UN environment programme

Too Little, Too Slow

Climate adaptation failure puts world at risk

Online Annexes

Adaptation Gap Report 2022

ISBN: 978-92-807-3982-4
Job Number: DEW/2480/NA

Suggested citation
United Nations Environment Programme (2022). *Adaptation Gap Report 2022: Too Little, Too Slow – Climate adaptation failure puts world at risk — Online Annexes.* Nairobi. https://www.unep.org/adaptation-gap-report-2022

Co-produced with:
UNEP Copenhagen Climate Centre and the World Adaptation Science Programme (WASP)

UN environment programme | copenhagen climate centre

WASP WORLD ADAPTATION SCIENCE PROGRAMME

Supported by:

MINISTRY OF FOREIGN AFFAIRS OF DENMARK

Belgium partner in development

Sweden Sverige

UNEP promotes environmentally sound practices globally and in its own activities. Our distribution policy aims to reduce UNEP's carbon footprint.

Too Little, Too Slow

Climate adaptation failure puts world at risk

Online Annexes

Adaptation Gap Report 2022

Annex 2.A: Data sources used to assess the status of national adaptation planning worldwide and the presence of quantified targets

To assess the state of national adaptation planning worldwide, the analysis presented in section 2.2.1 and 2.2.2 analysed national plans, strategies, policies or laws that were explicitly and primarily focused on adaptation, or more broadly, on climate change. This included national adaptation plans (NAPs), adaptation communications ('adcoms'), national communications and national climate change laws and policies available in the Climate Change Laws of the World (CCLW) and Climate Policy Radar databases as at 31 August 2022. Links to databases containing the national adaptation planning instruments assessed in sections 2.2.1 and 2.2.2 are provided in box 2.A.1.

Box 2.A.1 Databases containing national adaptation planning instruments

Climate laws and policies (via Climate Policy Radar): https://climatepolicyradar.org/.

Climate laws and policies (via CCLW): https://climate-laws.org/.

Nationally determined contributions (NDCs): https://www4.unfccc.int/sites/ndcstaging/Pages/Home.aspx.

National communications (Annex I): https://unfccc.int/NC7.

National communications (non-annex I): https://unfccc.int/non-annex-I-NCs.

Adaptation communications: https://unfccc.int/topics/adaptation-and-resilience/workstreams/adaptation-communications.

National adaptation plans (NAPs): https://www4.unfccc.int/sites/NAPC/Pages/national-adaptation-plans.aspx.

For countries for whom a national adaptation planning instrument was not identified through any of the databases in box 2.A.1, the assessment was supplemented by basic search engine (Google) research.

Other plans, strategies, policies or laws that were not primarily focused on these areas but that are nonetheless relevant for adaptation – such as national development plans, national environmental policies and national disaster risk management strategies – were therefore noted, but not included in this overall tally. National Adaptation Programmes of Action (NAPAs) were also considered separately from the overall tally due to their unique role as a tool for least developed countries (LDCs) to identify and act on urgent priority adaptation activities, rather than an instrument to facilitate an overarching or holistic adaptation response.

Annex 2.B: Examples of quantified targets

Table 2.B.1 referred to in section 2.2.2 of chapter 2 provides examples of quantified targets contained in national planning instruments.

Table 2.B.1 Examples of national quantified adaptation targets across sectors

Target sector/ area	Target type	Examples of quantified targets	Source
Cross-cutting	Outcome/ impact	Zero climate-related fatalities by 2030	Dominica NDC
Cross-cutting	Outcome/ impact	Enhance adaptive capacity, strengthen resilience and reduce vulnerability by half by 2030	Sierra Leone NAP
Cross-cutting	Outcome/ impact	Average damages per flood event (calculated in millions Albanian Lek) are reduced by 5% for each subsequent period of 5 years	Albania NAP
Health	Outcome/ impact	10% reduction in the number of cases of human vector-borne diseases associated with climate change (decadal average) by 2030	Portugal adcom
Coastal zones	Outcome/ impact	Prevent any permanent loss of land to rising sea levels on Tonga's four main islands	Tonga NDC
Coastal zones	Output	Every coastal community has a special management area and protected coastal environment by 2035	Tonga Climate Change Policy (2016)
Urban areas	Output	By 2025, adaptation measures have been promoted in at least 30% of cities with more than 5,000 inhabitants to address vulnerabilities and improve their adaptation capacities	Uruguay NDC
Education	Output	By 2025, climate change-related education will be included in all secondary schools and 2,000 climate change adaptation resource people will be mobilized locally	Nepal NDC
Infrastructure (energy)	Output	Increase the number of companies participating in energy-efficient water use initiatives by 40% from the baseline [by 2030]	Kenya NDC
Land use	Outcome/ impact	Increase forest cover to at least 10% of total land area	Kenya NDC
Land use	Outcome/ impact	Increase forest cover to at least 10% of total land area by 2022	Kenya National Climate Change Action Plan (NCCAP) 2018–2022
Infrastructure	Output and outcome	100% of community and sports infrastructure and assets are climate-resilient (to withstand, at a minimum, Category 4 tropical cyclones) and have adequate water harvesting and storage systems by 2030	Antigua and Barbuda NDC
Coastal zones	Output	10% coastal and marine areas gazetted as protected areas by 2020 against a 2016 baseline	Eleventh Malaysia plan 2016–2020

Annex 2.C: Inclusiveness

Annex 2.C provides additional information relevant to section 2.3 that could not be included in the main chapter due to a desire to keep the section short and concise. Information moved to this annex includes:

- A description of the methodology applied in this analysis (section 2.C.1)
- An expanded version of the key findings of this analysis (organized by disadvantaged group – section 2.C.2)
- An overview of the keywords used in this analysis (organized by disadvantaged group) and the number of documents in which these keywords appeared (section 2.C.3)

2.C.1 Methodology

Keyword lists were created for each group, and search tools were used to identify instances of each keyword across the full texts of 563 English-language national law and policy documents whose contents relate directly to climate change adaptation, drawn from the database maintained by Climate Policy Radar. These documents were in turn drawn from the corpus of the CCLW database, operated by the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science. This corpus includes documents from all world regions as defined by the World Bank (2022). Please see the CCLW methodology page for an account of how laws and policies were identified as relevant to adaptation.

While documents from a wide range of countries were studied, it has not been possible to search the full text of every adaptation-relevant law and policy document, and fewer documents published in certain regions were available compared with others. This analysis is therefore intended to provide a high-level overview, not an exhaustive account, of inclusiveness in adaptation laws and policies, with a view to demonstrating the potential for natural language processing and other technologies to support the analysis of adaptation policy in future research.

Scope of research

Tables 2.C.1, 2.C.2 and 2.C.3 provide an overview of the laws and policies evaluated in this analysis.

Table 2.C.1 Number of adaptation laws and policies examined

Parsed documents in corpus	1,006
Of which are adaptation-relevant	563
Total keyword instances	31,892

Table 2.C.2 Number of adaptation laws and policies examined, according to date of publication

Pre-2000	25
2000–2010	119
2011–2021	418

Table 2.C.3 Number of adaptation laws and policies examined, according to region of publication

East Asia and Pacific	Pre-2000	9
	2000–2010	38
	2011–2021	130
	Total	**177**
Europe and Central Asia	Pre-2000	3
	2000–2010	20
	2011–2021	87
	Total	**111***
Latin America and Caribbean	Pre-2000	1
	2000–2010	14
	2011–2021	34
	Total	**49**
Middle East and North Africa	Pre-2000	1
	2000–2010	2
	2011–2021	11
	Total	**14**
North America	Pre-2000	2
	2000–2010	0
	2011–2021	4
	Total	**6**
South Asia	Pre-2000	3
	2000–2010	13
	2011–2021	39
	Total	**55**
Sub-Saharan Africa	Pre-2000	6
	2000–2010	32
	2011–2021	113
	Total	**151**

*Excludes one document published in 2022

2.C.2 Detailed findings

Indigenous peoples

References to indigenous peoples were identified in 178 of the 563 adaptation laws and policies studied.

Mention of indigenous peoples frequently included reference to indigenous or traditional knowledge, particularly regarding adaptation in agricultural practice, weather and climate patterns, forecasts, disaster preparedness and early warning systems.

A strong theme in reference to indigenous or traditional knowledge in adaptation laws and policies was the acknowledgement that governments have so far insufficiently harnessed or understood it. Accordingly, where indigenous or traditional knowledge was referred to in the context of specific policy measures, these frequently included the creation of frameworks for recognizing and protecting knowledge as well as the creation of repositories for knowledge recording and documentation.

Gender

References to gender were identified in 345 of the 563 adaptation laws and policies studied, including frequent general recognition of the need to integrate gender considerations into adaptation policy design and development.

This analysis supports a number of trends around gender and adaptation policy identified in the 2021–2022 NAP Global Network Synthesis Report, for example:

- **Framing of gender issues:** references to gender issues in adaptation laws and policies appears to have increased over time, with a number of countries publishing strategies specifically devoted to addressing gender and climate change.

- **Positioning of women:** references to women range from accounts of the vulnerability of "women and children" to the impacts of climate change to recognition of the agency of women and their role in adapting to climate change, including through knowledge transfer and the preservation of biodiversity.

Migrants

References to migrants – a group which, for the purpose of this research, includes refugees and internally displaced persons,– were identified in 272 of the 563 adaptation laws and policies studied.

Displacement caused by climate change features strongly across references to migrants, both in the context of the strategic planning of countries more immediately exposed to the impacts of climate change and in immigration policy in less vulnerable countries (as discussed in Austria's [2017] Adaptation Strategy).

The analysis highlighted apparent differences in the principles underpinning the approaches taken by different countries to handling climate-related displacement. Whereas Kiribati's (2013) National Framework for Climate Change and Climate Change Adaptation articulates the Government's advocacy for "permanent migration as a form of adapting to the adverse effects of climate change", The Federated States of Micronesia's (2013) Nationwide Integrated Disaster Risk Management and Climate Change Policy makes the strategic objective to "Prevent environmental migration through adaptation strategies".

Children and young people and future generations

References to children, young people and future generations were identified in 436 of the 563 adaptation laws and policies studied.

Three key themes observable among these references are:

- Recognition that sound adaptation policy is necessary to ensure the socioeconomic well-being of future generations

- Education of young people and future generations as a means of facilitating improved adaptation to climate change

- Importance of ensuring continuity of education infrastructure as a key element of climate change adaptation

In light of the United Nations Children's Fund report, Are Climate Change Policies Child-Sensitive? (Pegram and Colon 2019), which found direct reference to children or youth in only 42 per cent of NDCs, these findings suggest that children and young people may be somewhat better represented within national adaptation laws and policies, though this does not necessarily suggest that they are the subject of concrete policy measures.

Local communities

References to local communities were identified in 386 of the 563 adaptation laws and policies studied.

In particular, references to community-based adaptation projects emerged as a trend and their importance was recognized in particular for disaster risk management, forestry conservation and resilience in the agriculture sector.

Persons with disabilities

References to persons with disabilities were identified in 186 of the 563 adaptation laws and policies studied.

These references are very frequently couched in the context of providing protections for vulnerable groups – a trend identified in Fiji's (2018) NAP as one which can "diminish agency", compared with rights-based frameworks for adaptation planning which emphasize disadvantaged groups as active agents of change.

It will be valuable to continue monitoring the framing of references to persons with disabilities within adaptation laws and policies.

2.C.3 Keyword counts

Persons with disabilities

able-bodied	11
adaptive technology	1
assistive technology	1
blindness	8
deafness	2
disabilities	459
disability	320
disabled	234
handicap	4
handicapped	22
hearing impaired	4
hearing impairment	1
hearing loss	1
physical accessibility	7
visual impairment	1
visually impaired	3

Future generations

future generations	549
future population	8
generations to come	32
intergenerational	66
succeeding generations	1

Gender

boys	150
empowerment of women	60
female	424
gbv	21
gem	21
gender	2998
gender bias	6
gender development index	5
gender discrimination	11
gender equality	504
gender equity	119
gender gap	19
gender inequality	42
gender norms	4
gender parity	56

gender roles	19
gender-based constraints	1
gender-based violence	83
gendered	24
gid	7
girls	413
patriarchal	5
reproductive rights	9
sexual and reproductive health and rights	1
transgender	2
women	3446
women in development	9
women's empowerment	7
women's rights	5

Indigenous peoples

first nations	19
indigenous communities	52
indigenous culture	6
indigenous knowledge	160
indigenous land	5
indigenous people	45
indigenous peoples	217
indigenous population	12
indigenous rights	2
indigenous society	1
indigenous territory	5
native communities	3
native land	9
native people	4
native peoples	6
native population	1
native rights	1
traditional ecological knowledge	9
traditional knowledge	250

Children and young people

babies	11
baby	20
child	831
childcare	28
children	2058
higher education	445

infancy	19
infant	203
juvenile	56
orphan	8
primary education	181
schools	1322
secondary education	234
tertiary education	183
young people	407
young persons	14
youth	1828

Migrants

asylum	11
border checks	1
border control	37
climate displacement	5
climate migration	2
deportation	2
displaced people	29
displaced persons	63
emigrant	1
emigration	43
forced displacement	2
human displacement	2
human mobility	18
human trafficking	87
immigrant	3
immigration	152
internal displacement	17
labour mobility	48
mass migration	3
migrant	70
migration	733
people smuggling	2
people trafficking	1
refugee	32
statelessness	6

Local communities

community development	344
community empowerment	28
local communities	1074
local community	261
local council	58
local customs	7
local democracy	2
local economies	50
local economy	72
local government	1767
local housing	9
local traditions	5
town council	19

Inclusiveness (general)

discrimination	415
equality	979
inclusive	1819
inclusiveness	155
inclusivity	58
marginalization	18
marginalized groups	42
minorities	66
minority groups	19
protected characteristics	1

Adaptation–mitigation co-benefits

synergies between adaptation and mitigation	10
synergies between mitigation and adaptation	2

Annex 2.D: Implementability

Annex 2.D provides additional information relevant to section 2.4 that could not be included in the main chapter due to a desire to keep the section short and concise. Information moved to this annex includes:

- A description of the methodology applied in this analysis (section 2.D.1)
- An expanded version of the key findings of this analysis (section 2.D.2)

2.D.1 Methodology

The analysis is based only on information from the 38 NAPs received, as at 31 August 2022. While this sample is relatively small, given there are 154 developing countries, the type of information contained in the NAPs and hence the results of the analysis will likely remain the same, while the consistency and quality will continue to improve over time. The NAPs are prepared based on the technical guidelines by the Least Developed Countries Expert Group (LEG) (United Nations Framework Convention on Climate Change [UNFCCC] LEG 2012) and hence contain the essential characteristics for effective adaptation planning and implementation based on national circumstances.

Each of the 38 NAPs was examined for information related to the five essential elements to enable implementation of adaptation as outlined in the main chapter. The elements are derived from the essential functions of a NAP developed by LEG (see UNFCCC LEG 2022), and further work on characteristics of a NAP ready for implementation:

- Adaptation vision, goals and/or objectives of the country
- Trends in climate changes
- Prioritized adaptation actions and indicative time frames
- Capacity needs for implementation
- Partners to support implementation

The analysis focused on the details related to the elements, going beyond the simple investigation of whether such elements existed or not. Text of sections of the NAPs relating to the elements was closely examined to identify specific characteristics and details. This was done in comparison with the information from the NAP technical guidelines (UNFCCC LEG 2012) and the essential functions for the NAP. For the vision, goals and objectives, for instance, the analysis considered what areas these focused on and the specific details regarding the national adaptation agenda and time frames. On climate trends, the analysis focused on the extent to which the details identified climate risks and vulnerabilities. Adaptation priorities were categorized into key systems observed in the NAPs, namely agriculture and food security, water resources, forestry, ecosystem services, coastal zones and low-lying areas, human health, disaster risk reduction, urban areas and human habitats, key economic activities and services, and vulnerable groups. The analysis of partners considered the types of partners envisioned and their specific roles in implementation. This included partners envisioned to provide technical assistance, financial support, technology transfer and capacity-building for adaptation.

2.D.2 Detailed findings

Adaptation vision, goals and/or objectives of the country

While all of the countries have clearly defined visions, goals and objectives to guide their adaptation planning and implementation, their focuses and levels of detail vary between countries according to each one's individual process of formulation and implementation of its NAPs. The vision, goals and objectives are either framed around climate-resilient development, are linked to the overall socioeconomic or sustainable development context pathways of the country, are focused on reducing vulnerability, strengthening resilience and building adaptive capacity, positioning the NAP as the main guiding framework for adaptation in the country, or a combination of these. These goals and objectives also contain provisions for coordination and leadership, inclusiveness, implementation, resource mobilization and finance, and internal and external cooperation towards climate-resilient development. In many cases, the vision, goals and objectives are also extended to territorial and subnational planning (such as in Albania [2021], Kuwait [2021], Nepal [2021], Paraguay [2021] and Sierra Leone [2021]).

Trends in climate changes

All of the 38 submitted first NAPs contain information on or make reference to trends in climate change, largely from existing studies. The information in them is of limited degree and scope due to the lack of available resources and information, making more comprehensive analyses impossible. Many of the countries are planning to undertake comprehensive analyses in subsequent iterations of their NAPs. Analysis of the past and present climate trends, variability and extremes, and potential future changes in climatic contributing factors help to identify baseline conditions as well as to describe an envisioned climate future for a country or particular area of focus (World Meteorological Organization [WMO] and Green Climate Fund [GCF] 2021). This in turn enables public and private actors, including development financing institutions, governments and private sector investors to take an evidence-based approach to addressing risks arising from climate variability and change.

Prioritized adaptation actions and indicative time frames

The main features of a NAP are the adaptation priorities planned to be implemented and their associated costs and timelines for implementation. When clearer and more details are provided, implementation of the NAP becomes easier. Prioritized adaptation actions in the form of policies, projects and/or programmes are the primary information to guide implementation (UNFCCC LEG 2012). The majority of the adaptation priorities from the NAPs are in agriculture and food security (16 per cent) and economic activities and services (20 per cent). The latter is becoming more relevant than in previous plans and strategies (such as the NAPAs) because NAPs by design link closely with national development, as evidenced in the vision, goals and objectives. Urban areas and human habitats (15 per cent) are also becoming salient in adaptation priorities, which can be linked to devastating climate impacts all over the globe. Ecosystems services (14 per cent) remain a strong foundational pillar for natural resilience.

Other important features include the explicit priorities that target vulnerabilities as well as overall cross-cutting considerations. Guided by the country's adaptation vision and objectives, the actions provide clear identification of systems to be addressed, how climate change is an issue and how interventions will help achieve development gains/ positive outcomes. Agriculture, livestock and fisheries (23 per cent), infrastructure and spatial planning (11 per cent), water resources (10 per cent), health (10 per cent) and ecosystem services (8 per cent) account for the largest number of prioritized projects. However, most of the actions cut across multiple sectors.

Table 2.D.1 provides the number of prioritized adaptation actions contained within NAPs submitted to the UNFCCC (as at 31 August 2022) broken down by sector.

