 2017a; 2020).

A limited number of studies have so far assessed the impacts of climate change on yields of cash crops or of food crops other than maize, rice or wheat in SGHA countries. This means that while there are some indications on the direction and size of such impacts, these are established at a relatively lower level of confidence, with a more specific focus on particular combinations of locations and crops (IPCC, 2022), and with sparse information about their past and potential future economic impact.

In the Sahel, sorghum yields have been found to have already declined as a result of climate change. Moreover, they are projected to decline even further across different scenarios of global warming, with an average reduction of an estimated 2% at 1.5°C global warming and a 5% decrease at 2°C (Faye et al., 2018). At a mean warming of 2.8°C, Sultan et al. (2014) estimate a 16–20% mean decrease in crop yields and an increase in the year-to-year variability of yields associated with projected shifts in monsoon seasonality in the western part of the Sahel, with less severe impacts expected in the eastern Sahel.

Across several East African countries, the areas that are considered suitable for the production of coffee and tea are expected to shrink as a result of climate change. In Kenya, for example, projections indicate a nearly 30% decrease in optimal tea production areas, resulting in a 10% decrease in yields under a scenario of 1.8–1.9°C of global warming. However, this decline in yields may be less severe at higher levels of global warming (IPCC, 2022; citing Beringer et al., 2020; Jayasinghe and Kumar, 2020; Rigden et al., 2020).

Similarly, in Uganda, the areas considered suitable for tea production may shrink by half (IPCC, 2022; citing Eitzinger et al., 2011; Läderach et al., 2013). Coffee-growing areas in East Africa are expected to shift upwards in elevation, resulting in about 10–30% less surface considered suitable for production under a scenario of 1.5–2°C of global warming (IPCC, 2022; citing Bunn et al., 2015; Ovalle-Rivera et al., 2015). Adaptation finance may help offset some of the economic impacts of these changes, for example by supporting shifts to alternative land use. However, the difference this could make on cumulative losses and damages from slow-onset processes remains unclear.

Livestock production systems are already heavily impacted by climate change and projected to be affected further in the future (IPCC, 2022). These impacts manifest through different pathways. In West Africa, for example, the overall net primary productivity of rangelands has been projected to decrease by 42% by 2050 with 2°C global warming, and by 46% with 2.4°C of warming (Boone et al., 2018). In Mali's Klela Basin, groundwater recharge may nearly halve due to climate change, while groundwater storage is projected to decline by a quarter under 2.4°C global warming, compared with 2006 (Toure et al., 2017). The impacts of these changes on livestock production may be exacerbated and result in acute livestock mortality and price shocks in years with extreme weather events such as drought and heatwaves (IPCC, 2022).

As well as threatening crop and livestock production systems, climate change is also likely to harm marine and freshwater fisheries in Africa. This will directly impact fish harvests and indirectly result in potential human health impacts by increasing people's vulnerability to nutrient deficiencies. These include deficiencies in iron (1.2–70 million people at risk by mid-century under 1.7°C global warming), vitamin A (188 million people at risk) and vitamin B12 and omega-3 fatty acids (285 million people at risk). Countries in Central, East and West Africa are projected to face the highest nutritional risk from reduced coastal fish harvests (IPCC, 2022; Golden et al., 2016).

One of the main pathways through which slow-onset climate change processes impact freshwater and coastal fish harvests is warming air and water temperatures (IPCC, 2022;

Golden et al., 2016). In African lakes, increased temperatures have already resulted in reduced fish biomass (IPCC, 2022). Under 2.5°C global warming, over half (55–68%) of fish species that are commercially harvested in African inland fisheries are at risk of extinction by the end of the 21st century. Under a 4.4°C warming scenario, this risk could extend to as much as three-quarters of fish species (IPCC, 2022).

More specific effects on inland fisheries will depend on the nature of fishery production and the respective associated hydrological dynamics. For example, catch projections differ between fishery production in lakes (overall lower likelihood of reduced yield, particularly in regions where precipitation is projected to increase, e.g. the African Great Lakes region) and fishery production in rivers and floodplains (overall higher likelihood of reduced yield, e.g. Niger basin) (IPCC, 2022; Harrod et al., 2018).