Table 2.D.1 Figures on number of adaptation priorities by sector contained in national adaptation plans submitted as at 31 August 2022

Systems	Number of projects	Percentage
Agriculture and food security	**76**	**17%**
Agriculture	36	8%
Livestock	7	2%
Fisheries	16	3%
Agriculture; Livestock; Fisheries	8	2%
Agriculture; Water resources	1	0%
Forestry; Agriculture; Livestock	8	2%
Water resources	**46**	**10%**
Forestry	**13**	**3%**
Ecosystem services	**66**	**14%**
Coastal zones and low-lying areas	**16**	**3%**
Human health	**55**	**12%**
Disaster risk reduction	**23**	**5%**
Urban areas and human habitats	**70**	**15%**
Urban areas	15	3%
Infrastructure and spatial planning	55	12%
Key economic activities and services	**91**	**20%**
Industry	1	0%
Energy	37	8%
Mining	7	2%
Education	17	4%
Tourism	29	6%
Vulnerable groups	**6**	**1%**

Capacity needs for implementation

In addition to projects and programmes in key systems, the NAPs contain activities to strengthen adaptation planning at the national level and to facilitate implementation of adaptation. These are presented as needs within the identified adaptation priorities or as part of implementation strategies. Notably, while all the NAPs identify capacity needs for implementation, availability of information and details vary. This is due to the absence of common methodologies for assessing adaptation needs as well as the fact that most countries apply learning by doing from their own adaptation experience. Capacity needs are mostly related to institutional arrangements and coordination (by 25 per cent), awareness and capacity development at all levels and parts of society (20 per cent), systems to access financial and other support (15 per cent), systems to facilitate the integration of adaptation into national development planning (15 per cent), data and information collection and analysis (13 per cent), multi-stakeholder engagement including regarding youth, private sector, local communities, indigenous peoples and others (13 per cent). The capacity needs are mostly related to institutional arrangements and coordination systems to facilitate the integration of adaptation into national development planning, data and information collection and analysis, systems to access financial and other support, approaches to address losses and damages, multi-stakeholder engagement including regarding youth, private sector, local communities, indigenous peoples and others, approaches to target the most vulnerable, awareness and capacity development at all levels and parts of society.

Partners to support implementation

A wide range of national, regional and international partners are identified throughout the NAPs to support implementation. Government agencies in charge of coordination climate change work and related national committees will serve as central coordination mechanisms for implementation, to engage the full set of partners including line ministries, local non-governmental organizations, civil society, local communities, special groups, academia, research institutions, bilateral and multilateral partners, international financing institutions, regional centres and networks. Some NAPs consider gender explicitly in their strategy on partners and resource mobilization.

Annex 3.A: Challenges in estimating international adaptation finance flows

The lack of universally agreed approaches to account for international adaptation finance has given rise to multiple accounting practices. Bilateral and multilateral adaptation finance providers interpret key accounting parameters in different ways. This makes it very difficult to compare the reported adaptation finance figures of countries and institutions and to interpret multi-year changes. This annex provides a detailed account of the various challenges to developing a coherent understanding of global finance for adaptation.

Defining adaptation: This report takes a highly context-specific view of adaptation. It must take into account multiple future climate scenarios, uncertainty within these scenarios and socioeconomic factors that cause vulnerability. Differentiating between adaptation and 'good' development can be complicated. This creates challenges for measuring adaptation finance as a separate category from development finance, disaster risk reduction finance or humanitarian finance. According to the Organisation for Economic Co-operation and Development (OECD) Rio marker for adaptation, which is used to guide reporting by climate finance providers on their financial contributions, an activity should be classified as adaptation-related if "it intends to reduce the vulnerability of human or natural systems to the current and expected impacts of climate change, including climate variability, by maintaining or increasing resilience, through increased ability to adapt to, or absorb, climate change stresses, shocks and variability and/or by helping reduce exposure to them. This encompasses a range of activities from information and knowledge generation, to capacity development, planning and the implementation of climate change adaptation actions" (OECD 2016, p. 4). In addition, private sector actors might not realize their activities are contributing to adaptation to climate change, instead referring to them as business continuity or contingency planning, for example. To address the potential challenge of defining and measuring adaptation, the *Adaptation Solutions Taxonomy* (Trabacchi *et al*. 2020) establishes an approach to identifying companies that are supportive of adaptation and climate resilience.

Precision: Only a small number of providers (mainly multilateral) have component-level adaptation finance accounting (where only a share of the project volume is counted as adaptation finance). Most providers count the whole amount of an adaptation project as adaptation finance. This can lead to huge differences in accounting, particularly for climate-resilient infrastructure, where the largest share of the total amount is not adaptation-related.

Financial instruments: While some providers only account for concessional flows that meet the strict official development assistance (ODA) criteria, others also account for non-concessional loans, equity or guarantees under adaptation finance. Adaptation finance provision is often reported at face value (instead of, for example, in grant equivalents). This can mean the financial contributions of such providers appear considerably larger on paper than in practice.

Newness and additionality: Some providers only account and report as adaptation finance the financial flows that they consider 'new and additional' to ODA. The terms "new and additional" are included in article 4.3 of the United Nations Framework Convention on Climate Change (UNFCCC). However, the interpretation of these terms varies considerably among providers.

Data coverage of sectors and sources: While good data coverage exists around international concessional public finance flows (predominantly ODA from OECD countries), far fewer data exist around mobilized finance from domestic and private sector sources. As data coverage increases, care must be taken to ensure it does not lead to overestimates of resources devoted to adaptation that are actually the product of better data availability.

Double counting: Climate finance contributors use multiple mechanisms for reporting (for example, OECD Development Assistance Committee (DAC) and biennial reporting to the UNFCCC). Climate finance can also flow through institutions (for example, contributor countries provide resources to climate funds implemented by multilateral development banks (MDBs), which report both these and their own resources annually). This means care must be taken when aggregating data to avoid overinflating climate finance flows.

Other parameters: Currency conversions to increase comparability can be challenging. In addition, disbursements are not often adjusted to reflect falling technology costs, inflation or purchasing power parity. While some providers report committed adaptation finance, other providers report disbursement figures. For large multi-year loans, significant differences and fluctuations could be observed between yearly commitments and disbursements.

Changing accounting methodologies: Many providers have changed their climate finance accounting methodologies over time, making multi-year comparisons almost impossible.

Differing accounting methodologies: There are also unresolved methodological differences with respect to climate finance accounting, for example between the MDBs and many bilateral providers of adaptation finance, that remain to be reconciled.

Sources: Adapted from UNEP (2021) and based on Weikmans and Roberts (2019); UNFCCC Standing Committee on Finance (2018).

Annex 3.B: Finance flows data sources, data limitations and methodology for calculating finance flows from OECD DAC

Annex 3.B provides a detailed overview of the various ways in which finance providers report the provision of adaptation finance, and the limitations around using this data to estimate the levels of adaptation finance being provided.

Finance flows data sources and data limitations

Biennial reports submitted by Annex II Parties[1] are the official channel for disclosing information on climate finance under the UNFCCC. However, the most recent finance flows included in the latest biennial assessment (United Nations Framework Convention on Climate Change Standing Committee on Finance 2021) are from 2018, and data for 2020 are still emerging.

International public bilateral and multilateral finance flows as reported by providers are documented by the DAC database of the OECD (OECD 2022c) up to 2020. However, in their reporting to the UNFCCC, Annex II Parties use different coefficients to account for activities that are only partially adaptation-related through the Rio markers (OECD 2022b). In addition, coefficients exist to estimate the multilateral climate finance commitments attributable to developed countries.

OECD DAC data sources and scope

Data on climate-related financial support from the External Development Finance Statistics on Climate Change compiled by the OECD DAC are used to quantify the financial commitments reported as international public finance targeting climate adaptation. The data cover ODA and Other Official Flows (OOF). ODA consists of concessional financial contributions (grants and low-interest loans) with a main objective of promoting economic development and welfare in developing countries. OOF are official transactions that do not meet the concessionality conditions for eligibility of ODA, either because they have an insufficient grant element or their primary objective is not development-based (OECD 2009). The data cover the 2011–2019 period. The finance amounts are presented in constant prices, with inflation and exchange rate variations taken into account by adjusting to the base-year 2019, as recommended by the OECD DAC.

Methodologies for reporting climate-related finance

Two methodologies are currently used across the landscape of bilateral and multilateral finance providers to track and report climate change finance. Except for MDBs, which have their own methodology called Climate Components in OECD DAC, all finance providers use the Rio marker methodology, although both methodologies use compatible definitions of climate mitigation and adaptation (OECD 2018).

According to the Rio marker methodology, adaptation and mitigation can be targeted as a "principal" objective (whereby mitigation or adaptation "is explicitly stated as fundamental in the design of, or the motivation for, the activity"), a "significant" objective (whereby the objective "is explicitly stated but is not the fundamental driver or motivation for undertaking the activity") or may not be "targeted" at all (OECD 2016). MDBs track and report data on their climate-related contributions following their own Climate Components methodology (European Bank for Reconstruction and Development 2019). Based on this approach, MDBs determine the specific components of a transaction that directly contribute to mitigation, adaptation or both simultaneously.

The principal and significant markers used under the Rio marker approach are not mutually exclusive. For example, the same financial transaction can be reported as contributing

1 Annex II countries: Australia, Austria, Belgium, Canada, Denmark, the European Economic Community, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States of America.

to both mitigation and adaptation at the same time. The Rio marker methodology was established to assess the degree to which the objectives of the Rio conventions are mainstreamed into ODA, allowing for further cross-cutting analyses (for example, on the extent to which adaptation finance is gender responsive) (see Annex 3.D).

Annex II Parties have used the methodology as a basis for reporting on climate finance since 2010 (Weikmans *et al.* 2017; OECD 2020). To account for the fact that the Rio markers methodology was not originally designed to monitor financial pledges, most Annex II Parties scale down the volume of finance associated with the Rio markers in their financial reporting to the UNFCCC. They do so by using coefficients to differentiate between funding marked as targeting adaptation as a significant objective – reflecting that these projects have other principal objectives (such as biodiversity conservation or gender). These coefficients differ across Annex II Parties and range from 0 to 100 per cent (OECD 2019a; OECD 2019b; Oxfam International 2020). These coefficients, available from OECD (2022b) were used to calculate the adaptation finance amounts presented in this report.

An important difference between the Climate Components approach, used by the MDBs, and the Rio marker methodology, as reported to the OECD DAC, is that the former approach reports only the portion of the transaction that specifically targeted climate change, rather than the full value of each transaction (for those marked as principal objective). In addition, coefficients exist to estimate the multilateral climate finance commitments attributable to developed countries. These coefficients differ across MDBs and range from 0 to 100 per cent (with the remainder being attributable to developing countries). These coefficients, available from OECD (2022a) were used to calculate the adaptation finance amounts by MDBs presented in this report.

In the analysis, figures reported using the two different methodologies were taken at face value, as reported to the OECD DAC.

Data limitations

Self-reporting comes with some limitations. The attribution of financial support is subjective because the judgment and reporting are done by the finance providers and not independently verified. The definition of adaptation used by both methodologies leaves room for interpretation and the accounting methods differ (see Annex 3.A). Several studies claim that the self-reporting of finance providers and the lack of independent quality control result in low data reliability and sometimes substantial overestimations of finance flows (Toetzke, Stünzi and Egli 2022; Junghans and Harmeling 2012; Weikmans *et al.* 2017), especially for activities tagged as "significant" (Weiler, Klöck and Dornan 2018).

Last year's Adaptation Gap Report (AGR) found that more than one third of activities marked as having adaptation as a principal objective did not meet the respective OECD criteria (UNEP 2021). Finally, finance providers report historical data of loan amounts at face value, rather than using the grant-equivalent amounts, resulting in overestimates of loan amounts (Oxfam International 2020; Roberts *et al.* 2021). Moreover, financial flows reported include the administrative costs of finance providers, which can be high in some cases (Atteridge and Savvidou 2020). Furthermore, not all financial transactions in the OECD DAC databases are screened against the Rio marker for adaptation, so there may be adaptation-related finance flows that are not captured (Savvidou *et al.* 2021).

The establishment of standardized reporting mechanisms would enhance data quality. Despite the aforementioned limitations, the OECD DAC data provide the most comprehensive and comparable picture on international development finance for climate change (Weiler and Sanubi 2019; Doshi and Garschagen 2020; UNEP 2021).

Substantially more allocations are tagged as "significant" than "principal". Although there is no firm evidence on this trend, it may reflect efforts by countries to make their finance flows consistent with climate-resilient development pathways (article 2.1(c) of the Paris Agreement) as part of mainstreaming, which integrates climate adaptation in existing policies, programmes and plans. However, analyses identify over-reporting of adaptation-related finance due to ambiguous definitions (Weikmans *et al.* 2017) and political motives in reporting by finance provider institutions (Junghans and Harmeling 2012; Adaptation Watch 2015; Michaelowa and Michaelowa 2011). This means that caution must be exercised when interpreting the data and trends.

Finally, it is important to acknowledge that tracking the provision and reporting of finance does not provide much information about effective use of funds and it is therefore necessary to examine the effectiveness of financial contributions (Savvidou *et al.* 2021; UNEP 2021) (see chapter 5).

Annex 3.C: List of multilateral development banks covered by the chapter analysis

MDBs include: the African Development Bank, the Asian Development Bank, the Asian Infrastructure Investment Bank, the Caribbean Development Bank, the Central American Bank for Economic Integration, the Development Bank of Latin America, the European Investment Bank, the European Bank for Reconstruction and Development, the Inter-American Development Bank Group, the Islamic Development Bank, and the World Bank Group. Multilateral climate funds included are the Adaptation Fund, the Global Environment Facility (Least Developed Countries Fund, Special Climate Changes Trust Fund, General Trust Fund), and the Green Climate Fund.

Annex 3.D: Gender and climate justice in adaptation finance

Gender and other social inequities including those based on race, ethnicity, age, income and geographic location increase vulnerability to climate change impacts (Schipper *et al.* 2022). Adaptation approaches with poor understanding of the positive and negative connections between gender equity and adaptation actions can worsen existing gender and other social inequities (Schipper *et al.* 2022). Therefore, increased finance for climate change adaptation approaches that are equity-based and gender-sensitive is a central issue for climate justice (Heffron and McCauley 2018; Khan *et al.* 2020) since such approaches reduce vulnerability for marginalized groups across multiple sectors, including water, health, food systems and livelihoods (Schipper *et al.* 2022).

Even though the Rio marker methodology allows reporting of the extent to which adaptation finance is gender responsive, the biennial reports submitted by Annex II Parties to the UNFCCC Secretariat do not systematically include data on gender. Around 63 per cent of bilateral finance from Annex II countries marked as relevant to adaptation in 2020 was also marked as supporting gender equality. However, most of this adaptation-related finance (84 per cent) has a significant objective for the gender marker, compared to just 16 per cent for a principal objective. This is despite the approval of the UNFCCC Gender Action Plan at COP 23, which includes the use of gender-responsive finance as a core tool for implementation (UNFCCC 2017) and even though funded programmes considering gender dynamics have been found to be more effective and efficient (Roy *et al.* 2022; UNDP 2018).

While a number of multilateral climate funds are increasingly taking into account gender considerations in their governance and implementation (Schalatek and Stiftung 2019), best practices on gender budgeting have not yet been compiled or adopted and only a few funds are reporting gender-disaggregated results. Recent assessments of progress in implementing the gender mandates of multilateral climate funds highlight the need for more capacity-building support for implementing entities and strengthened guidance on monitoring and reporting (Adaptation Fund 2019; Climate Investment Funds 2020).

Among the most vulnerable populations, access to and provision of adaptation finance are essential to achieving climate justice and should be considered carefully in finance for adaptation, including addressing gender and other social inequities.

Annex 3.E: Private finance for adaptation

Governments are increasingly recognizing the importance of stimulating private investments in adaptation. For example, 64 per cent of the 128 new and updated nationally determined contributions (NDCs) submitted up to 4 January 2022 mention private sector investments. Nine of these include a dedicated section, some of which focus on adaptation Schipper *et al.* 2022; Pauw *et al.* 2022). Private investment in adaptation may also be incentivized through lawyers, who are increasingly pursuing strategic cases to encourage private (and public) actors to increase such investments (Barker, Dellios and Mulholland 2021; Setzer and Higham 2022).

Private sector finance for adaptation is not a panacea. This type of investment gravitates towards opportunities with attractive risk-return profiles, meaning it is unlikely to target the most vulnerable in least developed countries (LDCs) or non-market sectors (Pauw 2015; UNEP 2021). Furthermore, effectiveness is uncertain. Some investments only shift vulnerability to others (Pauw 2021) or increase vulnerability. For example, property developers might make short-term financial gains from developing on vulnerable coasts, creating long-term risks for others (Siders 2019). Two important developments are therefore that investors are starting to ask companies to disclose climate risks (Dale *et al.* 2021) and that governments are starting to develop policies for sustainable financial systems (UNEP 2021). Both may also improve information flows on private investment in adaptation.

Annex 4.A: Aim and scope of the chapter

The implementation chapter aims for a better understanding of implemented adaptation by analysing what types of actions are undertaken, by and for whom, where and against which climate hazards and risks. Tracking of financial flows does not answer how the funds are being spent and whether the intended objectives are being achieved, yet this information is vital for understanding adaptation progress. The implementation chapter is therefore an essential complement to the finance and planning chapters. Information on implementation is also a prerequisite for assessments of effectiveness (see chapter 5).

One of the challenges of a global assessment of adaptation is the lack of data sources with global coverage (United Nations Environment Programme [UNEP] 2017). Some countries have established, or are in the process of establishing, national adaptation databases (e.g. Germany, South Africa and the United Kingdom; on the latter, see Jenkins *et al.* 2022), but such data sets are currently only available for a small number of countries. The Adaptation Gap Report (AGR) 2022 must therefore rely on data from international donors, country reports to the United Nations Framework Convention on Climate Change (UNFCCC) and on information about implemented adaptation documented in scientific articles. Since its first edition in 2020, the implementation chapter has added new data sources and new features every year (see table 4.A.1). To provide sufficient space for new content while keeping the chapter's length constant, not all the aspects covered in any given year can be updated annually. It is therefore recommended to the reader to also consult the implementation chapters of AGR2020 and AGR2021 to gain the most comprehensive overview of adaptation implementation globally. Table 4.A.1 provides orientation about each year's new features.

The combination of multiple data sources is a requirement for obtaining a comprehensive picture of adaptation progress (Leiter 2015). This approach has been pioneered by the first implementation chapter in AGR2020 and has recently also been recommended by the Intergovernmental Panel on Climate Change (IPCC) (Garschagen *et al.* 2022). The data sources used in the Adaptation Gap Reports since 2020 complement the analysis of observed adaptation responses in the recent IPCC Working Group II Sixth Assessment Report (IPCC WGII AR6), which draws largely on adaptation actions documented in the scientific literature (O'Neill *et al.* 2022).

Table 4.A.1 Data sources and new features in the Adaptation Gap Report implementation chapter since 2020

AGR	Data sources	New features
2020	• Project documents from UNFCCC funds (AF, GCF, LDCF, SCCF) • Implemented adaptation reported in academic journals – preview of data from the Global Adaptation Mapping Initiative	• Combined implementation data from global funds serving the UNFCCC and/or the Paris Agreement
2021	• Project documents from UNFCCC funds • Bilaterally funded adaptation actions as reported by donors under the OECD DAC Creditor Reporting System • Implemented adaptation reported in academic journals (Berrang-Ford et al. 2021)	• 10 years of bilaterally funded adaptation actions • Overview of implemented adaptation reported in journal articles including a global map of actions and evidence of risk reduction
2022	• Project documents from UNFCCC funds • Bilaterally funded adaptation activities as reported by donors under the OECD DAC Climate-Related Development Finance data set • Adaptation communications submitted under the Paris Agreement (data on implemented adaptation)	• Analysis of the potential of bilaterally funded projects to achieve reductions in exposure or vulnerability to climate hazards • Information from the first adaptation communications submitted under the Paris Agreement • Data on actions that jointly address mitigation and adaptation

Notes: Please find the full names of the acronyms listed in the table as follows: Adaptation Fund (AF), Green Climate Fund (GCF), Least Developed Countries Fund (LDCF), Special Climate Change Fund (SCCF), Organisation for Economic Co-operation Development (OECD) Development Assistance Committee (DAC).

Due to its focus on implementation, this chapter only includes actions whose implementation has already begun or has been completed. Planning and readiness activities are not part of the chapter, but rather fall into the scope of the planning chapter. Information on the results of adaptation actions and on achieved risk reduction was included in the first two editions of the implementation chapter (UNEP 2021a; UNEP 2021b). This year, the chapter features a section on the potential for risk reduction through bilaterally funded adaptation actions while effectiveness is discussed in an additional chapter (chapter 5). Due to the space limitations of the report, the implementation chapter cannot cover sectoral, regional or topical implementation matters. Coverage of specific topics requires a separate chapter like the one on nature-based solutions in AGR2020 (UNEP 2021a). More detailed information on adaptation in sectors and regions is available in the IPCC WGII AR6 (IPCC 2022).

Annex 4.B: Data sources

4.B.1 Sections 4.2–4.4 on implemented adaptation actions

Project documents from UNFCCC funds

The primary data source that has been used by all editions of the implementation chapter thus far are documents of adaptation projects funded by the global funds that serve the UNFCCC and/or the Paris Agreement, namely the AF, GCF and the two climate funds under the Global Environment Facility (GEF): the LDCF and SCCF. While the LDCF and the SCCF are the primary funding sources under the GEF that focus on adaptation, the GEF Trust Fund also funds adaptation-relevant activities (see GEF 2022 for the recent evaluation by the GEF Independent Evaluation Office). The implementation chapter has not yet considered GEF projects without funding from the LDCF and SCCF, except for 23 projects from the discontinued funding window, Strategic Priority on Adaptation (2006–2010), due to its explicit focus on adaptation. These 23 projects are included in the total amount of adaptation projects presented in figure 4.1.

The list of relevant projects was obtained through the global funds' websites and shared with the AF secretariat and the GEF for validation. The latter was required because the GEF website does not publish project start dates, which are needed to check whether projects had moved from approval to actual implementation. Validation with the GCF secretariat was not undertaken in 2022, unlike in previous years, because all necessary information was available on its website and its consistent numbering of projects ensures that no project would be missed. To be included in the implementation chapter, projects of the above listed global funds had to:

- **Have started or be completed by or before 31 August 2022**. The chapter only counts projects marked as "under implementation" or as "completed" by the respective fund. Having been approved is not sufficient for inclusion. For instance, projects approved at the GCF Board meeting in July 2022 are not included, since their implementation had not started by 31 August 2022 (this year's cut-off date). A project's implementation status and start date is indicated on the websites of the AF and the GCF which show timelines for every project. LDCF and SCCF projects' start dates are not shown on their website but have been provided by the GEF secretariat.

- **Be primarily aimed at adaptation.** Only projects that were primarily and explicitly about adaptation to climate change are included. By default, this includes all projects of the AF and of the LDCF. Projects under implementation with SCCF funding were screened based on their project description to determine whether they primarily and explicitly concerned adaptation. All but one SCCF project were included (the excluded one focused primarily on renewable energy). All projects classified by the GCF under its funding theme of "adaptation" were included. Projects marked by the GCF as "cross-cutting", that is, jointly addressing mitigation and adaptation, are not included in figure 4.1 and section 4.2. These projects are analysed separately in section 4.5.

- **Concern implementation of actions, not planning or readiness**. In line with the scope of the chapter, any preparatory activities that take place before implementation e.g. planning, proposal development, accreditation and other readiness activities are excluded (they fall into the scope of the planning chapter). Accordingly, the following actions were excluded:

- AF: Technical assistance grants
- GCF: Any readiness activities under the GCF readiness support programme
- LDCF/SCCF: Technical assistance grants (which were mainly provided for by the development of NAPAs.

All project development activities were also excluded.

- **Have a volume of at least US$500,000.** To ensure a level of comparability of what counts as a "project", a minimum value of US$500,000 was defined. A small number of cases that met the three criteria above but remained below this threshold were excluded.

Bilaterally funded adaptation activities as reported by donors under the OECD DAC

The second data source used in this year's edition, introduced into the chapter in 2021, is donors' development aid reporting under the OECD DAC. Through this system, donors tag their funding as supporting particular topics such as climate change. Climate actions can be marked as aiming for mitigation, adaptation or both. A distinction is made between actions that primarily aim at adaptation, known as principal adaptation, and those that partially aim at adaptation, known as significant adaptation. Principal adaptation is defined as activities where adaptation is "explicitly stated as fundamental in the design of, or the motivation for, the activity. […]. In other words, the activity would not have been funded (or designed that way) but for that objective." (OECD 2016). Sections 4.2, 4.3 and 4.4 of the chapter only consider actions marked as "principal adaptation" by donors.

The database that was used is identical to that used for the finance chapter, namely the OECD DAC External Development Finance Statistics on Climate Change (OECD 2022). In contrast to the finance chapter, the implementation chapter does not analyse financial flows, but the number of principal adaptation entries per year and per sector and, as a new feature in this year's edition, the proportion of principal adaptation entries that are simultaneously marked as either principal or significant on mitigation (see section 4.5.1). The sectoral definitions shown in figure 4.4 are directly taken from the database, therefore showing the sectors as the OECD DAC defines them.

There has been repeated and well-substantiated critique about the quality of donors' self-labelling practices on adaptation, meaning that a sizeable number of activities marked as "principal" and "significant" do not primarily nor sufficiently concern adaptation (e.g. Weikmans *et al.* 2017; Cooperative for Assistance and Relief [CARE] 2021; Toetzke, Stünzi and Egli 2022). Last year's implementation chapter found that more than one third of activities marked as "principal objective adaptation" did not meet the respective OECD criteria contained in OECD's Rio Markers for Climate report (2016) (UNEP 2021b). The absolute number of entries contained in the OECD DAC Creditor Reporting System database therefore needs to be interpreted with great care. For this reason, section 4.5.1 on mitigation–adaptation linkages does not report the absolute number of entries, but only the percentage of those marked as adaptation that are also marked as mitigation.

Adaptation communications submitted under the Paris Agreement

A new data source in this year's implementation chapter are adaptation communications that countries submit under the Paris Agreement (UNFCCC Adaptation Committee 2022). Adaptation communications can be sections in other documents (nationally determined contributions [NDCs], national adaptation plans [NAPs] or national communications) that countries designate as their adaptation communication, or they can take the form of stand-alone documents. This year's chapter only considers the latter, because almost all of them have been submitted over the preceding 12 months, meaning they contain potentially new information, and because the implementation chapter is only analysing data about already implemented adaptation actions which by default are rarely mentioned in NAPs and NDCs, which are typically future-oriented (i.e. they contain commitments or intentions for future action). The database used is the Adaptation Communications Registry (UNFCC 2022). By the cut-off date of 31 August 2022, adaptation communications of 45 countries were listed in the Registry. About half (24) of them were submitted as stand-alone documents and therefore included in the analysis of the chapter.

4.B.2 Section 4.5 on the linkages between implementing adaptation and mitigation

GCF projects that address both adaptation and mitigation

To analyse practical linkages between adaptation and mitigation, projects classified by the GCF as cross-cutting (i.e. addressing both objectives) were used as an additional data source in section 4.5.2. This data source was only employed within this section. Sections 4.2–4.4 and figure 4.1 only contain actions that are marked as primarily and explicitly aiming at adaptation. The list of cross-cutting projects and their proposals is listed on the GCF website.[2] In line with the scope of the chapter, only projects whose

2 See: https://www.greenclimate.fund/projects.

implementation had started by 31 August 2022 were included (41 out of 55 cross-cutting projects).

Annex 4.C: Calculation methods

4.C.1 Section 4.2 on the number of adaptation projects, size and funding value (figure 4.1)

Only projects that meet the four criteria outlined in section 4.B under "Project documents from UNFCCC funds" were included. The project size categories (micro, small, medium and large) were adopted from the GCF. However, unlike GCF practice, the allocation to the four sizes in section 4.2 was not based on the total project value, but rather the direct contribution from the respective fund (i.e. excluding co-financing from other donors or host countries). This approach was taken because the co-financing standards (i.e. what counts as co-financing) differ between the AF, GCF and GEF. Accordingly, the "Funding" bars in figure 4.1 are based on the sum of the project value that is directly funded by the AF, GCF and GEF (LDCF and SCCF) of all projects that started in the respective year. The actual disbursement of payments throughout a project's lifetime is not considered, because this information is not available from all funds. Instead, the entire funding amount is reported in figure 4.1 under the year a project started. For example, the GCF project FP124: Strengthening Climate Resilience of Subsistence Farmers and Agricultural Plantation Communities in Sri Lanka has a total value of US$49 million, of which the GCF contributes US$40 million. Hence, only these US$40 million are counted and shown for the year the project started (2020). Table 4.B.1 presents the data of figure 4.1.

Table 4.B.1 Number of new adaptation projects per start year and size, and committed annual funding under the Adaptation Fund, Green Climate Fund and the Least Developed Countries Fund and Special Climate Change Fund of the Global Environment Facility, as at 31 August 2022

Year of implementation start	Number of projects per size (US$ million)				Number of starting projects	Funding (excluding co-financing, US$ million)
	0.5–10	11–25	26–50	>50		
2022 (until 31.08)	8	2	0	2	12	312
2021	35	8	5	0	48	510
2020	22	13	5	0	408	550
2019	20	3	5	1	29	477
2018	20	5	9	0	34	538
2017	32	5	3	1	41	447
2016	35	0	0	0	41	205
2015	48	0	0	0	48	259
2010–2014	140	8	0	0	148	773
2006–2009	37	1	0	0	37	107
Total	397	45	27	4	**473**	**4178**

Note: The 2006–2009 period includes 23 projects (each under US$10 million) from the discontinued funding window Strategic Priority on Adaptation under the GEF.

4.C.2 Section 4.4 on estimating the potential for risk reduction (figure 4.3)

Gauging the potential for risk reduction is important considering debates surrounding the effectiveness of adaptation (see chapter 5) and because of consistent critique of the accuracy of donors' practice of labelling actions as "adaptation" (e.g. Weikmans *et al.* 2017; CARE 2021; Toetzke, Stünzi and Egli 2022). The analysis is based on a key word search among all 21,946 entries classified as "principal adaptation" in the OECD DAC External Development Finance

Statistics on Climate Change (the same data set as used by chapter 3). Entries were assessed for keywords related to climate change, risk, vulnerability, exposure, resilience and other concepts based on expert knowledge as either showing evidence of addressing climate risk directly or not. Evidence of risk reduction was considered provided if one or several of the keywords were used in the activity titles and/or descriptions in the context of the sectors and subsectors they were associated with.

While there were many entries that were evidently not related to adaptation, a large number of actions reviewed in this exercise that were potentially related to adaptation were excluded because insufficient evidence was available to discern whether they directly address climate risk. Therefore, while these actions could – theoretically – address climate risk, they were excluded on the basis that very limited amounts of information were available to suggest that they do.

Similarly, where entries contained the appropriate keywords, certain actions were still excluded because it was judged that the nature of that action meant that they were less likely to directly result in risk reduction (although that may still be the case via a more complex outcome pathway). For example, even when they are clearly related to reducing climate risk, actual climate risk reduction is rarely an immediate or short-term outcome of actions such as meetings. Similarly, actions carried out at the regional level are unlikely to directly lead to climate risk reduction as they are inherently disconnected from specific locations and therefore are unlikely to address specific climate hazards.

Finally, in some cases, entries were excluded because the volume of funding allocated to actions that could reduce climate risk, when taken in combination with other information provided, was considered too low to suggest that the action would meaningfully reducing climate risk.

Due to the large amount of time needed to manually scan the data set, the exercise could not be replicated and was therefore based on one expert's knowledge and understanding of risk reduction. While basing the assessment on multiple independent coding rounds would surely improve the analysis and could provide a measure of the error of individual bias, it is unlikely that the overall trends and thus the conclusions would have changed due to the very large data set that was analysed, which tends to balance individual errors.

4.C.3 Section 4.5.2 on cross-cutting projects of the Green Climate Fund

Adaptation share within cross-cutting GCF projects (figure 4.5)

The figure is based on the 41 cross-cutting GCF projects under implementation as at 31 August 2022. The adaptation share was determined based on the amount stated in the project proposal as the budget for the adaptation result areas that the project addressed.

Combinations of mitigation and adaptation result areas (table 4.1)

The result areas are indicated in the project proposals. As most projects respond to multiple result areas, all combinations among the result areas of a project were counted and added up over all cross-cutting projects. Result areas with contributions below 10 per cent of the total funding volume of a project were left out in order not to distort the most important combinations.

Type of cross-cutting project (table 4.2)

All 41 cross-cutting projects under implementation were qualitatively assessed by a member of the author team of the chapter (four of the seven authors participated). The analysis was undertaken along a template with guiding questions. This way, every project was placed into one of five types of cross-cutting projects (whether they mainly address mitigation or adaptation or both). Table 4.2 shows the proportion of the 41 implemented projects per type of cross-cutting project.

Type of integration between adaptation and mitigation

The coding author also assessed every project regarding its type of linkage:

Integrated: Activities on mitigation or adaptation directly help to achieve each other's objectives e.g. in climate smart agriculture, carbon sequestration reduces emissions while adjusted agricultural techniques (cropping cycles, seed varieties and so on) help farmers to adapt.

Somewhat interlinked: The activities are somewhat linked, but their implementation is separate. For example, in project FP077 on low-carbon and resilient housing in Mongolia, the mitigation activities include insulation and installation of photovoltaics while the adaptation activities seem to be around flood protection. Hence, while both take place at or around the same buildings, the measures are independent of each other and separately implemented.

Mainly separate: The activities proposed for mitigation and adaptation are separate and mostly unconnected, which means that while they are placed under one project, they could (almost) be separate projects.

The percentage of cross-cutting projects in each of these three types of linkages is reported in section 4.5.2.

ANNEX 5.A: Case study descriptions for the case studies assessed in section 5.2 and an expanded version of table 5.2

1. Adapting to extreme heat and heatwaves in North America

Communities in North America are experiencing more frequent and severe heatwaves, which are expected to continue at increasing warming levels. Heatwaves consistently lead to increased death and illness, and many communities and regions have developed heat action plans (HAPs). HAPs can include a range of measures, but typically include a combination of early warning systems, education campaigns to encourage safe behaviour, identification and outreach to vulnerable groups, collaboration across institutions to coordinate heatwave responses, provision of cooling spaces, and mobilization of health and social services and infrastructure.

HAPs are broadly effective in reducing the health impacts of extreme heat, though effectiveness depends on the types of actions and their implementation. Measures to reduce heat risk reduce heat-related deaths by up to 19 per cent in the United States of America (Lim and Skidmore 2020), while heat-related deaths declined after implementation of a HAP in Montreal (Benmarhnia *et al.* 2019). However, heat alerts and education do not necessarily translate into individual behaviour to decrease heat exposure (Hasan *et al.* 2021; Toloo *et al.* 2013).

Early warning systems may be more effective where heat alerts trigger an institutional response (e.g. outreach to vulnerable populations, mobilization of social and health care, coordination of response services) (Benmarhnia *et al.* 2019; Weinberger *et al.* 2018). To be effective, the threshold at which early warning systems trigger an alert needs to be specific to the heat tolerance of the local population (Davis *et al.* 2003; Kalkstein and Sheridan 2007).

The design and implementation of HAPs is flexible, with the potential to directly target and support vulnerable groups, though there is limited and mixed evidence on the effectiveness of HAPs among vulnerable populations (Kalkstein and Sheridan 2007). As mixed-approach plans, HAPs are flexible in terms of their potential to be adapted to changing needs and evidence, with the potential to maintain and increase effectiveness and equity over time. Some evidence suggests high cost-effectiveness of measures such as early warning systems and coordination of social and health services and infrastructure (Ebi *et al.* 2004; Toloo *et al.* 2013).

The contribution of HAPs to mitigation goals is largely positive, with nature-based solutions such as urban greening associated with improved energy efficiency and largely considered no-regrets options (Kim, Gu and Kim 2018; Stone, Vargo and Habeeb 2012). Although not typically included in HAPs, there is extensive evidence that mass roll-out of air conditioning is a highly effective adaptation for reducing health risks due to extreme heat (Barreca *et al.* 2016; Davis *et al.* 2003; Rogot, Sorlie and Backlund 1992). Significant trade-offs are well-documented, however, with air conditioning incurring substantial energy use, compromising mitigation goals and potentially increasing inequality due to the cost of purchase and energy use (Sheridan 2007).

There is limited evidence on the adequacy of HAPs at higher levels of warming. Many HAP measures provide incremental benefits, implying that greater action will be increasingly required at higher levels of warming, with the potential to reach both hard (e.g. no more space for urban greening) and soft (financially non-viable) limits to further effectiveness. While evidence of population acclimatization suggests that populations can adapt to extreme heat over time, it is unclear if this will be rapid enough and sufficient at high warming, particularly when approaching physiological limits for body heat. Notably, much of the evidence for historic acclimatization to extreme heat in North America has been attributed to the widespread uptake of air conditioning, implying that historic adaptations of populations to heat cannot be replicated in the future without substantial trade-offs for mitigation. Adequate adaptation at very high levels of warming may require HAPs that consider zero-emissions and equitable air conditioning options.

2. Effectiveness of flood risk measures in Western and Central Europe

For centuries, riverine and pluvial flood risks in Western and Central Europe have been a major concern and significant investments have been made to reduce flood risks. During this time, the region has seen population growth, rapid urbanization and increased socioeconomic wealth, all of which have increased exposure in the region. The IPCC Working Group II *Sixth Assessment Report* (IPCC WGII AR6) estimates that damages from river flooding are projected to increase to be three times higher at 1.5°C, four times higher at 2°C and six times higher at 3°C global warming, assuming low levels of adaptation (Bednar-Friedl *et al.* 2022). The number of fatalities due to riverine flooding is decreasing (1990–2010 compared with 1980–1989) (Bednar-Friedl *et al.* 2022) as are normalized economic losses (1970–2016 compared with previous periods) (Paprotny *et al.* 2018). This shows that effective adaptation to flood risks is feasible and happening in parts of Europe, although this cannot avoid all flood-related risks.