Marine fisheries in coastal areas of the SGHA region are particularly threatened by impacts of severe coral bleaching. This has already affected around 80% of reefs along the eastern African coast, including in the Red Sea and the western Indian Ocean (Hughes et al., 2018). The East African coral reef habitat is expected to further decrease and diminish fish stocks because of climate change. Under 2°C global warming, the maximum catch potential from marine fisheries in African Exclusive Economic Zones is projected to decrease by between 10% and potentially more than 30% in the Horn of Africa, West Africa and the western South African coast by the middle of the century.

This is likely to be a faster decline in maximum catch potential than other parts of Africa will experience (Cheung, Reygondeau and Frölicher, 2016; Cheung et al., 2016; IPCC, 2019). In Senegal, sea-level rise and coastal erosion have submerged fishing communities and destroyed boat landing sites, resulting in reconstruction costs and diminishing income from fisheries (Schäfer et al., 2021; Pronczuk, 2020; ENDA Energie, 2016).

It is important to note that disentangling the specific impacts of climate change from the broader degradation of coastal and marine ecosystems due to factors such as urbanisation, pollution, overfishing, etc. is complex. This can make it difficult in practice to attribute (a specific share of) such losses and damages to climate change-related slow-onset processes. For example, the observed bleaching of East African reefs has been exacerbated by other anthropogenic impacts, and projected declines in fisheries production based solely on, for example, temperature projections are highly uncertain.

Beyond its impacts on crop, livestock and fish yields, climate change may also influence the ways in which food is processed, stored, distributed and consumed, thus affecting the different components of food systems. However, existing studies on food-related climate change impacts in Africa tend to concentrate heavily on the production side. This means there is a major knowledge gap for the region – including for SGHA countries – around the wider impacts of climate change on food systems and the broader knock-on effects these may have, for instance on food security and nutrition or on livelihoods and income that rely on those parts of the food system that are not directly involved in food production (IPCC, 2022).

Further, monetary estimates on the scale of potential total agriculture losses and damages from the impacts of slow-onset processes as they gradually evolve – and as they may reach critical irreversible tipping points in the future – are lacking for the SGHA region. Such tipping points may be met when areas become too dry or too hot to continue growing crops or farming livestock there, or when agricultural land is permanently lost to desertification or sea-level rise.

5.2 Changes in the prevalence and spread of plant pests

There is potential for slow-onset processes such as changes in temperature and precipitation to increase the likelihood of plant pests, which in turn can have an effect on crop yields and pasture availability. In Africa, pest-driven losses may increase by up to 50% as a result of climate change under 2°C global warming, when compared with the period 1950—2000 (IPCC, 2022; Deutsch et al., 2018). Globally, studies focusing on cereal and horticultural crops point towards increased pest risk from insects, pathogens and weeds under climate change scenarios, in particular for regions outside the tropics (IPCC Secretariat, 2021).

For the tropics, which include the SGHA region, as well as in the cases of forestry and unmanaged ecosystems, fewer studies on the relationship between climate change and plant pests are available, and there tend to be bigger gaps in pest risk analysis, and surveillance and monitoring systems in the tropics compared with other regions (ibid.). Furthermore, there are challenges in modelling the effects of climate change on pests and disease, and a need to expand the studied range of diseases and crops (IPCC, 2022; Newbery et al., 2016). Nonetheless, there are indications that climate change may increase or at least shift the geographic distribution of (some) plant pest risks in SGHA countries.

As an example, Eritrea, Somalia and Yemen experienced a particularly severe desert locust outbreak in 2019—2020. Desert locusts swarm and devour crops such as maize and sorghum, pastures and other green vegetation, heavily affecting the livelihoods of farmers and pastoralists (IPCC Secretariat, 2021; Kimathi et al., 2020). The World Bank estimated that total damages and losses from the outbreak could be as high as $8.5 billion in 2020 (World Bank, n.d.). Another severe desert locust outbreak in the Sahel in 2003—2005 was estimated to have resulted in $2.5 billion in harvest losses alone across the region (FAO, 2020). In addition, spraying chemical pesticides, currently the main strategy for managing locust swarms and preventing major outbreaks, is detrimental to human and livestock health. The practice has negative impacts on the environment and on biodiversity which can result in further costs.