The effectiveness of adaptation measures is regionally dependent and determined by the flood hazard characteristics (e.g. slow-onset or rapid flash floods). Local interventions may alter flood hazard, such as through the construction of flood defences, bypass channels and water retention areas (Jongman 2018). For a 2°C global warming, optimal design and strengthening of structural flood defence systems, in particular heightening of dykes, could lead to 50 per cent lower annual flood damages in Europe by 2100 compared to no additional adaptation (Dottori *et al.* 2020). Implementation of retention areas could reduce economic damages by 71 per cent by the end of the century. These measures offer co-benefits (e.g. restoration of ecosystems, retention for periods of drought, recreation) but require significant investments and substantive land and may not be feasible in densely populated areas.

Flood-proofing buildings is typically cost-effective and easy to implement. Although it does not alter flood exposure, it can be effective in reducing damages, even when these are small-scale building interventions. For example, elevated electricity meters, power sockets and boilers are cost-effective flood risk measures for 1:1 year floods, but their effectiveness decreases when the magnitude of floods increases (Poussin *et al.* 2015).

Non-structural measures can be effective in reducing residual risks when combined with other structural measures, but their effectiveness is generally difficult to assess (Bednar-Friedl 2022). Early warning systems in Western and Central Europe have proven to be highly cost- effective, low-regret options (Pappenberg *et al.* 2015), but their effectiveness depends on whether people actually receive the warning (in time), believe the severity of the warning and know how to act (Kienzler *et al.* 2015). Flood risk communication strategies that are tailored and people-centred are more effective than common approaches of government communication (Haer, Wouter Botzen and Aerts 2016). Their effectiveness increases when the communication includes information about what to do, rather than only communicating event risk (Haer, Wouter Botzen and Aerts 2016). Transitions towards systems thinking, for example adaptive or integrated water management, have increased the range of options available to respond to future flood risks.

Combinations of structural and non-structural measures are needed to reduce flood risks to an acceptable level. Although hardly quantified, the effectiveness of individual measures can increase when combined with other measures (Bednar-Friedl *et al.* 2022). Specific impacts-response pathways or archetypes could allow for more effective combinations of options (Thieken *et al.* 2022).

3. Climate-smart agriculture in West Africa to adapt to drought and rainfall variability

In West Africa, mean annual and seasonal temperatures have increased by 1–3°C in most countries, with the Sahara and Sahel as hotspots (Cook and Vizy 2015; Lelieveld *et al.* 2016; Dosio 2017; Nikiema *et al.* 2017; Ranasinghe *et al.* 2021) and alongside associated increases in agricultural and hydrological drought frequency. The combined effect of these hazards negatively affects crop and animal production, including access to food, the length of growing seasons, and yield potential (Mohmmed *et al.* 2018; Verner *et al.* 2018).

In this region where 90–95 per cent of agricultural production relies heavily on rainfall (Waha *et al.* 2018), combined with high population growth and change in consumption patterns, climate-smart agriculture (CSA) emerged as a promising pathway for food security and climate resilience (Kaczan, Arslan and Lipper 2013; Serdeczny *et al.* 2017). It offers opportunities for smallholder farmers to increase productivity and income, improve household food security, and build adaptive capacity while reducing greenhouse gas (GHG) emissions from agricultural systems (Wekesa, Ayuya and Lagat 2018; Mutenje *et al.* 2019). CSA practices include conservation agriculture, access to climate information, agroforestry systems, improved irrigation practices such as using drip irrigation, planting pits and erosion control techniques (Partey *et al.* 2018; Antwi-Agyei *et al.* 2021).

While CSA has the potential to alleviate food insecurity, there is evidence that this only happens if CSA options are carefully considered and used in an integrated manner (Wekesa, Ayuya and Lagat 2018). For example, CSA interventions such as investing in early-maturing or drought-tolerant crop varieties and irrigation infrastructure can contribute to increasing resilience, but adoption of these technologies by smallholder farmers is often hindered by their unequal availability and affordability (Senyolo *et al.* 2018; Zerssa *et al.* 2021).

Even though CSA promotes small-scale irrigation infrastructure as being easy to manage directly by communities with limited resources, it is obvious that if these facilities are not considered carefully, their increased use may lead to negative environmental effects. For example, irrigation can exacerbate groundwater salinization and depletion (Hamed *et al.* 2018) and increase the risk of reduced soil moisture (Petrova *et al.* 2018). Likewise, it can serve as breeding grounds for malaria-causing mosquitoes (Attu and Adjei 2018).

Overall, the promotion of CSA options in Africa has largely been technology-driven, often following a de-contextualized blueprint approach as one-size-fits-all solutions with a limited understanding of the socio-institutional context (Totin *et al.* 2018). Rethinking the approach to promoting CSA technologies has the potential to provide opportunities for improving their effectiveness and avoiding unequal outcomes.

4. Infrastructural adaptation to coastal flooding in small island developing states

Small island developing states (SIDS) are at high risk of coastal flooding and sea level rise which threaten infrastructure, livelihoods, water availability, food security and the habitability of certain locations. In response to these hazards, a common adaptation measure has been the development of sea walls as an infrastructural approach to minimize coastal erosion and flooding stemming from sea level rise and tropical storms. SIDS that have implemented sea walls have found that these defences may be beneficial in the short term for the particular locations that are situated within the protective boundaries of the infrastructure (McNamara *et al.* 2017; Crichton and Esteban 2018).

However, sea walls need regular upgrading and replacement as their effectiveness decreases over time and locations that are outside the boundaries of this infrastructure often face increased risks from flooding and erosion (Donner and Webber 2014; Petzold, Ratter and Holdschlag 2018; Crichton and Esteban 2018). High costs of maintaining and upgrading sea walls are often unaccounted for in the project-based funding that is often used to initially erect such infrastructure, which may lead to the abandonment and eventual destruction of sea walls over time (McNamara and Des Combes 2015; Naylor 2015; Piggott-McKellar *et al.* 2020). Additionally, the high costs of initially erecting sea walls have proven difficult to procure – even in rich nations – and have prevented such adaptation measures from being implemented (Hinkel *et al.* 2018). Financial and institutional constraints have led to soft limits for sea walls and, with progressive sea level rise, sea walls will eventually become unaffordable and impractical, leading to hard limits for this adaptation approach (Strauss *et al.* 2021).

Using a cost/benefit approach to assess the effectiveness of sea walls as an adaptation strategy largely relies on benefit-to-cost ratios (BCRs) to determine the value of investing in expensive infrastructure. BCR values are generally high for urbanized coastal areas with high concentrations of assets and are generally low for small coastal settlements, areas where assets are of low economic value, isolated communities and areas where quantitative data are unavailable (Lincke and Hinkel 2018). For SIDS, a cost/benefit principle for assessing effectiveness would support the effectiveness of sea walls for densely populated urban cities and find that such infrastructure would be ineffective for smaller communities.

Sea walls may be deemed effective for smaller communities that may have limited economic importance but are, for this very reason, deemed at high risk to climate change. A cost/benefit lens would fail to consider non-economic benefits such as place attachment, community relationships, livelihoods, and spiritual and cultural significance of locations, which would justify sea walls for smaller communities (Thomas and Benjamin 2020). However, if using the principle that effective adaptation should invest in ecosystem conservation, management and restoration, sea walls would not be effective in any SIDS situation. Sea walls have negative effects on ecosystems and can lead to long-term loss of biodiversity.

Similarly, using the principles that adaptation should increase resilience or that adaptation should be economically, ecologically and socially sustainable means that sea walls may also be deemed ineffective due to the negative effects that this infrastructure has on surrounding communities and ecosystems, and the lack of long-term financial feasibility of sea wall maintenance and upgrading for resource-poor locations.

5. Relocation as adaptation to cyclones in Asia

As a region, Asia is highly prone to cyclones, with South and South-East Asia expected to see increasing frequency and intensity of cyclones and antecedent risks of flooding and strong winds under a warming climate (Seneviratne *et al.* 2021), thus exposing a large, highly vulnerable population to escalating risk (Glavovic *et al.* 2022). One of the key adaptation strategies being piloted and increasingly implemented is planned relocation, which typically encompasses strategic decisions, often enabled by governments, to relocate people, businesses and infrastructure out of harm's way.

Planned relocation has mostly taken place in response to disasters across South Asian countries and has tended to focus on providing built infrastructure and rehabilitating affected communities, often at the cost of strengthening livelihoods, providing public services and providing opportunities for place-making and social well-being in new sites (Jain, Singh and Malladi 2021). Although planned relocation is effective in reducing exposure to high-intensity hazards, it can often have unequal and potentially maladaptive outcomes by constraining relocated populations socially, culturally, financially and politically (IPCC 2019).

There are few studies that assess the effectiveness of planned relocation in reducing exposure to hazards. However, the existing literature highlights how poorly planned, exclusionary relocation that focuses on infrastructural solutions tends to increase vulnerability and hinder material and subjective well-being. For example, in greater Manila (the Philippines) and Chennai (India), planned relocations have increased exposure to new risks and exacerbated vulnerability, due to relocation sites being in environmentally sensitive areas and poor livelihood support in destination sites (Meerow 2017; Ajibade 2019; Jain, Singh and Malladi 2021). Further, modelling studies highlight how planned relocation efforts also need to examine risk reduction and resilience-building in destination areas: for example, examining requirements for safe relocation in Bangladesh, Davis *et al.* (2018) note that "to sufficiently accommodate the relocation of all of those estimated to be displaced by flooding in the year 2050 will likely require nearly 600,000 additional jobs, 200,000 residences, and 784 × 109 food calories".

There are grave concerns that planned relocation that is top-down and does not consider cultural norms and practices can lead to inequitable socioeconomic outcomes for resettled populations (Adger *et al.* 2020). Thus, overall, planned relocation has mixed outcomes on risk reduction and building adaptive capacity, but can reduce exposure to hazards.

Table 5.A.1 Expanded summary of cases assessed in section 5.2 and presented in Annex 5.A

Climate risks	Adaptation strategies	Effectiveness outcomes (positive, negative, neutral, mixed, insufficient evidence)					Context-specificity	Adaptation adequacy and limits
		For vulnerable people, groups	For at-risk ecosystems	For goals of equity, including gender justice	Over time	Mitigation		
Extreme heat, heatwaves	Heat action plans (HAPs) in North America	**Mostly positive.** HAPs frequently target vulnerable groups, particularly older people and those with chronic and pre-existing conditions. The nature of HAPs means that targeting of vulnerable groups is feasible and can be highly effective. Yet there is not always an emphasis on the differential vulnerability of people who are socially isolated, homeless or have limited capacity to change behaviour, in order to target them effectively. Effectiveness is closely related to the targeting and outreach of efforts to support vulnerable populations.	**Insufficient evidence, with potential for modest positive.** There is limited information on how HAPs impact local ecosystems, though approaches that involve urban greening (e.g. green roofs and spaces) may contribute to reducing ecosystem risk.	**Mixed.** Women and minorities may respond to HAPs more readily, with a greater protective effect and reduced health impact. Other research suggests some sub-populations are less able to shift behaviour to avoid risk (e.g. poor households who are unable to stay home, avoid outdoor work or access cooling spaces).	**Positive.** HAPs can be effective at shifting heat-health impacts and behaviour at low warming levels, contributing to acclimatization of populations to increased heat conditions over time. HAPs can be iteratively updated and revised to respond to changing heat risks and vulnerabilities.	**Mixed.** There is evidence that urban greening and albedo approaches (e.g. reducing heat absorption by painting surfaces white) can improve energy efficiency. Early warning systems and urban greening can be low-regret options for mitigation and adaptation. Air conditioning is highly effective in reducing heat-health risk, but leads to increased energy use, compromising mitigation goals unless low-carbon sources of energy are employed.	The efficacy of heat alerts depends on target vulnerable populations, support for action and behaviour change, and the choice of temperature thresholds based on local climate conditions. Urban greening approaches are broadly effective, but contextual (e.g. greening parking lots may be more effective in high-rise locations than green roofs in low-rise buildings). Air conditioning is consistently and highly effective in reducing mortality across contexts.	Warming levels are not taken into account in most HAPs. Typically actions within HAPs will be effective at lower warming levels. Evidence indicates that heat mortality is higher in northern cities of the United States of America, despite hotter temperatures. This is largely attributed to air conditioning and acclimatization. There is less evidence of adequacy at higher levels of warming, and as human physiological limits are approached. The benefits of typical HAP actions (e.g. urban greening and early warning systems) are relative, and may become insufficient unless widespread, extensive and combined with changes in labour laws, building codes, and changes in urban planning.

Climate risks	Adaptation strategies	Effectiveness outcomes (positive, negative, neutral, mixed, insufficient evidence)					Context-specificity	Adaptation adequacy and limits
		For vulnerable people, groups	For at-risk ecosystems	For goals of equity, including gender justice	Over time	Mitigation		
Riverine, inland floods	Flood risk management in Western Europe	**Mixed.** A combination of measures are implemented to reduce riverine flood risks, with varying levels of effectiveness. While these affect an entire population, studies highlight that differentiated vulnerability is based on income, location, adaptive capacities, community participation, risk awareness, local governance mechanisms, and so forth.	**Mixed**. Some flood risk measures such as retention areas and space for rivers have positive effects on ecosystem functioning. However, some measures such as heightening of dykes have either no effect or a negative effect.	**Mixed.** Several measures can contribute to equity and (gender) justice but these are not frequently considered in implementation processes.	**Mixed.** Although there are clear limits to some adaptation measures and risks for path dependencies (e.g. structural flood defences such as dykes and levees), many options have already proven to be effective in reducing flood risks. Under increased warming, some options will become less effective (e.g. protective measures) whereas other options remain effective (e.g. retreat options).	**Mixed.** Most measures have no direct effect on reducing emissions and may require substantive emissions in order to be constructed (e.g. concrete defences). Other measures offer opportunities for carbon sequestration (e.g. nature-based solutions and technological innovations in the building materials used).	Effectiveness depends on geographical location and flood hazard type, number of people exposed, prior investments in adaptation and current levels of vulnerability. In most of Western Europe, flood risk measures have been implemented but risks remain and will continue to increase. As traditional protection systems are now insufficient, alternative forms of flood risk management (e.g. adaptive water management) are being increasingly implemented, opening a new set of adaptation options.	There are several studies on the adequacy of measures, focusing mostly on risk reduction potential and cost-effectiveness. Most studies show that damages can be significantly reduced even at higher levels of warming (2–4°C) if high levels of adaptation are implemented. However, even when multiple options are implemented, the risk of flooding will remain.

Climate risks	Adaptation strategies	Effectiveness outcomes (positive, negative, neutral, mixed, insufficient evidence)					Context-specificity	Adaptation adequacy and limits
		For vulnerable people, groups	For at-risk ecosystems	For goals of equity, including gender justice	Over time	Mitigation		
Drought, rainfall variability	Climate-smart agriculture (CSA) in West Africa	**Mixed.** CSA – including conservation agriculture, access to climate information, agroforestry systems, drip irrigation, planting pits and erosion control techniques – offers opportunities for smallholder farmers to increase productivity, improve soil fertility, yield and household food security. Some of these options can have trade-offs (e.g. agroforestry can lead to loss of primary forests and excessive irrigation that can cause groundwater depletion). The use of early-maturing or drought-tolerant crop varieties may increase resilience, but adoption by smallholder farmers can also be hindered by affordability.	**Positive.** CSA can strengthen food security while improving soil and water quality, and overall ecosystem functioning.	**Mixed.** There is evidence that while the CSA's approach aims to address the issue of food security by promoting environmentally friendly options, it does not ensure inclusion. For instance, small-scale farmers or minorities are often excluded and fail to adopt or implement new practices and technologies because of limited resources.	**Insufficient evidence, with potential for positive.** There are often long-term benefits for households that adopt CSA practices or options as these contribute to increased yields, reduce the variability of yields and make the system more resilient to climate change.	**Positive.** CSA can have mitigation co-benefits – e.g. improved soil management practices and lower nitrogen-based fertilizers can increase carbon stocks and reduce emissions of GHGs respectively.	Outcomes of CSA are largely dependent on local agroecological conditions, farmer assets and capacities, and agriculture extension services.	In most of the current literature, warming levels are not considered when assessing the effectiveness of CSA.

Climate risks	Adaptation strategies	Effectiveness outcomes (positive, negative, neutral, mixed, insufficient evidence)					Context-specificity	Adaptation adequacy and limits
		For vulnerable people, groups	For at-risk ecosystems	For goals of equity, including gender justice	Over time	Mitigation		
Coastal flooding	Infrastructural adaptation (e.g. sea walls) in SIDS	**Mixed.** Sea walls may be beneficial in the short term for the particular locations that are situated within the protective boundaries of the infrastructure, but they are often detrimental to surrounding communities.	**Negative.** Sea walls displace ecosystems and contribute to long-term biodiversity loss.	**Mixed.** For SIDS, a cost/benefit principle for assessing effectiveness would support the effectiveness of sea walls for densely populated urban cities. However, such infrastructure would be ineffective for smaller or sparsely populated communities.	**Negative.** Sea walls need regular upgrading and replacement as their effectiveness decreases over time. High costs of maintaining and upgrading sea walls are often unaccounted for in the project-based funding that is often used to initially erect such infrastructure, leading to their abandonment and eventual destruction over time.	**Negative.** Sea walls displace natural habitats that may contribute to carbon sequestration. This infrastructure is often reliant on concrete, which is typically imported into SIDS and is a known contributor to emissions.	The effectiveness of structural adaptation depends on hazard intensity (e.g. rate of sea level rise), existing flood management protocols, and settlement density. The effectiveness of infrastructural options is also attenuated by whether they are implemented in conjunction with other measures such as mangrove restoration, managed retreat, and so forth.	At higher levels of sea level rise, sea walls will eventually become unaffordable and impractical.

Climate risks	Adaptation strategies	Effectiveness outcomes (positive, negative, neutral, mixed, insufficient evidence)					Context-specificity	Adaptation adequacy and limits
		For vulnerable people, groups	For at-risk ecosystems	For goals of equity, including gender justice	Over time	Mitigation		
Cyclones	Planned relocation in Asia (South and South-East)	**Mixed.** Effectiveness of planned relocation measures can be positive if done in a participatory manner that respects the needs and rights of relocated populations. Evidence suggests that planned relocation can reduce exposure to hazards but can also exacerbate vulnerability by eroding dignity and agency, placed-based identity and kinship networks, and shifting livelihoods.	**Insufficient evidence, slightly negative.** Sometimes planned relocation can have negative outcomes at destination sites (e.g. increased water use leading to overextraction). There is however insufficient evidence on the ecological outcomes of planned relocation in source and destination sites.	**Mixed.** Planned relocation can effectively move people out of harm's way (reduce exposure) but can increase women's work burdens and erode social ties and community networks, all of which tend to place higher care work demands on women. When implemented with local engagement, planned relocation can reduce vulnerability by expanding employment opportunities and reducing dependence on precarious livelihoods.	**Insufficient evidence, mostly mixed.** Long-term studies on the temporal outcomes of climate-induced relocation are few but effectiveness over time depends on the conditions under which people are relocated: where livelihoods and adaptive capacities are built, outcomes tend to be positive over time while relocation initiatives that focus on physical infrastructure alone tend to have negative outcomes on resilience (and human well-being) over time.	**Insufficient evidence.** There is no empirical evidence on how relocating people can have trade-offs for efforts on emissions reductions but there are possibly some embodied emissions in new building stock (in the case of rehabilitation).	The effectiveness of planned relocation depends on the conditions under which relocation is undertaken (e.g. willingness to move, capacities to assimilate socioculturally in new sites), and the destination conditions to which people are being relocated (e.g. risk in new sites, available livelihood opportunities).	In low-lying coastal areas, planned relocation will increasingly become part of a suite of adaptation strategies, with numbers increasing at higher warming levels. Limits can be reached in source areas where flooding is expected and destination areas where social protection, public services and employment will need to be provided. When and for whom these limits will be breached are available in modelling studies but there is a lot of disagreement in the literature.

Notes: The table presents how effective each of the assessed adaptations are for people, ecosystems and equity (including gender). It demonstrates that existing adaptation actions to varied hazards have mostly mixed outcomes that are highly risk- and context-specific. In all cases, there is insufficient evidence about the adequacy of these but soft limits are reached or being approached.

Annex 5.B: An expanded analysis of literature discussing gaps and shortcomings in adaptation practice

The literature review presented here is an expanded version of the analysis presented in section 5.2 of the main chapter.

Addressing gaps and shortcomings in adaptation practice

The actions and outcomes in figure 5.1 in the main chapter provide multiple entry points for assessing adaptation effectiveness. The figure demonstrates that the ultimate measures of adaptation effectiveness will involve changes in human and ecological well-being and losses and damages,[3] assessed in relation to evolving climate hazards (Brooks and Fisher 2014; Brooks *et al.* 2019). However, likely effectiveness may be inferred through assessments of changes in exposure, and vulnerability to climate hazards; the extent to which adaptation interventions target specific (albeit uncertain) future risks and create the enabling conditions for transformative change; and the extent to which interventions follow good practice in design and implementation based on established adaptation principles.

Risk reduction as evident through improved well-being and development outcomes

Adaptation effectiveness may be measured in terms of avoided impacts from climate-related hazards, and avoided declines in human and ecological well-being that would have occurred as a result of climate hazards in the absence of adaptation. Such measurement is most appropriate at the impact level of results frameworks, and involves comparing actual or anticipated losses and damages and changes in well-being with those that would have occurred in a 'no-adaptation' counterfactual.

This requires information relating to (a) losses, damages, well-being and development outcomes, and (b) the behaviour of relevant climate hazards. In addition, it requires the prediction of losses, damages, well-being and/or development outcomes in the absence of adaptation actions, based on plausible narratives and/or statistical relationships between climatic and well-being/development metrics over periods prior to adaptation actions being taken.

A variety of methodologies for undertaking such analyses exist, including established methodologies such as cost-benefit analysis (CBA) and novel or emerging methodologies for 'contextualizing' the interpretation of changes in well-being and development metrics using climate information. For example, Tran, Tran and Tran (2016) use conventional CBA to calculate the additional costs of building disaster-resilient infrastructure and compare these with the (avoided) costs of damages to regular 'non-resilient' infrastructure resulting from relevant hazards. Meanwhile, Alves (2015) and Yaron, Win and Wilson (2017) describe participatory CBA that extends the conventional CBA approach by including benefits that would be missed in conventional CBA analysis, addressing non-economic losses and damages (NELD). Figure 8.10 of the IPCC WGII AR6 lists some examples of NELD associated with specific climate hazards (Birkmann *et al.* 2022: 1210). NELD can include tangible and intangible heritage closely linked to culture and identity (Brooks *et al.* 2020).

Brooks *et al.* (2019) propose a simple matrix for identifying narratives of adaptation performance, based on comparing trends in well-being and trends in climate hazards (figure 5.B.1). Effective adaptation is inferred where human and ecological well-being are improving, or losses and damages are declining, despite intensifying or static hazards. Increased vulnerability and/or maladaptation is inferred where well-being is declining despite static or ameliorating hazards. Other cells in the matrix represent varying degrees of adaptation effectiveness. Such a narrative approach, supported by climate data, has been employed in practical contexts (e.g. Awraris *et al.* 2014).

3 In general terms, losses and damages "refer broadly to harm from (observed) *impacts* and (projected) *risks* and can be economic or non-economic" (IPCC 2022: 2914). In the context of the United Nations Framework Convention on Climate Change (UNFCCC) and the 2013 Warsaw Mechanism, 'Loss and Damage' refers to the "impacts of climate change, including extreme events and slow onset events, in developing countries that are particularly vulnerable to the adverse effects of climate change" (IPCC 2022: 2914). Loss and Damage extends beyond economic losses to include non-economic losses and damages and may be viewed as a subset of impacts on well-being and development outcomes.

Figure 5.B.1 Simple matrix for qualitative assessing adaptation performance based on comparisons of development/well-being and climate hazard metrics

	Amelioration of hazards	No change in hazards	Worsening hazards
Improved well-being	**LUCK?** Improved well-being may be due to hazard reduction; which may have been amplified by adaptation actions – *counterfactual needed to assess impacts of adaptation actions.*	**REDUCED VULNERABILITY** Impacts of hazards reduced due to reductions in vulnerability / increased resilience.	**SUCCESSFUL ADAPTATION** Well-being improves and development goals achieved despite possibly severe increase in hazards. Encompasses transformational adaptation.
Stable well-being	**LOST OPPORTUNITIES** Despite reduction in hazards, well-being does not improve – potential gains not realized.	**STATUS QUO** No change in either hazard prevalence or well-being, meaning the adaptation actions taken have had little impact.	**ADEQUATE/STABILIZING ADAPTATION** While well-being does not improve, worsening hazards do not undermine it. Adaptation has stabilized well-being and prevented losses.
Deteriorating well-being	**MALADAPTATION** Despite reduction in hazards, well-being worsens – development is dramatically increasing vulnerability and reducing resilience.	**INCREASED VULNERABILITY** Impacts of hazards increase despite no change in hazards themselves due to increases in vulnerability / reduced resilience.	**INADEQUATE ADAPTATION** Adaptation is either not effective or not sufficient – may partially offset impacts, but maladaptation may also be occurring – *counterfactual needed to assess impacts of adaptation actions.*

Source: Brooks *et al.* (2019)

Nonetheless, this approach has its limitations. Additional qualitative information is likely to be required to assess the contribution of specific adaptation actions or interventions to reduced climate risk. Little can be said about the effectiveness of adaptation for two of the cells in the matrix, in which (i) well-being declines in a context of worsening hazards, and (ii) well-being improves where hazards are declining in frequency and severity. In the former case, adaptation may be insufficient to negate the impacts of climate change, but may have prevented even greater declines in well-being. In the latter case, adaptation may have amplified benefits associated with an amelioration of hazards.

In such cases, more robust analytical methods are required. These may involve examining the statistical relationship between relevant climatic variables and development or well-being metrics, such as rainfall and agricultural output (World Bank 2006; Ejaz Qureshi, Hanjra and Ward 2013; Pandya *et al.* 2019), or thresholds in extreme temperatures and mortality (McMichael *at al.* 2008; Gasparrini *et al.* 2015).

In these contexts, effective adaptation might be apparent from a decoupling of climatic and well-being/development metrics that previously have been strongly correlated, or a reduction in the magnitude of losses or damages (e.g. mortality) above certain climatic (e.g. temperature) thresholds following adaptation actions. Such approaches may enable risk reduction to be quantified retrospectively in terms of avoided losses (Brooks, Faget and Heijkoop 2019). Barrett *et al.* (2020) present a methodology for predicting expected development outcomes in the context of climate stresses and shocks, and comparing these with observed outcomes following risk reduction interventions.

Indicators related to well-being and losses and damages are employed in the results frameworks of some international climate funds. For example, the Adaptation Fund includes a core 'impact-level' indicator measuring "increased income, or avoided decrease in income" (Adaptation Fund 2019: 2). The Green Climate Fund (GCF) includes a core indicator measuring "change in expected losses of economic assets due to the impact of extreme climate-related disasters in the geographic area of the GCF intervention" (GCF 2021: 10). However, tracking these metrics tells us little about adaptation effectiveness unless they are interpreted in the context of climate information, as already discussed.

The robust tracking of risk reduction using metrics relating to human and ecological well-being, losses and damages, and development outcomes, using relevant climate information, is a significant gap in our understanding and assessment of adaptation effectiveness. This is due to a combination of factors, including limited data availability, the need to track relevant climatic and development/well-being metrics over relatively long periods at appropriate scales, and the relative immaturity of appropriate methodologies. Greater attention to methodological issues and data requirements, the establishment of mechanisms for long-term tracking of appropriate metrics at relevant scales, and the building of capacity to carry out such assessments, are recommended.

Methodologies for assessing changes in the likelihood and severity of individual climate hazards such as heatwaves, droughts and floods are well established (National Academies of Sciences, Engineering, and Medicine 2016) and have been applied to numerous hazards through initiatives such as World Weather Attribution.[4] These methods can be used to estimate the contribution of anthropogenic climate change to losses and damages and thus to quantify climate change risks retrospectively using relevant metrics (Harrington and Otto 2019). Understanding the contribution of climate change to hazard frequency and severity can also provide a basis for more qualitative assessments of risks, for example in terms of impacts on culture, heritage and identity (Birkmann *et al.* 2022).

Risk reduction as enhanced resilience

A large body of literature addresses resilience to climate variability and change and its measurement. Brooks, Faget and Heijkoop (2019) review a diverse set of approaches to the framing and measurement of resilience and classify these into three broad categories:

1) Hazard-focused approaches, in which resilience is viewed and measured in terms of the type and magnitude of hazard that a system can accommodate without experiencing a specified level of harm, or in terms of the time taken for a system (e.g. household, community) to recover from a hazard

2) Impact-focused approaches, which measure resilience in terms of the actual or anticipated consequences of a hazard for a system, for example in terms of losses and damages (consistent with the category of human and ecological well-being and losses and damages represented by the highest tier of figure 5.2 in the main chapter)

3) System-focused or capacity-based approaches, which use indicators representing the characteristics or attributes of a system that influence its capacity to deal with a hazard or hazards (equivalent to approaches based on exposure, vulnerability and adaptive capacity as already discussed and in figure 5.2 in the main chapter)

The hazard-focused approach is closely related to the coping range concept (e.g. European Commission 2013) and is well suited to assessing risks associated with climate hazards whose frequency and/or severity may be increased by anthropogenic warming. The coping range of a system is the range of values in a variable representing the magnitude of a hazard (e.g. extreme temperature, river level) that the system can accommodate without experiencing significant harm (European Commission 2013). However, it is rarely used outside of infrastructural and engineering contexts (Venable, Brooks and Vincent 2022).

The impact-focused approach includes calculations of actual or anticipated losses, or avoided losses from disasters or climate change (e.g. Zimmerman *et al.* 2010; United Nations Framework Convention on Climate Change 2011), overlapping with approaches based on measuring the aforementioned losses and damages.

The system-focused or capacity-based approach is the most common approach to resilience measurement, and is used widely in studies that define dimensions of resilience and identify associated system-related indicators (e.g. Bahadur *et al.* 2015). It is similar to approaches for measuring vulnerability based on the earlier IPCC (2001: 995; 2007: 883) definition of vulnerability, livelihoods frameworks (e.g. Solesbury 2003) and other approaches that frame resilience or vulnerability in terms of capitals and capacities (e.g. Food and Agriculture Organization of the United Nations 2016).

The system/capacity approach to measuring resilience has the advantage that resilience indicators are effectively predictors of outcomes associated with shocks and stresses, and in principle can be measured regularly, whether or not a shock has occurred (Brooks and Fisher 2014). However, identifying appropriate proxies for resilience can be challenging, and resilience indicators are often contested and poorly validated against outcomes from shocks. In addition, the collection of appropriate local data can be highly resource intensive, resulting in a reliance on secondary data that may miss important contextual aspects of resilience (Venable, Brooks and Vincent 2022). Incremental increases in resilience indicators may not necessarily indicate that a system is 'resilient' to a particular type and magnitude of hazard, for example where resilience-building actions are insufficient to expand the coping range of a system to accommodate high-magnitude hazards that may become much more likely and frequent under climate change.

Venable, Brooks and Vincent (2022) identify principles and best practice for resilience measurement, including the collection of context-specific indicators tailored to needs and capacities, attention to cross-scale interlinkages, sensitivity to timescales, the development of counterfactuals, and the blending of quantitative and qualitative information.

4 See https://www.worldweatherattribution.org/.

Critically, measurement of resilience needs to be based on an understanding of whose resilience is being measured, to what (hazards), in relation to what consequences, and over what timescales.

A greater focus on hazard-focused approaches would help focus attention on whether adaptation interventions and actions are adequate for addressing future hazards and risks that might be significantly greater in magnitude than – and perhaps different in nature from – existing hazards and risks. This would go some way towards enhancing adaptation ambition and moving away from incremental approaches to risk reduction that focus on current risks (Eriksen *et al.* 2021).

Risk reduction as reduced vulnerability

As discussed in section 5.2, the framing of climate risk as a function of hazard, exposure and vulnerability (O'Neill *et al.* 2022) means that reductions in risk can be inferred from evidence that exposure and/or vulnerability have been reduced. Approaches to the measurement of exposure and vulnerability echo the abovementioned system or capacity approach to resilience, and typically involve the construction of indicators or indices. Exposure and vulnerability are discussed separately here.

Conclusions that risk has been reduced based on changes in vulnerability indicators should be treated with caution, particularly where vulnerability is defined in a very general sense rather than in relation to specific hazards of particular magnitude. For example, a large number of adaptation projects focus on general environmental protection (see section 4.3 in the main report). However, such protection may be insufficient to preserve existing environmental systems in the face of climatic range shifts and future conditions outside the range of historical climate (Bellard *et al.* 2012).

Like incremental improvements in resilience, incremental reductions in vulnerability inferred from indicators may or may not be sufficient to expand the coping range of systems to accommodate historically infrequent but high-magnitude hazards, or future hazards that may be novel in nature or whose magnitudes may exceed those of historical extremes. As with resilience, vulnerability needs to be defined in terms of who is vulnerable, to what, with respect to what consequences, and over what timescales (Fawcett *et al.* 2017; Singh *et al.* 2021). While there may be general factors that increase vulnerability to a range of hazards, certain factors will be relevant to some types of hazards but not others. Secondary data may miss important drivers of vulnerability that are specific to a given context (Brooks, Adger and Kelly 2005).

There is evidence that some adaptation interventions inadvertently increase risk by reinforcing existing vulnerability, redistributing vulnerability, or creating new risks or new sources of vulnerability (Juhola *et al.* 2016; Eriksen *et al.* 2021). Such maladaptation (Magnan 2014; Schipper 2020; Bakaki 2022) is driven by a variety of factors, including: co-option of adaptation resources by dominant groups, reinforcing existing power relations; exclusion of marginalized groups from intervention design due to their geographic isolation or lack of capacity to engage; interventions being overly top-down or technocratic and paying insufficient attention to local contexts and underlying drivers of vulnerability; near-term adaptation measures constraining future adaptation options or creating path dependencies that increase risks (e.g. irrigation in water constrained environments); adaptation measures in one location increasing risks in other locations (e.g. dams adversely affecting flood recession agriculture); adaptation measures increasing the vulnerability of certain groups e.g. through displacement or reduced access to key resources (e.g. dams, conservation schemes); externally driven adaptation processes undermining local coping and adaptation strategies; co-option of adaptation by existing development agendas and the 'retrofitting' of development initiatives as adaptation without sufficient attention being paid to specific climate risks and their potential future evolution (Gajjar, Singh and Deshpande 2019; Eriksen *et al.* 2021).

These shortcomings are evident when adaptation interventions are disproportionately donor-driven, top-down, technocratic and incremental in nature, focusing on the near term and 'quick wins' while ignoring the underlying structural drivers or 'root causes' of vulnerability (Eriksen *et al.* 2021). These tend to be associated with political structures, power relations, patterns of inequality, marginalization and exclusion, and rooted in historical trajectories that are often embedded in colonialism and post-colonial international relations (Chakraborty *et al.* 2021; Sultana 2022). Addressing these structural factors is challenging for donors and implementing organizations, as doing so requires transformative changes in governance, finance, institutions, power relations, capacities, norms, values, worldviews and ideologies (Brooks 2020; Chakraborty *et al.* 2021).

The marginalization and exclusion of certain groups also results in inadequate integration of local, traditional and indigenous knowledge into adaptation design, implementation, monitoring, evaluation and learning (Leal Filho *et al.* 2022). Such integration can enhance local 'buy-in' and ownership of adaptation actions, increasing the effectiveness of risk reduction and the likelihood that these actions will deliver benefits that are sustained beyond the end of an intervention's lifetime (Zvobgo *et al.* 2022). Local knowledge integration into monitoring, evaluation and learning (MEL) systems can improve the tracking of adaptation outcomes and related phenomena (e.g. climate trends and changes in hazard behaviour and associated impacts), and enhance useful learning (Barratt and Bosak 2018). Such integration also expands definitions of adaptation effectiveness and 'success', which otherwise risk being narrowly defined in terms of the economic and development priorities set by donors (see Adger, Arnell and Tompkins 2005 and Weiler, Klöck and Dornan 2018).

Taylor *et al.* (2022) make several recommendations to address some of the aforementioned shortcomings, including (i) a focus on the rights of the most vulnerable to ensure their adaptation needs are met, (ii) acknowledging the role of power and politics in driving vulnerability, (iii) embracing diverse forms of knowledge and the inclusion of local, traditional and indigenous knowledge in the development of adaptation responses, (iv) supporting coalitions including local communities and the most vulnerable and marginalized, (v) recognizing risks, trade-offs and unintended consequences of adaptation actions to identify and avoid maladaptation risks and potential winners and losers.

Risk reduction through targeted adaptation measures

Adaptation actions that directly address specific hazards and risks to particular systems and locations may in principle represent a clearer path to risk reduction than generalized vulnerability reduction or resilience-building measures. Some of these actions seek directly to reduce exposure to climate hazards and their impacts. These may include strengthening artificial or natural coastal defences to reduce the extent and severity of coastal flooding, storm surges and erosion; introducing shading and green spaces in urban environments to reduce exposure to heat extremes; and relocating people, infrastructure, species and economic activities away from high-risk areas. Relocation of people may be permanent or temporary (e.g. through seasonal migration) and policies and actions focusing on relocation should avoid forced displacement while recognizing the critical role of migration in adaptation (Maharjan *et al.* 2020; Cundill *et al.* 2021).