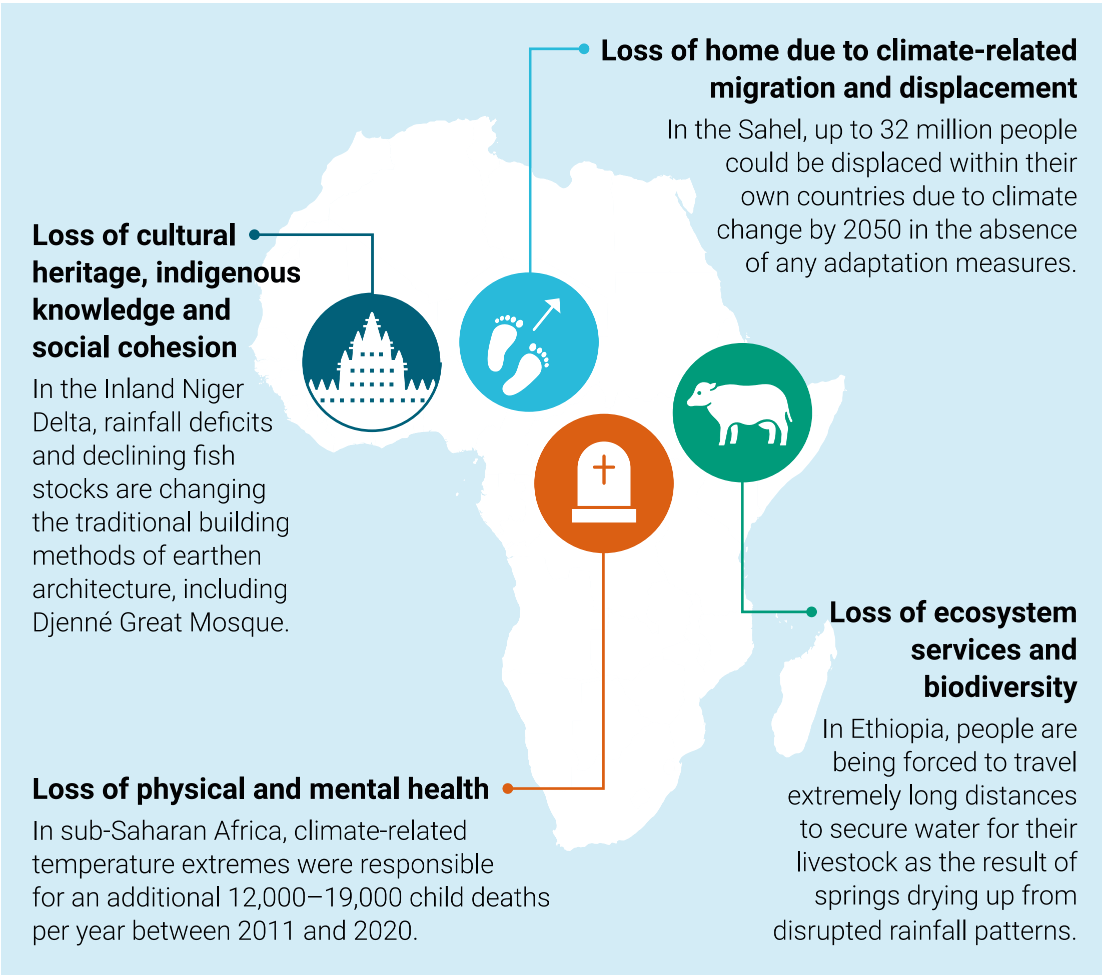
While it is difficult to attribute single events such as the 2003—2005 or 2019—2020 desert locust outbreaks to climate change, it is clear that climatic conditions such as high temperatures and increases in rainfall and wind speed influence pest behaviour. This means that climate change may result in future conditions that increase the likelihood of breeding, development and migration of desert locusts in parts of the SGHA region (IPCC Secretariat, 2021).