Other examples include early warning systems, modifications to urban infrastructure to accommodate increased volumes of floodwater, increased tolerances of built infrastructure that expand their coping ranges in relation to specific hazards, water harvesting and storage, irrigation, the adoption of short-cycle crops in response to shorter growing seasons, and the installation of storm and heat shelters.

Nonetheless, even these highly targeted measures may inadvertently increase risk. For example, relocation may result in people losing access to key resources and social networks on which they previously relied to cope with climatic shocks and stresses. Irrigation may encourage agricultural intensification and expansion in areas where agriculture is not viable in the long term due to increases in temperature and declines in rainfall, thereby increasing the risk of collapse of agricultural and associated social and economic systems.

Even where adaptation actions are effective in the near term, they may be inadequate in the longer term, particularly where the focus is on responding to current and emerging risks at the expense of planning for future risks. Addressing such future risks, particularly large and potentially existential risks, requires a significant increase in adaptation ambition, informed by improved risk assessments based on climate projections and methods for addressing uncertainties such as decision-scaling and robust decision-making (Brown *et al.* 2012; Daron 2015; Ray and Brown 2015; Bhave *et al.* 2016). These techniques are informed by climate projects but are not dependent on them, and are based on asking under which conditions systems and actions succeed or fail and how plausible these conditions are in the future, rather than starting by asking what future conditions will look like.

Where current systems and practices are likely to be unviable under future climatic conditions, transformational adaptation involving phased transitions will be required. Rippke *et al.* (2016) propose three overlapping phases of transformational changes: a phase of incremental adaptation focusing on better, adaptive management of existing systems and practices; a preparatory phase to establish appropriate policies and enabling environments; and a transformational adaptation phase involving the substitution of previous systems and practices with alternatives that are viable under new climatic conditions.

This final phase may also involve abandoning certain systems and practices, or relocating people, infrastructure and economic activities. Transformational adaptation can be supported by continuous tracking of climate hazards and impacts, to identify where and when thresholds of viability may be reached. These may be thresholds in temperature, rainfall or other climate parameters, or thresholds of economic viability based on the frequency of failures in key systems, for example crop failures (Rippke *et al.* 2016).

Such transformational approaches will be extremely challenging and have significant potential to create winners and losers, resulting in potential resistance. It is therefore essential that they are based on genuine participation and co-production, in which those affected by climate hazards and adaptation responses play a leading role in adaptation planning, design, implementation and MEL, while working with relevant external expertise, for example to identify future risks based on climate projections (Brooks *et al.* 2019).

The existential nature of some climate risks, in specific geographical contexts, needs to be recognized and addressed at the policy level. These include existential risks from phenomena such as sea level rise (Lincke and Hinkel 2021) and risks that wet-bulb temperatures, which measure the combined effects of heat and humidity, will exceed human tolerances (Pal and Eltahir 2015; Im, Pal and Eltahir 2017; Andrews *et al.* 2018; Kang, Pal and Eltahir 2019).

ANNEX 5.C: Key sets of adaptation principles in the academic and grey literature underpinning table 5.2

Table 5.C.1 Key sets of adaptation principles in the academic and grey literature

Source	Principles (summarized)
Principles for effective adaptation research and practice (Singh *et al.* 2021)	• Minimize costs and maximize benefits. • Support achievement of material, subjective and relational well-being goals. • Reduce vulnerability and/or increase adaptive capacity, especially of the most vulnerable and those most at risk to climate change. • Increase resilience by building functional persistence over long timescales. • Be economically, ecologically and socially sustainable. • Address unintended negative consequences and long-term impacts. • Invest in ecosystem conservation, management and restoration to enhance ecosystem services and reduce impacts on human systems. • Co-produce with communities for inclusivity and sustainability. • Ensure transparency, accountability and representation in governance through multi-scalar, participatory and inclusive processes. • Be oriented towards socially just and equitable processes and outcomes. • Change thinking and practices and overtly challenge power structures that generate vulnerability.
Locally Led Adaptation Principles (Soanes *et al.* 2021)	• Devolve decision-making to the lowest appropriate level. • Address structural inequalities to support meaningful participation. • Provide patient and predictable funding: more than seven years. • Invest in local capabilities for understanding climate risks and uncertainties and generate solutions without depending on donors. • Build a robust understanding of climate risk and uncertainty integrating local and scientific knowledge. • Ensure flexible programming and learning for adaptive management and flexible finance. • Ensure transparency and accountability for local involvement in governance, finance, MEL. • Foster collaborative action and investment for efficiency and good practice.
Article 7 Adaptation Principles (Brooks *et al.* 2019)	• Country-driven for national ownership/priorities. • Gender-responsive for differentiated risks, vulnerabilities and impacts. • Participatory and transparent throughout for genuine stakeholder involvement. • Addressing vulnerabilities: target most vulnerable people, locations and systems. • Guided by best science and (local) knowledge relating to specific climate risks. • Integration of adaptation with national development priorities, activities and Sustainable Development Goals (SDGs).
Principles for sustainable adaptation (Eriksen *et al.* 2021)	• Recognize vulnerability contexts, including multiple stressors. • Acknowledge the role of values and interests. • Integrate local knowledge into adaptation responses. • Consider feedbacks across scales.
Power-sensitive design principles (Vij *et al.* 2021)	• Shift from 'transfer of knowledge' to 'co-creation of knowledge'. • Creation of safe spaces for continuous dialogue, interaction and raising concerns for future planning. • Democratic devolution in a multi-actor environment to support long-term policymaking and implementation. • Creation of mechanisms to build capacity, communication and negotiation skills for empowerment.

References

Annexes to chapter 2

Albania (2021). *Albania's Revised Nationally Determined Contribution*. Tirana. https://unfccc.int/sites/default/files/2022-08/Albania%20Revised%20NDC.pdf.

Austria (2017). *Austrian Strategy for Adaptation to Climate Change*. Vienna. https://www.bmk.gv.at/en/topics/climate-environment/climate-protection/austrian-strategy-adaptaion.html.

Climate Policy Radar (2022). Climate Policy Radar. https://app.climatepolicyradar.org/. Accessed 19 October 2022.

Dazé, A. and Hunter, C. (2022). *Gender-Responsive National Adaptation Plan (NAP) Processes: Progress and Promising Examples (NAP Global Network Synthesis Report 2021–2022)*. Winnipeg: International Institute for Sustainable Development. https://napglobalnetwork.org/resource/gender-responsive-nap-processes-progress-promising-examples/.

Fiji (2020). *Fiji's Updated Nationally Determined Contribution*. Suva. https://unfccc.int/sites/default/files/NDC/2022-06/Republic%20of%20Fiji%27s%20Updated%20NDC%2020201.pdf.

Grantham Research Institute on Climate Change and the Environment (2022). Methodology - legislation. https://climate-laws.org/methodology-legislation. Accessed 19 October 2022.

Kiribati (2013). *Kiribati's National Framework for Climate Change and Adaptation*. Tarawa. https://www.president.gov.ki/presidentgovki/wp-content/uploads/2019/04/National-Framework-for-Climate-Change-Climate-Change-Adaptation.pdf.

Kuwait (2021). *Kuwait's Updated Nationally Determined Contribution*. Kuwait City. https://unfccc.int/sites/default/files/NDC/2022-06/Kuwait%20updating%20the%20first%20NDC-arabic.pdf.

Nepal (2020). *Nepal's Second Nationally Determined Contribution*. Kathmandu. https://unfccc.int/sites/default/files/NDC/2022-06/Second%20Nationally%20Determined%20Contribution%20%28NDC%29%20-%202020.pdf.

Paraguay (2021). *Paraguay's Updated Nationally Determined Contribution*. Asunción. https://unfccc.int/sites/default/files/NDC/2022-06/Actualizaci%C3%B3n-NDC%20VF%20PAG.%20WEB_MADES%20Mayo%202022.pdf.

Pegram, J. and Colon, C. (2019). *Are Climate Change Policies Child-Sensitive?* New York: United Nations Children's Fund. https://www.unicef.org/globalinsight/media/646/file/are-climate-change-policies-child-%20sensitive-2019.pdf.

Sierra Leone (2021). *Sierra Leone's Updated Nationally Determined Contribution*. Free Town. https://unfccc.int/sites/default/files/NDC/2022-06/210804%202125%20SL%20NDC%20%281%29.pdf.

United Nations Framework Convention on Climate Change Least Developed Countries Expert Group (2012). *National Adaptation Plans: Technical Guidelines for the National Adaptation Plan Process*. Bonn. https://unfccc.int/files/adaptation/cancun_adaptation_framework/application/pdf/naptechguidelines_eng_high__res.pdf.

__________ (2022). *Constituted Body GST Synthesis Report: LEG Synthesis Report for the Technical Assessment Component of the First Global Stocktake*. Bonn. https://unfccc.int/documents/493304.

World Meteorological Organization and Green Climate Fund (2021). *Developing the Climate Science Basis for Climate Action*. Geneva: WMO. Available at https://library.wmo.int/index.php?lvl=notice_display&id=21974#.YlE7VJFBw2w.

World Bank (2022). Countries and Economies. https://data.worldbank.org/country. Accessed 19 October 2022.

Annexes to chapter 3

Adaptation Fund (2019). *Assessment Report on Progress in the Implementation of the Adaptation Fund's Gender Policy and Gender Action Plan*. 8 October. AFB/B.34/Inf.9. https://www.adaptation-fund.org/wp-content/uploads/2019/10/AFB.B.34.Inf_.9_Assessment-report-on-progress-in-the-implementation-of-the-Adaptation-Funds-Gender-Policy-and-Gender-Action-Plan_final_ready-for-posting1.pdf.

Adaptation Watch (2015). *Toward Mutual Accountability: The 2015 Adaptation Finance Transparency Gap Report*. https://unfccc.int/files/cooperation_and_support/financial_mechanism/standing_committee/application/pdf/aw_report_24_11_15_lo_res.pdf.

Atteridge, A. and Savvidou, G. (2020). Five things we learned about development finance while building Aid Atlas. SEI Policy Brief, June 2020. Stockholm Environment Institute. https://www.sei.org/publications/five-things-learned-development-finance-aid-atlas/.

Barker, S., Dellios, J. and Mulholland, A. (2021). *Legal Action as a Driver and Consequence of Climate-Related Physical Risk Adaptation. Liability Risk and Adaptation Finance*. MinterElisson.

Climate Investment Funds (2020). *Engagement of Women and Gender-Related Groups in the Climate Investment Funds: An Assessment*. https://climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/wedo_final_report_7april2020.pdf.

Dale, T.W., Gao, J., Avashia, V.K., Konrad, S. and Garg, A. (2021). *Private Sector Adaptation Reporting as a Source of Input to the Global Stocktake*. UNEP DTU Partnership and Indian Institute of Management Ahmedabad.

Doshi, D. and Garschagen, M. (2020). Understanding adaptation finance allocation: Which factors enable or constrain vulnerable countries to access funding? *Sustainability* 12(10), 4308. https://doi.org/10.3390/su12104308.

European Bank for Reconstruction and Development (2019). World's first dedicated climate resilience bond, for US$ 700m, is issued by EBRD, 20 September. https://www.ebrd.com/news/2019/worlds-first-dedicated-climate-resilience-bond-for-us-700m-is-issued-by-ebrd-.html#:~:text=The%20EBRD%20has%20successfully%20launched,40%20investors%20in%2015%20countries.

Heffron, R.J. and McCauley, D. (2018). What is the 'just transition'? *Geoforum; Journal of Physical, Human, and Regional Geosciences* 88, 74-77. https://doi-org.ezp.sub.su.se/10.1016/j.geoforum.2017.11.016.

Junghans, L. and Harmeling, S. (2012). Different tales from different countries: a first assessment of the OECD 'adaptation marker'. Germanwatch Briefing Paper. https://germanwatch.org/en/5375.

Khan, M., Robinson, S.A., Weikmans, R., Ciplet, D. and Roberts, J. T. (2020). Twenty-five years of adaptation finance through a climate justice lens. *Climatic Change* 161(2), 251-269. DOI:10.1007/s10584-019-02563-x.

Michaelowa, A. and Michaelowa, K. (2011). Coding error or statistical embellishment? The political economy of reporting climate aid. *World Development* 39(11), 2010-2020. https://doi.org/10.1016/j.worlddev.2011.07.020.

Organisation for Economic Co-operation and Development (2009). *Managing Aid. Practices of DAC Member Countries*. Paris. www.oecd.org/dac/peer-reviews/35051857.pdf.

__________ (2016). *OECD DAC Rio Markers for Climate. Handbook*. The Development Assistance Committee. https://www.oecd.org/dac/environment-development/Revised%20climate%20marker%20handbook_FINAL.pdf.

__________ (2018). *Climate-related Development Finance Data*. The Development Assistance Committee. https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/Climate-related-development-finance-in-2018.pdf.

__________ (2019a*). Aligning Development Co-operation and Climate Action: The Only Way Forward*. Paris: OECD Publishing. https://doi.org/10.1787/5099ad91-en.

__________ (2019b). Results of the first survey on coefficients that Members apply to the Rio marker data when reporting to the UN Conventions on Climate Change and Biodiversity. Paris. https://www.oecd.org/dac/financing-sustainable-development/Results%20of%20the%20first%20survey%20on%20coefficients%20that%20Members%20apply%20to%20the%20Rio%20marker%20data%20when%20reporting%20to%20the%20UN%20Conventions%20on%20Climate%20Change%20and%20Biodiversity.pdf.

__________ (2020). *Climate Finance Provided and Mobilised by Developed Countries in 2013-18*. Paris. https://www.oecd.org/environment/climate-finance-provided-and-mobilised-by-developed-countries-in-2013-18-f0773d55-en.htm.

__________ (2022a). *Aggregate Trends of Climate Finance Provided and Mobilised by Developed Countries in 2016-2020: Insights from Disaggregated Analysis*. Paris, France. https://www.oecd.org/environment/climate-finance-provided-and-mobilised-by-developed-countries-in-2016-2020-286dae5d-en.htm.

__________ (2022b). Results of the survey on the coefficients applied to 2019-20 Rio marker data when reporting to the UN environmental conventions. DAC Working Party on Development Finance Statistics. https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=DCD/DAC/STAT(2022)24&docLanguage=en.

__________ (2022c). Climate Change: OECD DAC External Development Finance Statistics. https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm. Accessed 11 July 2022.

Oxfam International (2020). *Climate Finance Shadow Report 2020: Assessing Progress Towards the $100 Billion Commitment*. www.oxfam.org/en/research/climate-finance-shadow-report-2020.

Pauw, W.P. (2015). Not a panacea: private-sector engagement in adaptation and adaptation finance in developing countries. *Climate Policy* 15(5), 583-603. https://doi.org/10.1080/14693062.2014.953906.

__________ (2021). The adaptation finance gap can only be closed by limiting the adaptation costs. *One Earth* 4(10), 1352-1355. https://doi.org/10.1016/j.oneear.2021.09.002.

Pauw, W.P, Beck, T., Valverde, M.J. *et al.* (2022). NDC Explorer. German Development Institute/Deutsches Institut für Entwicklungspolitik (DIE), African Centre for Technology Studies (ACTS), Stockholm Environment Institute (SEI), Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance. Accessed 24 October 2022. https://www.idos-research.de/en/ndc/.

Roberts, J.T., Weikmans, R., Robinson, S.A., Ciplet, D., Khan, M. and Falzon, D. (2021). Rebooting a failed promise of climate finance. *Nature Climate Change* 11, 180-182. https://doi.org/10.1038/s41558-021-00990-2.

Roy, J., Prakash, A., Some, S., Singh, C., Kerr, R.B., Caretta, M.A. *et al.* (2022). Synergies and trade-offs between climate change adaptation options and gender equality: a review of the global literature. *Humanities & Social Sciences Communications* 9, article 251. https://doi.org/10.1057/s41599-022-01266-6.

Savvidou, G., Atteridge, A., Omari-Motsumi, K. and Trisos, C.H. (2021). Quantifying international public finance for climate change adaptation in Africa. *Climate Policy* 21(8), 1020-1036. https://doi.org/10.1080/14693062.2021.1978053.

Schalatek, L. and Stiftung, H.B. (2019). *Gender and Climate Finance*: *Climate Funds Update*. Washington, D.C. https://climatefundsupdate.org/wp-content/uploads/2019/11/CFF10-2019-ENG-DIGITAL.pdf.

Schipper, E.L.F., Revi, A., Preston, B.L., Carr, E.R, Eriksen, S.H., Fernandez-Carril, L.R. *et al.* (2022). Climate resilient development pathways. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Pörtner, H.-O., Roberts, D.C. , Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. et al. (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press.* 2655-2807. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter18.pdf.

Setzer, J. and Higham, C. (2022). *Global Trends in Climate Change Litigation: 2022 Snapshot*. London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science.

Siders, A.R. (2019). Managed retreat in the United States. *One Earth* 1(2), 216-225. https://doi.org/10.1016/j.oneear.2019.09.008.

Toetzke, M., Stünzi, A. and Egli, F. (2022). Consistent and replicable estimation of bilateral climate finance. *Nature Climate Chang* 12, 897-900. https://doi.org/10.1038/s41558-022-01482-7.

Trabacchi, C., Koh, J., Shi, S. and Guelig, T. (2020). *Adaptation Solutions Taxonomy.* Adaptation SME Accelerator Project. https://lightsmithgp.com/wp-content/uploads/2020/09/asap-adaptation-solutions-taxonomy_july-28-2020_final.pdf.

United Nations Development Programme (2018). *Climate Change Adaptation in Africa: UNDP Synthesis of Experiences and Recommendations*. Bangkok: Bangkok Regional Hub. https://www.undp.org/publications/climate-change-adaptation-africa.

United Nations Environment Programme (2021). *Adaptation Gap Report 2021: The Gathering Storm – Adapting to Climate Change in a Post-Pandemic World*. Nairobi.

United Nations Framework Convention on Climate Change (2017). *Establishment of a Gender Action Plan.* 8 February. FCCC/CP/2017/11/Add.1. https://undocs.org/en/FCCC/CP/2017/11/Add.1.

United Nations Framework Convention on Climate Change Standing Committee on Finance (2018). *2018 Biennial Assessment and Overview of Climate Finance Flows*. Bonn.

__________ (2021). *Fourth (2020) Biennial Assessment and Overview of Climate Finance Flows*. Bonn. https://unfccc.int/topics/climate-finance/resources/biennial-assessment-and-overview-of-climate-finance-flows.

Weikmans, R. and Roberts, J.T. (2019). The international climate finance accounting muddle: is there hope on the horizon? *Climate and Development* 11(2), 97–111. https://doi.org/10.1080/17565529.2017.1410087.

Weikmans, R., Timmons Roberts, J., Baum, J., Bustos, M.C. and Durand, A. (2017). Assessing the credibility of how climate adaptation aid projects are categorised. *Development in Practice* 27, 458-471. https://doi.org/10.1080/09614524.2017.1307325.

Weiler, F., Klöck, C. and Dornan, M. (2018). Vulnerability, good governance, or donor interests? The allocation of aid for climate change adaptation. *World Development* 104, 65-77. https://doi.org/10.1016/j.worlddev.2017.11.001.

Weiler, F. and Sanubi, F.A. (2019). Development and climate aid to Africa: Comparing aid allocation models for different aid flows. *Africa Spectrum* 54(3), 244-267. https://doi.org/10.1177/0002039720905598.

Annexes to chapter 4

Berrang-Ford, L., Siders, A.R., Lesnikowski, A., Fischer, A.P., Callaghan, M.W., Haddaway, N.R. *et al.* (2021). A systematic global stocktake of evidence on human adaptation to climate change. *Nature Climate Change* 11, 989-1000. https://www.nature.com/articles/s41558-021-01170-y.

Cooperative for Assistance and Relief Everywhere (2021). *Climate Adaptation Finance: Fact or Fiction?* The Hague. https://careclimatechange.org/climate-adaptation-finance-fact-or-fiction/.

Garschagen, M., Leiter, T., Biesbroek, R., Magnan, A.K., Reckien, D., New, M. *et al.* (2022). Cross-chapter box PROGRESS | Approaches and challenges to assess adaptation progress at the global level. In *Climate Change 2022. Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Pörtner, H.-O., Roberts, D.C., Tignor, M.M.B., Poloczanska, E., Mintenbeck, K., Alegria, A. *et al.* (eds.). Cambridge and New York: Cambridge University Press. Chapter 17. 2610-2613. https://www.ipcc.ch/report/ar6/wg2/.

Global Environment Facility (2022). *Study on Resilience, Climate Change Adaptation and Climate Risks in the GEF Trust Fund. Prepared by the Independent Evaluation Office of the GEF*. https://www.gefieo.org/sites/default/files/documents/council-documents/c-62-e-03.pdf.

Intergovernmental Panel on Climate Change (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Pörtner, H.-O., Roberts, D.C., Tignor, M.M.B., Poloczanska, E., Mintenbeck, K., Alegria, A. *et al.* (eds.). Cambridge and New York: Cambridge University Press. https://www.ipcc.ch/report/ar6/wg2/.

Jenkins, K., Ford, A., Robson, C. and Nicholls, R.J. (2022). Identifying adaptation 'on the ground': Development of a UK adaptation inventory. *Climate Risk Management* 36, 100430. https://doi.org/10.1016/j.crm.2022.100430.

Leiter, T. (2015). Linking monitoring and evaluation of adaptation to climate change across scales: Avenues and practical approaches. *New Directions for Evaluation* 147, 117-127. https://www.onlinelibrary.wiley.com/doi/full/10.1002/ev.20135.

O'Neill, B., van Aalst, M., Ibrahim, Z.Z., Ford, L.B., Bhadwal, S., Buhaug, H., Diaz, D. *et al.* (2022). Key risks across sectors and regions: Synthesis of observed adaptation-related responses. In *Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Pörtner, H.-O., Roberts, D.C., Tignor, M.M.B., Poloczanska, E., Mintenbeck, K., Alegria, A. *et al.* (eds.). Cambridge and New York: Cambridge University Press. Chapter 16. 2428-2443. https://www.ipcc.ch/report/ar6/wg2/.

Organisation for Economic Co-operation and Development (2016). *OECD DAC Rio Markers for Climate: Handbook*. Paris. https://www.oecd.org/dac/environment-development/Revised%20climate%20marker%20handbook_FINAL.pdf.

__________ (2022). Climate Change: OECD DAC External Development Finance Statistics. https://www.oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm. Accessed 21 October 2022.

Toetzke, M., Stünzi, A. and Egli, F. (2022). Consistent and replicable estimation of bilateral climate finance. *Nature Climate Change* 12, 897-900. https://doi.org/10.1038/s41558-022-01482-7.

United Nations Environment Programme (2017). *Adaptation Gap Report 2017*. Nairobi. https://www.unep.org/resources/adaptation-gap-report-2017.

__________ (2021a). *Adaptation Gap Report 2020*. Nairobi. https://www.unep.org/resources/adaptation-gap-report-2020.

__________ (2021b). *Adaptation Gap Report 2021: The Gathering Storm. Adapting to Climate Change in a Post-Pandemic World*. Nairobi. https://www.unep.org/resources/adaptation-gap-report-2021.

United Nations Framework Convention on Climate Change (2022). Adaptation Communications Registry. https://unfccc.int/ACR. Accessed 21 October 2022.

United Nations Framework Convention on Climate Change Adaptation Committee (2022). *Draft Supplementary Guidance for Voluntary Use by Parties in Communicating Information in Accordance with the Possible Elements of an Adaptation Communication (AC22)*. 25 August. AC22/GUID/6B. https://unfccc.int/documents/611369.

Weikmans, R., Roberts, J.T., Baum, J., Bustos, M.C. and Durand, A. (2017). Assessing the credibility of how climate adaptation aid projects are categorised. *Development in Practice* 27, 458-471. http://dx.doi.org/10.1080/09614524.2017.1307325.

Annexes to chapter 5

Adaptation Fund (2019). *Strategic Results Framework*. https://www.adaptation-fund.org/document/strategic-results-framework-of-the-adaptation-fund-amended-in-march-2019/.

Adger, N.W., Arnell, N. and Tompkins, E.L. (2005). Successful adaptation to climate change across scales. *Global Environmental Change* 15(2), 77-86. https://doi.org/10.1016/j.gloenvcha.2004.12.005.

Adger, W.N., Crépin, A.S., Folke, C., Ospina, D., Stuart Chapin, F., Segerson, K. *et al.* (2020). Urbanization, migration, and adaptation to climate change. *One Earth* 3(4), 396-399, https://doi.org/10.1016/j.oneear.2020.09.016.

Ajibade, I. (2019). Planned retreat in Global South megacities: disentangling policy, practice, and environmental justice. *Climatic Change* 157(2), 299-317. https://link.springer.com/article/10.1007/s10584-019-02535-1.

Alves, F.M.M (2015). Cost-benefit analysis in climate change adaptation. Thesis for Master in Economics and Public Policy. Universidade NOVA de Lisboa. https://repositorio.iscte-iul.pt/bitstream/10071/11386/1/Alves_FilipeM_CB%20in%20CC%20adaptation_jan2015.pdf.

Andrews, O., Le Quéré, C., Kjellstrom, T., Lemke, B. and Haines, A. (2018). Implications for workability and survivability in populations exposed to extreme heat under climate change: a modelling study. *The Lancet Planetary Health* 2(12), e540–47. https://doi.org/10.1016/S2542-5196(18)30240-7.

Antwi-Agyei, P., Dougill, A.J., Doku-Marfo, J. and Abaidoo, R.C. (2021). Understanding climate services for enhancing resilient agricultural systems in Anglophone West Africa: The case of Ghana. *Climate Services* 22(April), 100218. https://www.sciencedirect.com/science/article/pii/S2405880721000066

Attu, H. and Adjei, J.K. (2018). Local knowledge and practices towards malaria in an irrigated farming community in Ghana. *Malaria Journal* 17, 1-8. https://doi.org/10.1186/s12936-018-2291-8

Awraris, M., Endalew, G.J., Guerrier, D. and Fikreyesus, D. (2014). *Tracking Adaptation and Measuring Development in Ethiopia*. London: International Institute for Environment and Development. https://www.iied.org/10104iied.

Bahadur, A.V., Peters, K., Wilkinson, E., Pichon, F., Gray, K. and Tanner, T. (2015). The 3AS: Tracking resilience across BRACED. Working paper. Overseas Development Institute. https://www.odi.org/publications/9840-3as-tracking-resilience-across-braced.

Bakaki, Z. (2022). The impact of climate summits. *Nature Climate Change* 12(7), 617-618. https://doi.org/10.1038/s41558-022-01416-3.

Barrett, K. and Bosak, K. (2018). The role of place in adapting to climate change: A case study from Ladakh, Western Himalayas. *Sustainability* 10(4), 898. https://doi.org/10.3390/su10040898.

Barreca, A., Clay, K., Deschenes, O., Greenstone, M. and Shapiro, J.S. (2016). Adapting to climate change: The remarkable decline in the US temperature-mortality relationship over the twentieth century. *Journal of Political Economy* 124(1). https://www.journals.uchicago.edu/doi/abs/10.1086/684582.

Barrett, S., Brooks, N., Quadrianto, N., Anderson, S. and Nebsu, B. (2020). Measuring climate resilience by linking shocks to development outcomes. *Climate and Development* 12(7), 677–88. https://doi.org/10.1080/17565529.2019.1676689.

Bednar-Friedl, B., Biesbroek, R., Schmidt, D.N., Alexander, P., Børsheim, K.Y., Carnicer, J. *et al.* (2022). Europe. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. *et al.* (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter13.pdf.

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W. and Courchamp, F. (2012). Impacts of climate change on the future of biodiversity: Biodiversity and climate change. *Ecology Letters* 15(4), 365–77. https://doi.org/10.1111/j.1461-0248.2011.01736.x.

Benmarhnia, T., Schwarz, L., Nori-Sarma, A. and Bell, M.L. (2019). Quantifying the impact of changing the threshold of New York City heat emergency plan in reducing heat-related illnesses. Environmental Research Letters 14, 114006. https://iopscience.iop.org/article/10.1088/1748-9326/ab402e/pdf.

Bhave, A.G., Conway, D., Dessai, S. and Stainforth, D.A. (2016). Barriers and opportunities for robust decision making approaches to support climate change adaptation in the developing world. *Climate Risk Management* 14, 1-10. https://doi.org/10.1016/j.crm.2016.09.004.

Birkmann, J., Llwenga, E., Pandey, R., Boyd, E., Djalante, R., Gemenne, F. *et al.* (2022). Poverty, livelihoods and sustainable development. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. *et al.* (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. 2411-2538. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter08.pdf.

Brooks, N. (2020). Shifting norms and values for transitions to net zero. Working Paper. Climate Innovation Insights Series 5. EIT Climate-KIC. https://www.climate-kic.org/insights/shifting-norms-and-values-for-transitions-to-net-zero/.

Brooks, N. and Fisher, S. (2014). *Tracking Adaptation and Measuring Development: A Step-by-Step Guide*. London: International Institute for Environment and Development. https://pubs.iied.org/10100IIED/.

Brooks, N., Adger, W.N. and Kelly, P.M. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change* 15(2), 151-63. https://doi.org/10.1016/j.gloenvcha.2004.12.006.

Brooks, N., Anderson, S., Aragon, I., Smith, B., Kajumba, T. and Beauchamp, E. *et al.* (2019). Framing and tracking 21st century climate adaptation. Working paper. Monitoring, Evaluation and Learning; Climate Change. London, UK: International Institute for Environment and Development. https://www.iied.org/sites/default/files/pdfs/migrate/10202IIED.pdf.

Brooks, N., Clarke, J., Wambui Ngaruiya, G. and Wangui, E.E. (2020). African heritage in a changing climate. *Azania: Archaeological Research in Africa* 55(3), 297–328. https://doi.org/10.1080/0067270X.2020.1792177

Brooks, N., Faget, D. and Heijkoop, P. (2019). *Tools for Measurement of Resilience in Nepal*. London, UK: Department for International Development. https://assets.publishing.service.gov.uk/media/5cff7c18e5274a3cc494e7b1/Resilience_measurement_LitRev_FINAL-updated1_ML_June_2019.pdf.

Brown, C., Ghile, Y., Laverty, M. and Li, K. (2012). Decision scaling: Linking bottom-up vulnerability analysis with climate projections in the water sector. *Water Resources Research* 48(9). https://doi.org/10.1029/2011WR011212.

Chakraborty, R., Gergan, M.D., Sherpa, P.Y. and Rampini, C. (2021). A plural climate studies framework for the Himalayas. *Current Opinion in Environmental Sustainability* 5, 42-54. https://doi.org/10.1016/j.cosust.2021.02.005.

Cook, K.H. and Vizy, E.K. (2015). Detection and analysis of an amplified warming of the Sahara Desert. *Journal of Climate* 28, 6560-6580. y H. https://doi.org/10.1175/JCLI-D-14-00230.1.

Crichton, R. and Esteban, M. (2018). Limits to coastal adaptation in Samoa: Insights and experiences. In: *Limits to Climate Change Adaptation.* Filho, W.L. and Nalau, J. (eds.). Springer Cham. 283-300. https://doi.org/10.1007/978-3-319-64599-5_16

Cundill, G. (2021). Toward a climate mobilities research agenda: Intersectionality, immobility, and policy responses. *Global Environmental Change* 69(July), 102315. https://doi.org/10.1016/j.gloenvcha.2021.102315.

Daron, J. (2015). Challenges in using a robust decision making approach to guide climate change adaptation in South Africa. *Climatic Change* 132(3), 459-473. https://doi.org/10.1007/s10584-014-1242-9 .

Davis, K.F., Bhattachan, A., D'Odorico, P. and Suweis, S. (2018). A universal model for predicting human migration under climate change: examining future sea level rise in Bangladesh. *Environmental Research Letters* 13(6), 064030. https://iopscience.iop.org/article/10.1088/1748-9326/aac4d4.

Davis, R.E., Knappenberger, P.C., Novicoff, W.M. and Michaels, P.J. (2003). Decadal changes in summer mortality in U.S. cities. *Int J Biometeorol* 47, 166-175. https://doi.org/10.1007/s00484-003-0160-8.

Donner, S.D. and Webber, S. (2014). Obstacles to climate change adaptation decisions: a case study of sea-level rise and coastal protection measures in Kiribati. *Sustainability Science* 9(3), 331-345, https://link.springer.com/article/10.1007/s11625-014-0242-z.

Dosio, A. (2017). Projection of temperature and heat waves for Africa with an ensemble of CORDEX Regional Climate Models. *Climate Dynamics* 49, 493-519. https://link.springer.com/article/10.1007/s00382-016-3355-5.

Dottori, F., Mentaschi, L., Bianchi, A., Alfieri, L. and Feyen, L. (2020). *Adapting to Rising River Flood Risk in the EU Under Climate Change*. JRC PESETA IV project: Task 5. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2760/14505.

Ebi, K., Teisberg, T., Kalkstein, L., Robinson, L. and Weiher, R. (2004). Heat watch/warning systems save lives: Estimated costs and benefits for Philadelphia 1995-1998. *Epidemiology* 14(5), S35. https://doi.org/10.1175/BAMS-85-8-1067.

Ejaz Qureshi, M., Hanjra, M.A. and Ward, J. (2013). Impact of water scarcity in Australia on global food security in an era of climate change. *Food Policy* 38(February), 136-45. https://doi.org/10.1016/j.foodpol.2012.11.003.

Eriksen, S., Schipper, E.L.F., Scoville-Simonds, M., Vincent, K., Adam, H.N., Brooks, N. *et al.* (2021). Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance? *World Development* 141, 105383. https://doi.org/10.1016/j.worlddev.2020.105383.

European Commission (2013). Adapting infrastructure to climate change. Commission Staff Working Document SWD (2013) 137. Brussels. https://climate-adapt.eea.europa.eu/en/metadata/publications/adapting-infrastructure-to-climate-change.

Fawcett, D., Pearce, T., Ford, J.D. and Archer, L. (2017). Operationalizing longitudinal approaches to climate change vulnerability assessment. *Global Environmental Change* 45, 79-88. https://doi.org/10.1016/j.gloenvcha.2017.05.002.

Food and Agriculture Organization of the United Nations (2016). *RIMA-II: Resilience Index Measurement and Analysis - II*. Rome. https://www.fao.org/3/i5665e/i5665e.pdf.

Gajjar, S.P., Singh, C. and Deshpande, T. (2019). Tracing back to move ahead: a review of development pathways that constrain adaptation futures. *Climate and Development* 11(3), 223-237. https://www.tandfonline.com/doi/abs/10.1080/17565529.2018.1442793?journalCode=tcld20.

Gasparrini, A., Guo, Y., Hashizume, M., Lavigne, E., Zanobetti, A., Schwartz, J. *et al.* (2015). Mortality risk attributable to high and low ambient temperature: a multicountry observational study. *The Lancet* 386(9991), 369-75. https://doi.org/10.1016/S0140-6736(14)62114-0.

Glavovic, B.C., Dawson, R., Chow, W., Garschagen, M., Haasnoot, M., Singh, C. *et al.* (2022). C CP2 c ities and settlements by the sea. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. *et al.* (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. 2163-2194. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_CCP2.pdf.

Green Climate Fund (2021). Integrated Results Management Framework. https://www.greenclimate.fund/document/integrated-results-management-framework.

Haer, T., Wouter Botzen, W.J., Aerts, J.C.J.H. (2016). The effectiveness of flood risk communication strategies and the influence of social networks—Insights from an agent-based model. *Environmental Science & Policy* 60(June), 44-52. https://doi.org/10.1016/j.envsci.2016.03.006.

Hamed, Y., Hadji, R., Redhaounia, B., Zighmi, K., Bâali, F and El Gayar, A. (2018). Climate impact on surface and groundwater in North Africa: a global synthesis of findings and recommendations. *Euro-Mediterranean Journal for Environmental Integration* 3, 25. https://doi.org/10.1007/s41207-018-0067-8.

Harrington, L.J., Otto, F.E.L. Attributable damage liability in a non-linear climate. *Climatic Change* 153, 15–20 (2019). https://doi.org/10.1007/s10584-019-02379-9.

Hasan, F., Marsia, S., Patel, K., Agrawal, P. and Razzak, J.A. (2021). Effective community-based interventions for the prevention and management of heat-related illnesses: a scoping review. *International Journal of Environmental Research and Public Health* 18(16), 8362. https://doi.org/10.3390/ijerph18168362.

Hinkel, J., Aerts, J.C.J.H., Brown, S., Jiménez, J.A., Lincke, D., Nicholls, R.J. *et al.* (2018). The ability of societies to adapt to twenty-first-century sea-level rise. *Nature Climate Change* 8(7), 570-578. https://doi.org/10.1038/s41558-018-0176-z.

Im, E.-S., Pal, J.S. and Eltahir, E.A.B. (2017). Deadly heat waves projected in the densely populated agricultural regions of South Asia. *Science Advances* 3(8): e1603322. https://doi.org/10.1126/sciadv.1603322.

Intergovernmental Panel on Climate Change (2001). Climate change 2001: Impacts, adaptation, and vulnerability. *Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. McCarthy, J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White, K.S. (eds.). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. https://www.ipcc.ch/report/ar3/wg2/.

__________ (2007). Climate change 2007: Impacts, adaptation and vulnerability. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. https://www.ipcc.ch/report/ar4/wg2/.

__________ (2019). *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. Pörtner, H.-O., Roberts, D.C., Masson-Delmonte, V., Zhai, P., Tignor, M., Poloczanska, E, Mintenbeck, K. *et al.* (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. https://www.ipcc.ch/srocc/.

__________ (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. *Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. *et al.* (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. https://www.ipcc.ch/report/ar6/wg2/.

Jain, G., Singh, C. and Malladi, T. (2021). (Re)creating disasters – A case of post-disaster relocations in Chennai. In: *Rethinking Urban Risk and Resettlement in the Global South*. Johnson, C., Jain, G. and Lavell. A. (eds.). UCL Press. 269-289. https://doi.org/10.2307/j.ctv1ctgr0k.25.