In turn, other plant pest risks could decrease somewhat in parts of SGHA countries or shift their geographic expansion due to slow-onset climate change processes. This is the case, for example, with the fall armyworm, which has its origins in the tropics and subtropics of the Americas and causes severe damage to crops such as maize, sorghum, rice, cotton and soybean. On the African continent, it was first reported in western Africa in 2016 and then later throughout sub-Saharan Africa in 2019 (Goergen et al., 2016; EPPO, 2020; IPCC Secretariat, 2021). The fall armyworm's spread is highly dependent on climatic conditions and has been projected to reduce or partially disappear in parts of the southern hemisphere where warmer and drier conditions are expected by mid- or end-century (Ramirez-Cabral et al., 2017).

6. NON-ECONOMIC LOSSES AND DAMAGES FROM CLIMATE CHANGE

Non-economic losses and damages tend to be marginalised in the climate change discourse and research, where understanding the economic impacts of climate change is often prioritised (Anderson, 2023). Yet non-economic losses can be severe. The loss of life, health, livelihood traditions and identity all have enormous – and potentially permanent – consequences and are very difficult to address adequately (Hirsch et al., 2017). See Figure 9 for specific examples in the SGHA region.

FIGURE 9: NON-ECONOMIC LOSSES AND DAMAGES FROM CLIMATE CHANGE EXPERIENCED IN THE SAHEL AND GREATER HORN OF AFRICA REGION AT A GLANCE



Source: Authors' own, based on Brooks et al. (2020), Chapman et al. (2022), Rigaud et al. (2021) and Cooper et al. (2019).

Non-economic losses and damages are inherently difficult to value with conventional measures. A non-economic loss, such as the death of a close loved one in a flood, the loss of a home due to involuntary migration, or the damage to heritage as sea-level rise threatens traditional sacred sites, cannot be quantified only in monetary terms. In fact, non-economic loss and damage tends to be highly subjective and dependent on context, as the value of the non-economic loss or damage is in relation to the people experiencing it (Serdeczny et al., 2016). For this reason, any assessment of non-economic loss and damage would ideally include the people involved, since they are best placed to articulate the true extent of that loss or damage.

As in most places, systematic attempts to document non-economic loss and damage in the SGHA do not yet exist. The evidence for non-economic loss and damage that does exist is largely concentrated among some specific groups and geographies, such as indigenous people living in the Arctic or small island states, where permafrost thaw or sea-level rise directly threatens burial grounds, seasonal dwellings and migration routes (Red Cross Climate Centre, 2023; Pearson et al., 2023). The following section aims to help fill in some of these gaps, though the published academic knowledge remains sparse.

6.1 Loss of physical and mental health

Climate variability is known to negatively affect human health directly through exposure to extreme climate events and indirectly through infectious disease transmission (Sheffield and Landrigan, 2011). Child mortality is one of the most distressing consequences of extreme weather events, with children in low-income settings at risk of heat stress mortality due to heightened vulnerabilities, including pre-existing exposure to infections, undernutrition and inadequate access to health care (Chapman et al., 2022).

A model estimating the impact of climate change on annual heat-related child deaths between 1995 and 2020 in sub-Saharan Africa found that climate-related temperature extremes were responsible for an additional 12,000—19,000 deaths per year between 2011 and 2020, depending on whether high or low sensitivity to heat was used (ibid.).

From 2009 onwards, heat-related child mortality in sub-Saharan Africa doubled compared with what would be expected without climate change, from a tragic baseline of 4,000—6,000 deaths per year. The study found that in a high-emissions scenario, child mortality could reach over 23,000 deaths per year in sub-Saharan Africa by 2050. With the number of days with maximum temperatures likely to exceed 35°C – a threshold with significant human health impacts, especially when combined with humid conditions – reaching more than 100 days a year in some parts of the Sahel by the 2050s (IPCC, 2021; 2022), large numbers of people are at risk of dangerous heat stress.

In addition to direct heat stress, the disease burden and mortality from climate change in sub-Saharan Africa is largely related to diarrhoeal disease and childhood undernutrition (World Health Organization, 2014). As temperatures rise, bacterial pathogens increase more quickly, causing a greater incidence of diarrhoeal disease (Singh et al., 2020). Because of the greater exposure to diarrhoeal illnesses, World Health Organization models estimate that in Eastern Africa there could be 11,000 more deaths of children below 15 years old by 2030 compared with a base climate scenario (World Health Organization, 2014).

In rural Nigeria, rainfall shocks have a statistically significant impact on children's short-term health, both in terms of weight-for-height and height-for-age, as well as on the incidence of diarrhoea (Rabassa et al., 2012). Similarly, malnutrition related to crop failure and livestock deaths from extreme weather events is expected to worsen. Stunting, an indicator of childhood malnutrition, has been declining in the Horn of Africa, but projections show that this trend may slow (Singh et al., 2020). Climate change impacts will effectively cancel out the benefits of socioeconomic development that have driven the current decline in stunting (IPCC, 2014). Children and pregnant women have been found to be disproportionately affected by adverse health and nutrition impacts from extreme weather events in East Africa (Gebremeskel et al., 2019; IPCC, 2022).

Malaria may not be as significant in the climate-related disease burden across the SGHA region as sometimes assumed. In West Africa, models show that climate change may not increase the malarial disease burden (Yamana et al., 2016). Yamana et al. (2016) found that the impact of future climate change on malarial disease in the Sahel is negative at best, and positive, but largely insignificant, at worst. This is particularly true as projected wet season temperatures approach or exceed the limits of mosquito survival. In East Africa, however, malaria risk is expected to shift to highland areas not previously suitable for malaria transmission (Richardson et al., 2022). In Ethiopia, Kenya and Tanzania alone, approximately 75 million people live in newly exposed altitudes between 1,000 and 2,500 m (Bouma et al., 2011).

Mental health is also intimately tied with environmental conditions, though the climate-related impacts on mental health are understudied in SGHA countries. A 2019 study of pastoralists in Afar, Ethiopia, pointed to the heavy burden of water insecurity on emotional well-being. Pastoralists described feeling a range of anxieties and negative emotions tied to their environmental conditions: deep sadness after losing livestock to drought, and fear when they could not collect enough water for children.

Men and women described deep worry when they were unable to meet basic household needs, and women described feeling fatigued when they had to dig in riverbeds for water that was insufficient for their needs (Cooper et al., 2019). Though women were responsible for fetching water for the household, and men were responsible for finding water for livestock, both men and women experienced similar distressed emotional states related to water insecurity.

Single-headed households faced the largest mental health burdens, however. Across the board, pastoralists associated their water situation with negative emotional well-being, specifically extreme worry and fatigue during the dry season. Beyond this study, direct assessments of mental health impacts of climate change remain scarce in the literature (Atwoli et al., 2022).

6.2 Loss of cultural heritage, indigenous knowledge and social cohesion

Traditional knowledge is information that is unique to a particular group and place, often passed down through generations. As climate change shifts environmental patterns that have long informed traditional knowledge, people practising traditional livelihoods in SGHA will no longer be able to rely on this wealth of understanding of their environments. In most cases, this knowledge has not been documented and categorised formally, but a study of non-economic losses and damages in Ethiopia found that these losses are already manifesting. In the highlands of Amhara, shifts in the bimodal rainy season due to climate change have eroded the value of traditional knowledge of the agricultural calendar (Hirsch et al., 2017). Rainfall is already too volatile to rely on traditional knowledge to know when to plant and harvest crops, undermining existing adaptive capacity and contributing further to agriculture-related losses.

Pastoralist livelihoods and traditions are also distorted and damaged by extreme weather events. In the persistent droughts in 2010—2012, transhumant pastoralists in Mali had to shift their traditional patterns, moving both earlier in the year and travelling further south. This put them into competition over land and water resources with ethnic groups with whom they lacked prior experience of dispute resolution mechanisms, ultimately increasing risk of conflict (Hegazi et al., 2021). A 2023 study of Malian and Mauritanian herders found that 60% of pastoralists surveyed were forced to change their traditional destinations due to lack of forage and/or difficulty accessing water points.

Sahelian pastoral mobility patterns are hampered not only by climate pressures but also by border policies and changes in agricultural policies (International Organization for Migration, 2023), as well as land tenure insecurity and growing privatisation of land (Opitz-Stapleton et al., 2023). Trying to distinguish between these intermeshing factors is often not feasible. But among pastoralists, there is a perception that these changes in forage availability and water access are primarily due to successive poor rainy seasons driven by changes in the climate (ibid.).