Jongman, B. (2018) Effective adaptation to rising flood risk. *Nature Communications* 9(May), 1986. https://doi.org/10.1038/s41467-018-04396-1.

Juhola, S., Glaas, E., Linnér, B.O. and Neset, T.S. (2016). Redefining maladaptation. *Environmental Science and Policy* 55(Part 1), 135-140. https://doi.org/10.1016/j.envsci.2015.09.014.

Kaczan, D., Arslan, A. and Lipper, L (2013). Climate-smart agriculture. A review of current practice of agroforestry and conservation agriculture in Malawi and Zambia. ESA working paper no. 13-07. https://ageconsearch.umn.edu/record/288985/?ln=en.

Kalkstein, A.J. and Sheridan, S.C. (2007). The social impacts of the heat–health watch/warning system in Phoenix, Arizona: assessing the perceived risk and response of the public. *International Journal of Biometeorology* 52(1), 43-55. https://doi.org/10.1007/s00484-006-0073-4.

Kang, S., Pal, J.S. and Eltahir, E.A.B. (2019). Future heat stress during Muslim pilgrimage (Hajj) projected to exceed "extreme danger" levels. *Geophysical Research Letters* 46(16): 10094–100. https://doi.org/10.1029/2019GL083686.

Kienzler, S., Pech, I., Kreibich, H., Müller, M. and Thieken, A. H. (2015). After the extreme flood in 2002: changes in preparedness, response and recovery of flood-affected residents in Germany between 2005 and 2011. *Nat. Hazards Earth Syst. Sci.* 15, 505–526. https://doi.org/10.5194/nhess-15-505-2015.

Kim, H., Gu, D. and Kim, H.Y. (2018). Effects of Urban Heat Island mitigation in various climate zones in the United States. *Sustainable Cities & Society* 41, 841-52. https://doi.org/10.1016/j.scs.2018.06.021

Leal Filho, W., Wolf, F., Totin, E., Zvobgo, L., Simpson, N.P., Musiyiwa, K. *et al.* (2022). Is indigenous knowledge serving climate adaptation? Evidence from various African regions. *Development Policy Review*, e12664. https://doi.org/10.1111/dpr.12664.

Lelieveld, J., Proestos, Y., Hadjinicolaou, P., Tanarhte, M., Tyrlis, E. and Zittis, G. (2016). Strongly increasing heat extremes in the Middle East and North Africa (MENA) in the 21st century. *Climatic Change* 137: 245-260. https://doi.org/10.1007/s10584-016-1665-6.

Lim, J. and Skidmore, M. (2020). Heat vulnerability and heat island mitigation in the United States. *Atmosphere* 11(6), 558. https://doi.org/10.3390/atmos11060558.

Lincke, D. and Hinkel, J. (2018). Economically robust protection against 21st century sea-level rise. *Global Environmental Change* 51(July), 67-73, https://doi.org/10.1016/j.gloenvcha.2018.05.003.

__________(2021). Coastal migration due to 21st century sea-level rise. *Earth's Future* 9(5). https://doi.org/10.1029/2020EF001965.

Magnan, A. (2014). Avoiding maladaptation to climate change: towards guiding principles. *SAPIENS Online* 7(1), 12. http://journals.openedition.org/sapiens/1680.

Maharjan, A., Safra de Campos, R., Singh, C., Das, S., Srinivas, A., Rashed Alam Bhuiyan, M. *et al.* (2020). Migration and household adaptation in climate-sensitive hotspots in South Asia. *Current Climate Change Reports* 6(1), 1-16. https://doi.org/10.1007/s40641-020-00153-z.

McMichael, A.J., Wilkinson, P., Kovats, R.S., Pattenden, S., Hajat, S., Armstrong, B. *et al.* (2008). I nternational s tudy o f temperature, heat and urban mortality: the "ISOTHURM" project. *International Journal of Epidemiology* 37(5), 1121-31. https://doi.org/10.1093/ije/dyn086.

McNamara, K.E. and Des Combes, H.J. (2015). Planning for community relocations due to climate change in Fiji. *International Journal of Disaster Risk Science* 6(3), 315-319. https://doi.org/10.1007/s13753-015-0065-2.

McNamara, K.E., Westoby, R. and Smithers, S.G. (2017). Identification of limits and barriers to climate change adaptation: case study of two islands in Torres Strait, Australia. *Geographical Research* 55(4), 438-455. https://doi.org/10.1111/1745-5871.12242.

Meerow, S. (2017). Double exposure, infrastructure planning, and urban climate resilience in coastal megacities: A case study of Manila. *Environment and Planning A: Economy and Space* 49(11), 2649–2672. https://doi.org/10.1177/0308518X17723630.

Mohmmed, A., Li, J.H., Elaru, J., Elbashier, M.M.A., Keesstra, S., Artemi, C. *et al.* (2018). Assessing drought vulnerability and adaptation among farmers in Gadaref region, Eastern Sudan. *Land Use Policy* 70, 402-413. https://doi.org/10.1016/j.landusepol.2017.11.027.

Mutenje, M.J., Farnworth, C.R., Stirling, C., Thierfelder, C., Mupangwa, W. and Nyagumbo, I. (2019). A cost-benefit analysis of climate-smart agriculture options in Southern Africa: Balancing gender and technology. *Ecological Economics* 163, 126-137. https://doi.org/10.1016/j.ecolecon.2019.05.013.

National Academies of Sciences, Engineering, and Medicine (2016). *Attribution of Extreme Weather Events in the Context of Climate Change*. Washington, D.C.: The National Academies Press. https://doi.org/10.17226/21852.

Naylor, A. (2015). Island morphology, reef resources, and development paths in the Maldives. *Progress in Physical Geography: Earth and Environemnt* 39(6), 728-749, https://doi.org/10.1177/0309133315598269.

Nikiema, P.M., Sylla, M.B., Ogunjobi, K., Kebe, I., Gibba, P. and Giorgi, F. (2017). Multi-model CMIP5 and CORDEX simulations of historical summer temperature and precipitation variabilities over West Africa. *International Journal of Climatology* 37, 2438-2450. https://doi.org/10.1002/joc.4856.

O'Neill, B., van Aalst, M., Zaiton Ibrahim, Z., Berrang Ford, L., Bhadwal, S., Buhaug, H. *et al.* (2022). Key risks across sectors and regions. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Pörtner, H.-O., Roberts, D.C. , Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. *et al.* (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. 2411-2538. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Chapter16.pdf.

Pal, J.S. and Eltahir, E.A.B. (2015). Future temperature in southwest Asia projected to exceed a threshold for human adaptability. *Nature Climate Change* 6(2), 197-200. https://doi.org/10.1038/nclimate2833.

Pandya, P.A., Mashru, H.H., Patel, R.J. and Rank, H.D. (2019). Rainfall variations and its correlation with groundnut productivity. *International Journal of Multidisciplinary Research and Development* 6(3), 87-90. https://www.researchgate.net/profile/Rajnikumar-Patel2/publication/332633255_Rainfall_variations_and_its_correlation_with_groundnut_productivity/links/5cc18fe94585156cd7b0157a/Rainfall-variations-and-its-correlation-with-groundnut-productivity.pdf.

Pappenberger, F., Cloke, H.L., Parker, D.J., Wetterhall, F., Richardson, D.S. and Thielen, J. (2015). The monetary benefit of early flood warnings in Europe. *Environmental Science & Policy* 51, 278–291. https://doi.org/10.1016/j.envsci.2015.04.016.

Paprotny, D., Sebastian, A., Morales-Nápoles, O. and Jonkman, S.N. (2018). Trends in flood losses in Europe over the past 150 years. *Nature Communication* 9, 1985. https://doi.org/10.1038/s41467-018-04253-1.

Partey, S.T., Zougmoré, R.B., Ouédraogo, M. and Campbell, B.M. (2018). Developing climate-smart agriculture to face climate variability in West Africa: Challenges and lessons learnt. *Journal of Cleaner Production* 187(June), 285-295. https://doi.org/10.1016/j.jclepro.2018.03.199.

Petrova, I.Y., Van Heerwaarden, C.C., Hohenegger, C. and Guichard, F. (2018). Regional co-variability of spatial and temporal soil moisture–precipitation coupling in North Africa: an observational perspective. *Hydrology and Earth System Sciences* 22(6), 3275-3294. https://doi.org/10.5194/hess-22-3275-2018.

Petzold, J., Ratter, B. and Holdschlag, A. (2018). Competing knowledge systems and adaptability to sea-level rise in The Bahamas. *Area* 50(1), 91-100. https://doi.org/10.1111/area.12355.

Piggott-McKellar, A.E., Nunn, P.D., McNamara, K.E. and Sekinini, S.T. (2020). Dam(n) seawalls: A case of climate change maladaptation in Fiji. *Climate Change Management*. https://doi.org/10.1007/978-3-030-40552-6_4.

Poussin, J.K., Botzen, W.J.W. and Aerts, J.C.J.H. (2015). Effectiveness of flood damage mitigation measures: Empirical evidence from French flood disasters. *Global Environmental Change* 31, 74-84. https://doi.org/10.1016/j.gloenvcha.2014.12.007.

Ranasinghe, R., Ruane, A.C., Vautard, R., Arnell, N., Coppola, E., Cruz, F.A. *et al.* (2021). Climate change information for regional impact and for risk assessment. In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. 4215-4232. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter12.pdf.

Ray, P.A. and Brown, C.M. (2015). *Confronting Climate Uncertainty in Water Resources Planning and Project Design*. World Bank Group. https://openknowledge.worldbank.org/handle/10986/22544.

Rippke, U., Ramirez-Villegas, J., Jarvis, A., Vermeulen, S.J., Parker, L., Mer, F. *et al.* (2016). Timescales of transformational climate change adaptation in sub-Saharan African agriculture. *Nature Climate Change* 6(6), 605–9. https://doi.org/10.1038/nclimate2947.

Rogot, E., Sorlie, P.D. and Backlund, E. (1992). Air-conditioning and mortality in hot weather. *Am J Epidemiol* 136(1), 106-116. https://doi.org/10.1093/oxfordjournals.aje.a116413.

Schipper, E.L.F. (2020). Maladaptation: When adaptation to climate change goes very wrong. *One Earth* 3(4), 409-14. https://doi.org/10.1016/j.oneear.2020.09.014.

Singh, C., Iyer, S., New, M.G., Few, R., Kuchimanchi, B., Segnon, A.C. *et al.* (2021). Interrogating 'effectiveness' in climate change adaptation: 11 guiding principles for adaptation research and practice. *Climate and Development* (August), 1-15. https://doi.org/10.1080/17565529.2021.1964937.

Seneviratne, S.I., Zhang, X., Adnan, M., Badi, W., Dereczynski, C., Di Luca, A. *et al.* (2021). Weather and climate extreme events in a changing climate. In: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Pörtner, H.-O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A. *et al.* (eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter11.pdf.

Senyolo, M.P., Long, T.B., Blok, V. and Omta, O. (2018). How the characteristics of innovations impact their adoption: An exploration of climate-smart agricultural innovations in South Africa. *Journal of Cleaner Production* 172(January), 3825-3840. https://doi.org/10.1016/j.jclepro.2017.06.019.

Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W. *et al.* (2017). Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. *Regional Environmental Change* 17: 1585-1600. https://doi.org/10.1007/s10113-015-0910-2.

Sheridan, S.C. (2007). A survey of public perception and response to heat warnings across four North American cities: an evaluation of municipal effectiveness. *International Journal of Biometeorology* 52, 3-15. https://link.springer.com/article/10.1007/s00484-006-0052-9.

Singh, C., Iyer, S., New, M.G., Few, R., Kuchimanchi, B., Segnon, A.C. *et al.* (2021). Interrogating 'effectiveness' in climate change adaptation: 11 guiding principles for adaptation research and practice. *Climate and Development* (August), 1-15. https://doi.org/10.1080/17565529.2021.1964937.

Soanes, M., Bahadur, A.V., Shakya, C., Smith, B., Patel, S., Rumbaitis del Rio, C. *et al.* (2021). Principles for locally led adaptation. Issue paper January. International Institute for Environment and Development. https://www.iied.org/principles-for-locally-led-adaptation.

Solesbury, W. (2003). Sustainable livelihoods: A case study of the evolution of DFID policy. Working paper 217. London, UK: Overseas Development Institute. https://cdn.odi.org/media/documents/172.pdf.

Stone, B., Vargo, J. and Habeeb, D. (2012). Managing climate change in cities: Will climate action plans work? *Landscape & Urban Planning* 107(3), 263-271. https://doi.org/10.1016/j.landurbplan.2012.05.014.

Strauss, B.H., Orton, P.M., Bittermann, K., Buchanan, M.K., Gilford, D.M., Kopp, R.E. *et al.* (2021). Economic damages from Hurricane Sandy attributable to sea level rise caused by anthropogenic climate change. *Nature Communications* 12(1), 2720. https://www.nature.com/articles/s41467-021-22838-1.

Sultana, F. (2022). The unbearable heaviness of climate coloniality. *Political Geography* (March), 102638. https://doi.org/10.1016/j.polgeo.2022.102638.

Taylor, M., Eriksen, S., Vincent, K., Brooks, N., Scoville-Simonds, M. and Schipper, E.L.F. (2022). *Putting "Vulnerable Groups" at the Centre of Adaptation Interventions by Promoting Transformative Adaptation as a Learning Process*. Report submitted to the Norwegian Agency for Development Cooperation (Norad). Oslo, Norway: Norwegian University of Life Sciences. https://www.nmbu.no/fakultet/landsam/diverse/node/45360.

Thieken, A.H., Samprogna Mohor, G., Kreibich, H. and Müller, M. (2022). Compound inland flood events: different pathways, different impacts and different coping options. *Nat. Hazards Earth Syst. Sci.* 22(1), 165-185. https://doi.org/10.5194/nhess-22-165-2022.

Thomas, A. and Benjamin, L. (2020). Non-economic loss and damage: lessons from displacement in the Caribbean. *Climate Policy* 20(6), 715-728. https://doi.org/10.1080/14693062.2019.1640105.

Toloo, G., FitzGerald, G., Aitken, P., Verrall, K. and Tong, S. (2013). Evaluating the effectiveness of heat warning systems: systematic review of epidemiological evidence. *International Journal of Public Health* 58(5), 667-681. https://doi.org/10.1007/s00038-013-0465-2.

Totin, E., Segnon, A., Schut, M., Affognon, H., Zougmoré, R., Rosenstock, T., et al. (2018). Institutional perspectives of climate-smart agriculture: A systematic literature review. *Sustainability* 10, 1-20. https://doi.org/10.3390/su10061990.

Tran, A.T., Tran, T.H. and Tran, P.C.V. (2016). *Cost-Benefit Analysis of Climate-Resilient Housing in Central Vietnam*. EEPSEA Research Report No. 2016-RR6. Laguna, Philippines: Economy and Environment Program in Southeast Asia. https://www.i-s-e-t.org/_files/ugd/558f8a_b2245e6b83f2423c9f3c31ebab7825b0.pdf.

United Nations Framework Convention on Climate Change (2011). *Assessing the Costs and Benefits of Adaptation Options: An Overview of Approaches*. Bonn, Germany: United Nations Climate Change Secretariat. https://unfccc.int/resource/docs/publications/pub_nwp_costs_benefits_adaptation.pdf.

Venable, L., Brooks, N. and Vincent, K (2022). *Lessons for Measuring Resilience from the BRACC Programme.* Learning Brief. BRACC. https://bracc.kulima.com/sites/default/files/2022-03/Resilience%20Measurement%20Brief.pdf.

Verner, D., Treguer, D., Redwood, J., Christensen, J., McDonnell, R., Elbert, C. *et al.* (2018). Climate variability, drought, and drought management in Morocco's agricultural sector. Working paper. Washington, D.C.: World Bank. https://elibrary.worldbank.org/doi/epdf/10.1596/30603.

Vij, S., Biesbroek, R., Stock, R., Gardezi, M., Ishtiaque, A., Groot, A. *et al.* (2021). ' Power-sensitive d esign p rinciples' f or climate change adaptation policy-making in South Asia'. *Earth System Governance* 9 (September): 100109. https://doi.org/10.1016/j.esg.2021.100109.

Waha, K., Van Wijk, M.T., Fritz, S., See, L., Thornton, P.K., Wichern, J. *et al.* (2018). Agricultural diversification as an important strategy for achieving food security in Africa. *Global Change Biology* 24(8), 3390-3400. https://doi.org/10.1111/gcb.14158.

Weiler, F., Klöck, C. and Dornan, M. (2018). Vulnerability, good governance, or donor interests? The allocation of aid for climate change adaptation. *World Development* 104 (April), 65-77. https://doi.org/10.1016/j.worlddev.2017.11.001.

World Bank (2006). *Ethiopia: Managing Water Resources to Maximize Sustainable Growth. A World Bank Water Resources Assistance Strategy for Ethiopia.* Washington D.C.: The International Bank for Reconstruction and Development / The World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/8170/360000REVISED01final1text1and1cover.pdf.

Wekesa, B.M., Ayuya, O.I. and Lagat, J.K. (2018). Effect of climate-smart agricultural practices on household food security in smallholder production systems: micro-level evidence from Kenya. *Agriculture & Food Security* 7, 80. https://doi.org/10.1186/s40066-018-0230-0.

Weinberger, K.R., Zanobetti, A., Schwartz, J. and Wellenius, G.A. (2018). Effectiveness of National Weather Service heat alerts in preventing mortality in 20 US cities. *Environment International* 116, 30-38. https://doi.org/10.1016/j.envint.2018.03.028.

Yaron, G., Win, K. and Wilson, D. (2017). Resilience dividends of community-level interventions: Evidence from Myanmar. Asian Development Bank. https://themimu.info/sites/themimu.info/files/documents/Resilience_Programme_Cost_Benefit_Aanlysis_ADB_ENG.pdf.

Zerssa, G., Feyssa, D., Kim, D.G. and Eichler-Löbermann, B. (2021). Challenges of smallholder farming in Ethiopia and opportunities by adopting climate-smart agriculture. *Agriculture* 11(3), 192. https://doi.org/10.3390/agriculture11030192.

Zimmerman, R.A., Russell, J., McClosky, J., Wick, T. and Chabel, S. (2010). *Evaluating Losses Avoided Through Acquisition Projects*. Moorhead, Minnesota, USA: FEMA. https://dps.mn.gov/divisions/hsem/hazard-mitigation/Documents/Moorhead%20Losses%20Avoided%20Report.pdf.

Zvobgo, L., Johnston, P., Williams, P.A., Trisos, C.H., Simpson, N.P. and Global Adaptation Mapping Initiative Team (2022). The role of indigenous knowledge and local knowledge in water sector adaptation to climate change in Africa: a structured assessment. *Sustainability Science* 17(April). https://doi.org/10.1007/s11625-022-01118-x.

UN environment programme

United Nations Avenue, Gigiri
P O Box 30552, 00100 Nairobi, Kenya
Tel +254 720 200200
communication@unep.org
www.unep.org