Linking conflict and climate events is tenuous, with an array of political and economic factors clouding the linkages with climatic drivers. However, there is some evidence that extreme weather events may indirectly exacerbate some types of conflict in certain settings (IPCC, 2022; Peters et al., 2020). A study of how drought exacerbates extremist violence in sub-Saharan Africa found that, at the local level, drought reduced economic activity by 8.1% and coincided with a 29% higher incidence of extremist violence (Maconga, 2023).

In Mali, the accumulation of multiple years of drought predicted changes in economic activity, which was then linked to increases in violence by Al-Qaeda in the Maghreb and contributed to civil war in the country (ibid.). These findings must be interpreted with caution, as in West Africa there is still little evidence that there is a climate change signal in historical droughts (see Chapter 3 and Supplementary Annex). The conflict has also been linked to loss of tangible cultural heritage through the destruction of the Timbuktu manuscripts, which were burned by Al-Qaeda in the Maghreb (Steadman et al., 2022). These losses are indirect, with economic losses as a key mechanism that leaves scope for extremist violence and loss of cultural heritage. However, they demonstrate the complex web of non-economic losses and damages related to extreme weather events.

In many cases, the loss of cultural heritage due to climate change is more subtle. In the Inland Niger Delta, traditional building methods of earthen architecture are so impressive that Djenne's old town, with its Great Mosque, has been deemed a UNESCO World Heritage Site. Yet the quality of mud bricks used to build and annually resurface these buildings has been degraded by rainfall deficits and related declining fish stocks in the annual floods, as the calcified fish bones have traditionally made the mud more robust to extreme weather events (Brooks et al., 2020). To cope, people are repairing traditional houses with a combination of cement, radically altering the original form and aesthetic of the architectural tradition (ibid.). Over time, these traditional forms of architecture may be lost entirely.

Loss and damage extends to the intangible social dimensions of traditional societies, such as social cohesion. In Ethiopia's highlands, there have traditionally been strong norms of social reciprocity to survive difficult times. These include sharing food during times of drought, loaning seeds to each other, providing labour or sharing oxen for free, and supporting poor people with agricultural inputs (Hirsch et al., 2017). Recently, these forms of mutual aid have been highly stressed by the sheer difficulty of maintaining livelihoods for all farmers. People are no longer able to make contributions for free, removing the natural social safety net that held the community together (ibid.).

6.3 Loss of home due to climate-related migration and displacement

Human mobility is a complex phenomenon, with interlinking push and pull factors that are highly personal and challenging to disentangle (Opitz-Stapleton et al., 2017). Voluntary migration (in which climate is just one factor of many) could be a positive adaptation strategy, enabling people to seek less climate-sensitive livelihoods, for instance. Loss and damage finance is primarily concerned with displacement (involuntary migration). In this scenario, people are forcibly displaced by extreme weather events such as droughts and floods, or slow-onset changes such as sea-level rise (Thalheimer and Webersik, 2020).

In the Sahel, up to 32 million people could be displaced within their own countries due to climate change by 2050, in the absence of any adaptation or resilience-building measures (Rigaud et al., 2021). Regardless of whether more optimistic or pessimistic climate scenarios are analysed, mobility in the region in which climate impacts play a consideration is likely to increase over the next 30 years and make up a larger proportion of overall internal migrants over time (ibid.).

A study modelling climate change-related migration found that water availability is the most important factor influencing migration. The Mali—Mauritania border and southern Niger are considered potential hotspots for outmigration. Coastal areas of West Africa are also likely to be hotspots of outmigration, as sea-level rise and flood hazards make life increasingly untenable (ibid.).

Linking extreme weather events and human mobility has not yet been a focus of attribution studies in the Horn of Africa (Thalheimer, 2020). Yet there in particular, increasing temperatures, drought and erratic rainfall have been factors in displacement and migration. As recently as November 2022, 1.8 million people were displaced by meteorological drought in Djibouti, Ethiopia, Kenya and Somalia (International Organization for Migration, 2022). This was exacerbated by higher temperatures due to climate change (Kimutai et al., 2023).

Similarly, the consecutive droughts of 2016–2017 and 2021–2023 triggered widespread migration among pastoralists on the Ethiopia—Kenya—Somalia border. More than 1.2—1.3 million people have been forced to move to Somalia since 2022 (Bogale and Erena, 2022; OCHA, 2024). In these contexts, the loss of home, whether temporary or permanent, is only one component of people's suffering. Research in Ethiopia, Kenya and Somalia shows that this large-scale displacement is linked to migration and lack of vaccination, gender-based violence for women and girls, and mental health problems (Lindvall et al., 2020).

6.4 Loss of ecosystem services and biodiversity

Ecosystem services form the backbone of a broad range of economic and social systems but can be highly susceptible to climate change impacts. Ecosystem services provide the linkage between natural and human systems, and are important for provisioning food and water supply, regulating flood impacts or the spread of disease, and supporting agricultural productivity, among a range of other services (UNEP, 2016).

When ecosystem services are lost or damaged, there are cascading effects on human systems, particularly in rural communities where livelihoods are intimately tied to environmental conditions. Importantly, however, linking loss of ecosystem services exclusively to changes in the climate is an oversimplification of the range of human actions that affect ecosystem service provisioning. Insufficient investment in water infrastructure, agricultural inputs and technologies, and poor land-use planning can greatly impact ecosystem services. These adaptation measures should be a first defence against avoidable losses and damages (ibid.).

The drylands of East Africa have experienced decreased precipitation in the long rainy season from 1980 to 2010, which, combined with land degradation, has resulted in loss of soil moisture (ibid.). In Ethiopia, a study of non-economic loss and damage recorded the loss of ecosystem services as the result of springs drying up from disrupted rainfall patterns. People were forced to travel extremely long distances to secure water for their livestock. Among the loss and damage people experienced associated with disrupted rainfall, the loss of ecosystem services was felt particularly severely (Hirsch et al., 2017). These findings align with studies such as that of Anyamba (2014), which found that disrupted rainfall patterns and severe droughts are likely to cause variations of up to 80% in agricultural production and create conditions conducive to disease outbreaks. These environmental impacts not only threaten agricultural productivity but also compromise the resilience of food production systems (IPCC, 2014).

7. CONCLUSIONS AND POLICY RECOMMENDATIONS

This study has produced original analysis and provided a review of existing literature to highlight the current and potential future losses and damages from climate change in the SGHA region. This is intended to support governments in their assessment of loss and damage and in their accessing of loss and damage finance.

This study has revealed a number of important gaps and biases in the availability and quality of data and information on losses and damages (see Figure 10 for an overview of these gaps). Yet one of the most important conclusions from the research is that data gaps should not present an obstacle to allocating urgently needed finance for addressing loss and damage from climate change. If loss and damage finance were to be directed only towards places with comprehensive quantitative data of climate-attributable loss and damage, distribution of loss and damage finance would be highly unequitable.

The Transitional Committee of the Loss and Damage Fund recognises that allocation decisions should rely on: *'the best available data and information from entities such as the IPCC and/or pertinent knowledge from Indigenous Peoples and vulnerable communities on […] loss and damage, recognising that such data, information, and knowledge may be limited for specific regions and countries'* (Transitional Committee, 2023). This is critical to ensuring that loss and damage can be directed to those who suffer most acutely from different forms of loss and damage.

On the basis of the findings of this study, we present our recommendations to members of the Loss and Damage Fund Board, loss and damage negotiators from SGHA countries, and the entities supporting loss and damage finance mechanisms. We hope they will assist them in their efforts to establish the details of the Fund:

1. **Speed up the establishment of the Loss and Damage Fund, resource it adequately and ensure access for vulnerable countries.** Loss and damage from climate change is occurring on a massive scale, with an estimated $26.2 billion in direct losses in the SGHA region between 2000 and 2022, of which $11.5 billion could be attributable to climate change. By addressing these losses and damages in vulnerable countries as quickly as possible, the Loss and Damage Fund and complementary loss and damage financing arrangements will avoid compounding losses and entrenching poverty traps.

2. **Increase adaptation and anticipatory humanitarian finance to avert and minimise the disproportionately high human cost of climate change in the SGHA region, to complement finance to address loss and damage through the Loss and Damage Fund.** Overall, SGHA countries experienced 4.7 times more human deaths that can be attributable to climate change. Moreover, 2.3 times more people were affected in the region, compared with all other African countries combined, between 2000 and 2022. Where climate-related loss and damage is exacerbated by underlying factors such as poverty, fragility or conflict, major investments in adaptive capacity and sufficient anticipatory humanitarian finance are needed. This will help avert and minimise loss and damage. Furthermore, any additional

finance, for example finance made available through the Loss and Damage Fund, can help address the residual loss and damage that cannot be reduced through adaptation measures.

3. **Invest in more comprehensive loss and damage data collection in fragile and conflict-affected states.** In more fragile contexts, data and other information on loss and damage is weaker and/or missing. Rather than a sign that loss and damage is not occurring, this usually indicates low institutional capacity, which disguises acute needs. Investment in data collection needs to close existing gaps in national and international disaster impact databases as well as broaden them to cover 'under-represented' types of loss and damage, for example indirect impacts, losses and damages from slow-onset processes, and non-economic losses and damages. Gaps in the geographic and hazard coverage of attribution studies to facilitate analysis of the share of total losses and damages attributable to climate change are another area worthy of attention. The Santiago Network is well placed to support these efforts globally and through technical assistance directly to countries. In the meantime, by ensuring that access to, and allocation from, the Loss and Damage Fund is not conditional on data and attribution studies being available, the Board and management entity of the Fund can help ensure the Fund seeks to redress rather than contribute to inequities in terms of international climate finance flows.

4. **Expand beyond standard data collection and assessment methodologies to better document and quantify indirect, non-economic and slow-onset losses and damages.** National governments lack data on slow-onset and non-economic loss and damage in current PDNAs. These tend to be strongly focused on crop losses, infrastructure damage, and deaths or injury from hazards. Alternative methodologies, such as contingent valuation methods or other participatory data collection approaches, can help capture more diverse losses and damages: loss of heritage, social cohesion, climate-induced migration, mental distress, loss of health or loss of education. They are also more appropriate for understanding the subjective nature of losses and damages that cannot be bought and sold on markets.

5. **Prioritise understanding how loss and damage affect women, children, elderly people and marginalised groups to determine the true distribution of loss and damage costs and design targeted measures to address them.** Losses and damages fall disproportionately on the most vulnerable members of society. At a minimum, PDNAs need to disaggregate gender and other key indicators of social vulnerability. Where possible, the government, local civil society and academic institutions should conduct bespoke assessments of loss and damage that consider gender, age and sociopolitical marginalisation, so these losses can be better reflected in national loss and damage financing strategies.

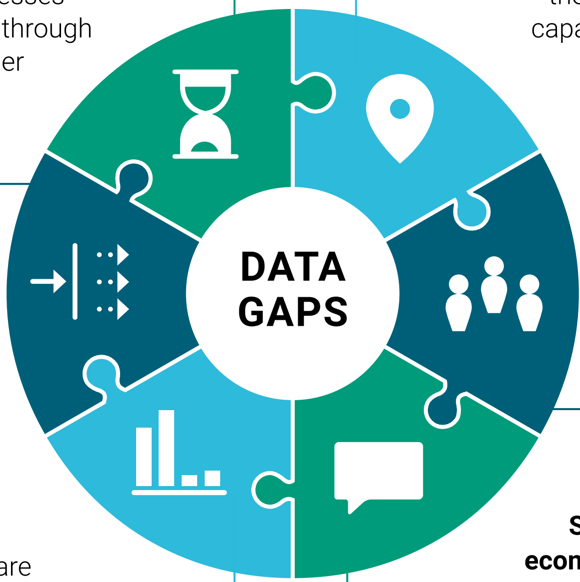
FIGURE 10: DATA GAPS AND BIASES IN THE AVAILABILITY AND QUALITY OF DATA AND INFORMATION ON LOSSES AND DAMAGES

Slow-onset processes

Information on losses and damages from slow-onset processes tends to be assessed through individual studies rather than systematically.

Geographic bias

Low-income countries lack the financial and technical capacity for data collection.



Indirect impacts

Human health and well-being, access to education, income, and cultural and social factors are poorly documented.

Gender, marginalised groups and indigenous people

Existing data is not often disaggregated by gender or focused on marginalised groups.

Hazard data

Floods and droughts are represented more clearly than slow-onset events and heat stress.

Subjective data on non-economic loss and damage

People's perspectives are not well captured in loss and damage studies and are not easily quantified.

Source: Authors' own.

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